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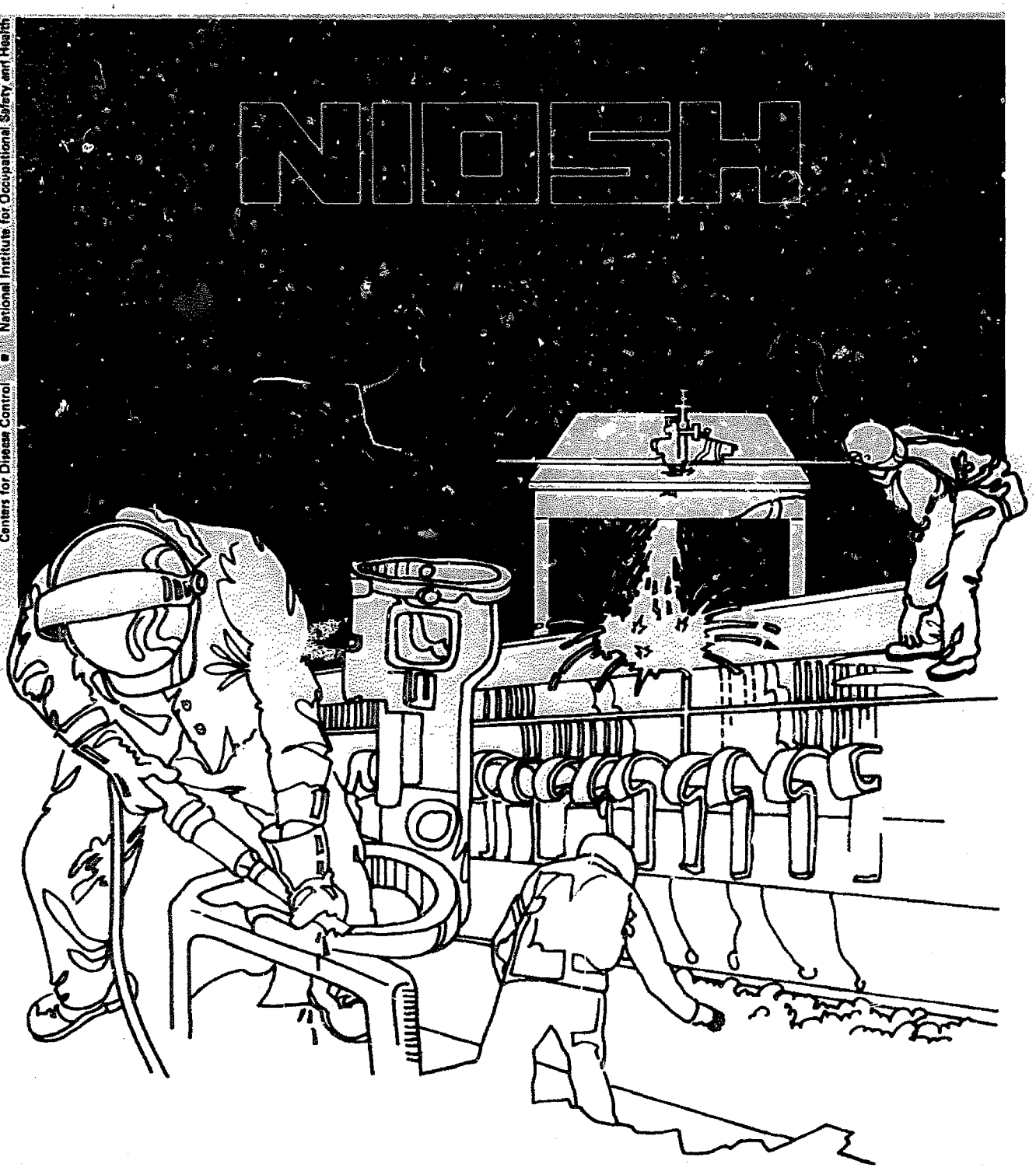

Health Hazard Evaluation Report

HETA 83-195-1426
DAVID MAYER POULTRY FARM
HOBGOOD, NORTH CAROLINA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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HETA 83-195-1426
February, 1984
David Mayer Poultry Farm
Hobgood, North Carolina

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I. SUMMARY

On February 17, 1983, the David Mayer Poultry Farm and other poultry growers near Hobgood, North Carolina requested that NIOSH conduct a health hazard evaluation of their poultry confinement houses ("broiler houses"). The poultry growers had noticed an increase in eye and throat irritation, headaches, shortness of breath, and tightness in the chest since they began raising chickens.

A "broiler house" is typically a 36'x360' clearspan building equipped with automatic feeders and waterers, and is heated with gas-fired unvented space heaters. Windows and large fans provide ventilation. Approximately 20,000 birds are confined per house. Growers are inside houses an average of 12 hours per house per week (7 days per week), and 44 to 48 weeks per year. A grower usually manages 2 to 4 houses.

Following an initial survey March 11, 1983, several broiler houses were monitored for airborne dust, endotoxins, microorganisms, and gases in June and October, 1983, and pulmonary function tests and health questionnaires were administered to 25 poultry growers on October 24, 1983.

Dust concentrations inside houses were higher during the March and October surveys, when both natural and induced ventilation were minimal; also, concentrations were higher in houses with adult birds and older litter than in houses with young birds and fresh litter. About 4 to 12% of the airborne dust was respirable. Total dust concentrations of four area air samples exceeded the ACGIH recommended limit of 10 mg/m^3; no personal total dust or area respirable dust samples exceeded recommended limits for nuisance dust. Endotoxin concentrations were 1.4 to 70.2 ng/m^3 in total dust (excluding one extreme sample) and 1.6 to 14.0 ng/m^3 in respirable dust.

Ammonia concentrations in air ranged from 6.0 to 13.1 ppm in June, and from 15 to 80 ppm in March and October (when house windows and doors were closed). Carbon dioxide concentrations ranged from 500 to 1,000 ppm. Airborne bacteria concentrations ranged from 74,000 to 360,000 colony-forming units per cubic meter of air (CFU/m^3), and fungi from 2,500 to 23,000 CFU/m^3. There are no exposure standards for airborne endotoxins, bacteria or fungi. Concentrations found were comparable to those observed in other studies of poultry houses.

Twenty-five growers with exposure in broiler houses were given spirometry tests and completed questionnaires for respiratory symptoms.

The primary exposures to poultry growers were found to be airborne dust and ammonia. Carbon dioxide concentrations were well below recommended limits and other gases and vapors assayed were not detected.

Ammonia concentrations in air may reach levels associated with eye and upper respiratory irritation. Although a high prevalence of respiratory symptoms was found, no clear association between acute symptoms or acute changes in pulmonary function on the day of the study and indices of exposure was found. Ventilation adequate to reduce ammonia and total particulate concentrations to the lowest feasible levels is recommended to prevent acute irritative effects. Unused, unventilated spaces should be thoroughly aired out before work is performed inside. Growers should consider wearing combination dust/ammonia respirators while inside the houses.

KEYWORDS: SIC 0251, respiratory symptoms, ammonia, endotoxins, poultry growers

II. INTRODUCTION

On February 17, 1983, the David Mayer Poultry Farm and other poultry growers in the Hobgood, North Carolina area requested a health hazard evaluation of environmental conditions in their poultry houses. The request stated that a number of the poultry growers had noticed an increase in eye and throat irritations, headaches, shortness of breath, and a tightness in the chest since they began raising chickens.

An initial survey of several poultry confinement houses was conducted March 11, 1983 by two industrial hygienists. Follow-up surveys on June 15 and 16, 1983 and October 24, 1983 were conducted at several poultry houses by three industrial hygienists, a physician, a medical student, and a pulmonary function technician. These surveys involved extensive environmental monitoring, administration of health questionnaires, and pre- and/or post- shift pulmonary function testing of 25 poultry growers. The goals of the surveys were to evaluate the environmental conditions for possible excess respiratory exposure to chemicals and biological agents, detect and evaluate any adverse pulmonary functions among poultry growers and develop appropriate recommendations to poultry growers to alleviate any occupationally- related health problems found.

III. BACKGROUND

North Carolina is ranked fourth in the nation in gross income from poultry products (1), producing $819.7 million worth of broilers, eggs, turkeys, and "other poultry" in 1981, of which $437.7 million came from broilers alone (2). An estimated 2000 independent "growers" currently produce approximately 400 million broilers per year in North Carolina (3). "Broilers" generally weigh 2.5 to 4.8 pounds when marketed (4). Almost all broilers raised in North Carolina are produced through contractual arrangement between a "contract producer" or "grower", and an "integrated" firm such as Perdue or Holly Farms. Usually, the grower owns the "broiler house" and the equipment in it. The birds, feed, and often, heating fuel, are supplied by the firm. The grower supplies the labor required for the care of the birds and pays annual expenses such as utilities, taxes, insurance, mortgage payments, and maintenance costs. The grower receives a payment per pound which varies depending on the efficiency with which (s)he converts inputs (feed, heating fuels) into output (pounds of chicken) (5). All growers participating in this study raise "broilers."

A typical "broiler house" is a 40' x 400' or 36' x 360' clear-span building with insulated ceiling and sidewalls, is equipped with automatic feeders and waterers, and is heated with gas-fired unvented spaceheaters. Large fans are also provided for ventilation. To maximize production efficiency, the grower must use as little fuel as possible, yet maintain the necessary temperature for the chickens in cold weather. This in turn means the house must be well insulated and ventilation kept to the minimum compatible with

keeping bird mortality down to an acceptable level, 2% being an average mortality rate (5). The North Carolina Extension Poultry Science division recommends that growers use minimum ventilation ("0.1 to 0.2 cfm per bird during first part of brooding period is sufficient") to conserve energy (6). The result is that much less ventilation is provided in winter than in summer. Another way for the grower to save money is to leave floor litter in place from one flock to the next. This practice decreases air quality due to increased generation of ammonia and biologically active aerosols (7,8).

The amount of time a poultry grower spends inside a poultry house varies with the age of the chickens and other factors, but averages about 12 hours per house per week (7 days per week), and 44 to 48 weeks per year, according to several of the growers participating in the study. This agrees with published labor estimates (5). A grower will usually have more than one house, often four. The jobs which must be performed every day include removing dead chickens, checking ventilation and temperature, maintaining water and feed systems, and, for baby chicks, filling up small waterers and putting feed out manually. Jobs performed less frequently include cleaning water troughs and dusting off heaters, walls, and plumbing. Also, between flocks old litter may be removed and new litter put down.

Initial discussions with growers confirmed the occurrence of the physical complaints reported in Section II. Symptoms are attributed by growers to dust and gases in the houses, and are reportedly worse in winter, when houses are closed, than in summer.

Specific descriptions of the several poultry confinement houses surveyed follow. Figure 1 is a diagram showing both plan and cross-sectional views of a typical poultry house in the Hobgood, NC area. Figures 2-4 show photographs of the house. These long and rather narrow houses are designed to be energy efficient. Only the front third of the house is used initially when the young chicks are received, as shown in Figure 3, the remainder being partitioned off by canvas curtains. As the birds grow and more space is needed, partitions are moved until finally the birds occupy the entire house. Approximately 20,000 birds are confined per house. All poultry houses surveyed had automatic feed and water systems and propane gas heating.

Windows are located along both sides of each house, with shutters and curtains which may be opened or closed depending on the weather (see Figure 2). Forced draft ventilation is provided by approximately 12 36" disc-blade, thermostat-controlled exhaust fans placed in exterior walls. During hot weather, these fans may be relocated (as shown in Figures 1 and 4) to provide air circulation and cooling in the houses. Large double doors (8'x10') at each end of the houses may be opened during hot weather to promote additional ventilation.

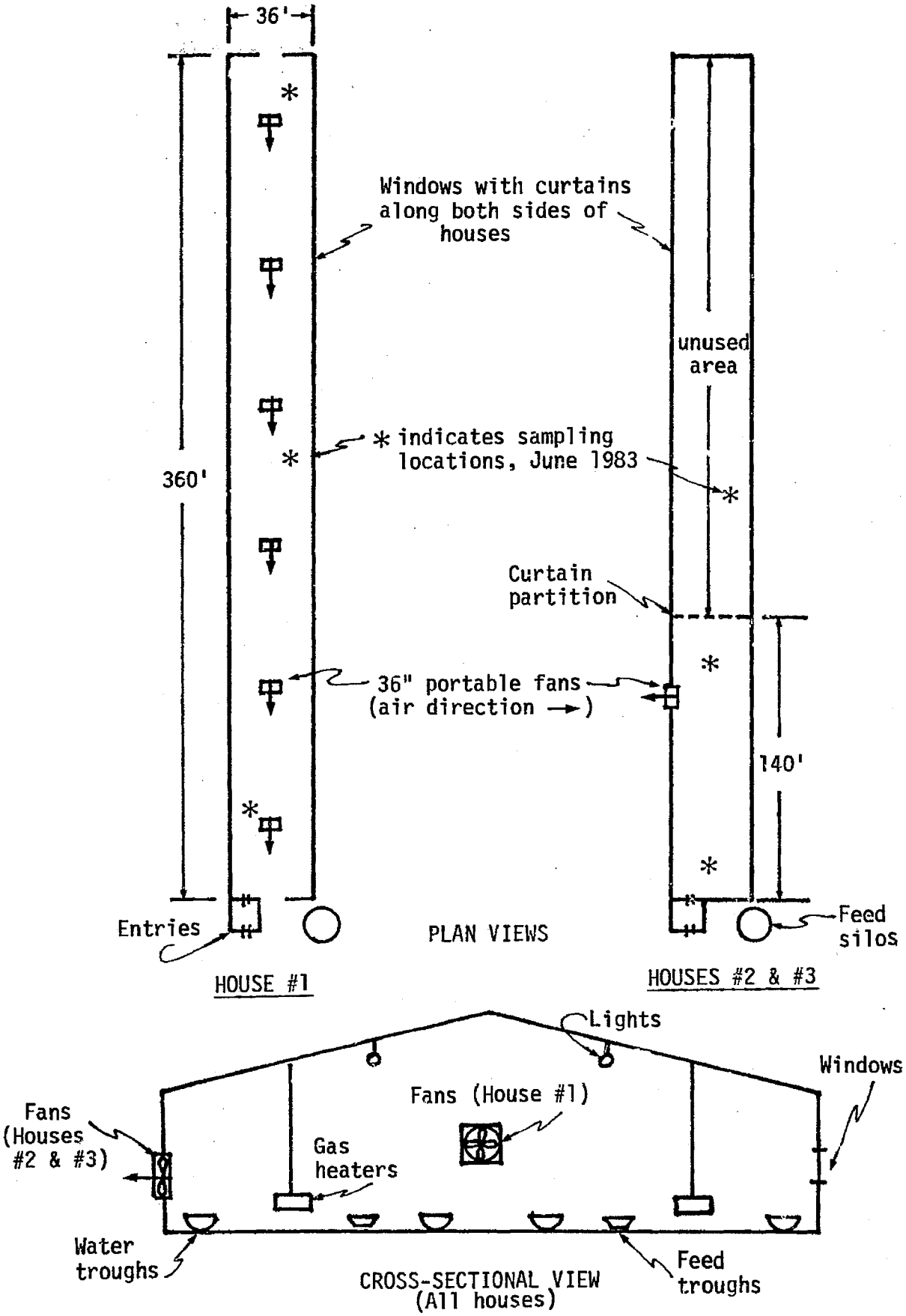
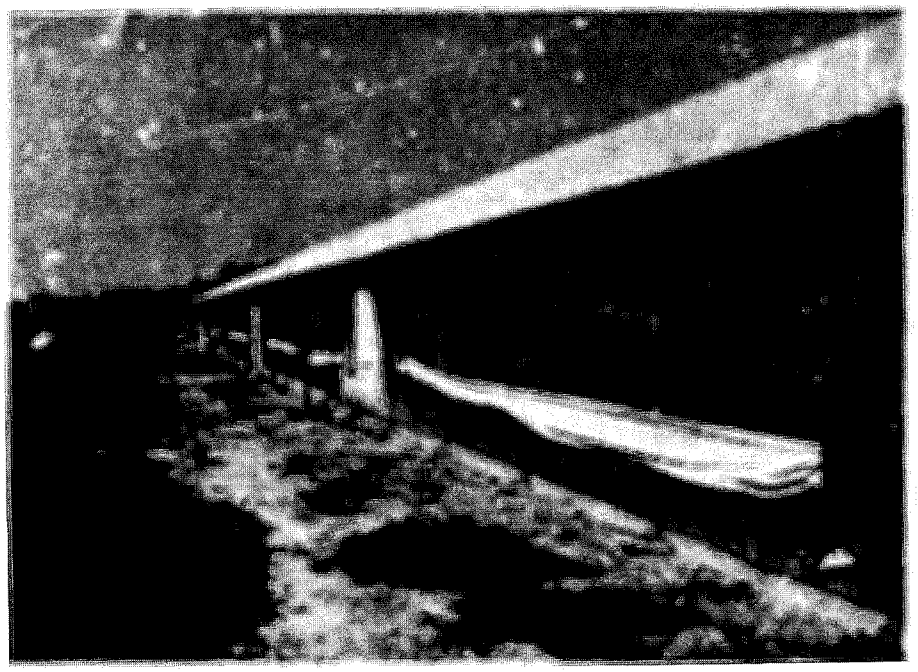


FIGURE 1 - TYPICAL POULTRY HOUSES IN THE HOBGOOD, N. C. AREA



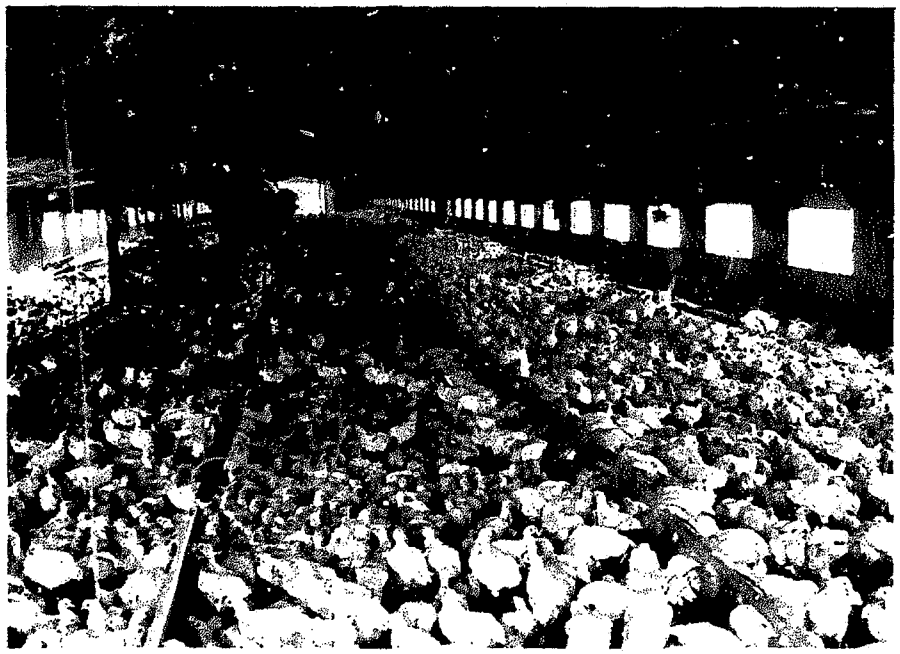


FIGURE 2 (above) - View of long side of poultry house with window curtains open.

FIGURE 3 (upper left) - Seven-day old chicks confined to 1/3 of the house; heater units in place but not operating; several windows open.

FIGURE 4 (left) - Thirty-day old chicks; all windows and end doors open; six circulating fans along length of house blowing air in same direction.

IV. METHODS AND MATERIALS

A. Environmental

Environmental evaluation consisted of interviews with poultry growers about environmental conditions and work practices, a walk-through industrial hygiene survey, and the collection and analyses of air samples for total and respirable particulates, organic vapors, gases, endotoxins, and microbial organisms. Airborne particulates were analyzed for size distribution. No ventilation measurements were made.

1. Particulate Sampling

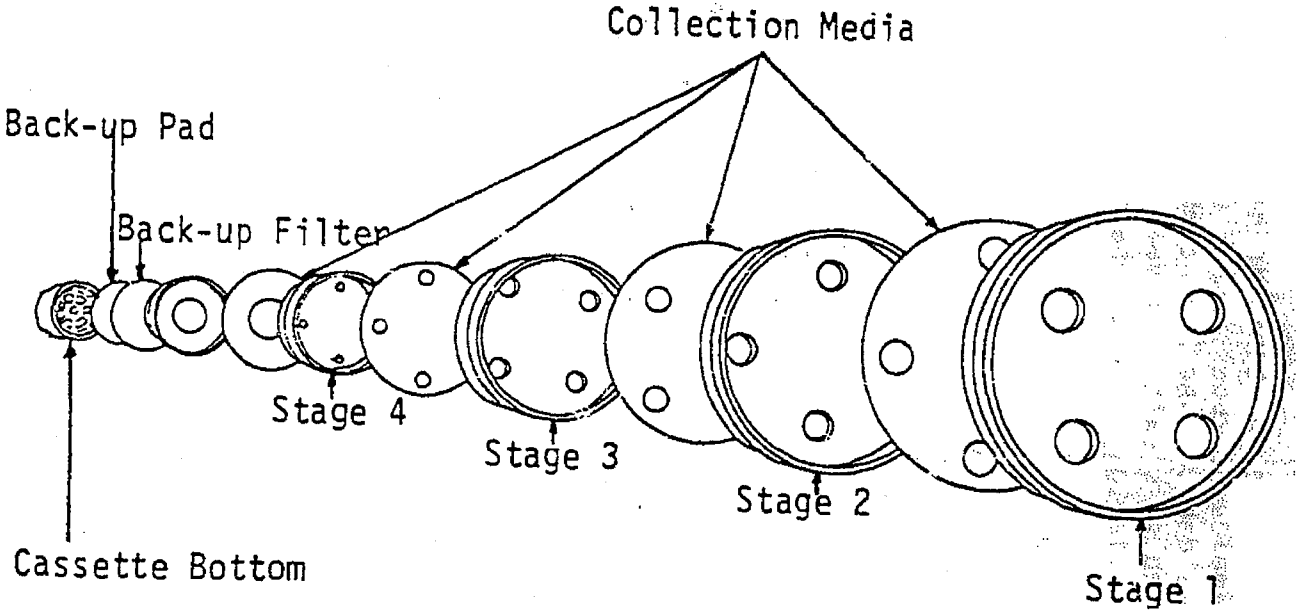
Total and respirable dust samples were collected in areas and on personnel within the poultry houses using two different monitoring systems. One system used Dupont P-4000 pumps to draw air at a flow rate of 2 liters per minute (lpm) through FWSB filters (Mine Safety Appliance). The filters were mounted in 3-piece 37mm cassettes and sampling was performed open faced. Filters were weighed to the nearest 0.01 mg before and after sampling using a Cahn model 4700 electrobalance. The respirable dust samples were collected by drawing air at 1.7 lpm first through a 10mm nylon cyclone and then through a pre-weighed FWSB filter.

Another monitoring system for both total and respirable dust utilized 37mm diameter Gelman Vinyl Metricel (VM-1 filters) 5 μm pore size in open face mode or with 10mm cyclone at a sampling rate of 1.7 liters/minute using MSA pumps.

Particle size distribution of the dust was measured by using a recently described cascade impactor (9) fabricated from 37mm cassette pieces (Figure 5). A flow rate of 2 LPM was maintained through the impactors using Dupont P-4000 pumps. At this flow rate, the 50% cut points are 20, 15, 10, and 3.5 μm. Glass fiber filters were used as collection media for the four stages and for the back-up filter. Sample times for the impactor samples and the total and respirable dust samples ranged from about 4-6 hours. Sampler inlets were placed about five feet from the floor to approximate a breathing zone level, and samples were collected in areas in the front, middle, and back sections of the houses. Sampling locations are indicated by asterisks in Figure 1.

A portion of the total, respirable, and impactor dust samples were analyzed for endotoxins. These filters were first extracted with 5.0 or 10.0 ml sterile, non-pyrogenic water (Travenol Laboratories, Inc., Deerfield, IL) by rocking at room temperature for 60 min. Sterile, non-pyrogenic plastic ware was used during all phases of the endotoxin analysis. The fluid was centrifuged at 1000 g for 10 min. and the gram negative bacterial endotoxin content of the supernatant fluid was quantified in duplicate by a spectrophotometric modication of the *Limulus* amebocyte lysate gel test (Pyrostat; Millipore Corp., Bedford, MA) (10). Blank, unused filters were treated similarly and used as negative controls.

FIGURE 5 - "EXPLODED" VIEW OF CASSETTE IMPACTOR



Source: Reference 9

2. Gas Sampling

Ammonia concentrations in the houses were assayed with long-term Draeger indicator tubes. Dupont P-4000 pumps were used to draw air through tubes at nominally 15 ml/min. Tubes were read immediately after sampling. Sampling times ranged from about 30 to 120 minutes.

Concentrations of the following contaminants were assayed using Draeger short-term indicator tubes: NH_3, CO, CO_2, H_2S, NO_2, NO_x, CH_4, mercaptan, formaldehyde, and hydrocarbons. Most of these samples were collected at breathing levels in general areas of the houses; a few were collected close to the floor.

3. Microbial Sampling

Microbial samples were collected from air in the houses with Andersen viable 6-stage samplers (Andersen Samplers, Inc., Atlanta, GA) operated at 1 cubic foot per minute (cfm). Samplers were placed in central areas of the houses approximately one meter above floor level. Plastic petri dishes containing tryptic soy agar with cycloheximide (TSA) or rose bengal-strepomycin agar (RBS) were used in the samplers to assay bacteria and fungi, respectively. The RBS collection plates were protected from direct sunlight and kept at room temperature. After collection, the TSA samples were iced to slow the growth of bacteria during transport to the laboratory. At the laboratory both bacteria and fungi were counted under magnification so that multiple colonies under any given sampler impaction jet could be resolved, thus eliminating the need for "positive hole" correction. Counts were made approximately 48 hours after sample collection.

In addition to the 6-stage Andersen sampler measurements, samples of bacteria and fungi were collected in the same areas by a modified method, using only the last stage of the Andersen sampler to collect microbes directly onto a single culture plate. Since this sampling system is more prone to overloading, these samplers were run for 30 seconds while the 6-stage samplers were operated for 2 minutes.

B. Medical

A medical evaluation of 25 persons with a history of exposure to poultry confinement houses was performed. Participation in the study was solicited through local poultry growers who contacted other growers in the area. Preliminary questionnaires were distributed to poultry growers, and those with potential exposure in poultry houses were contacted and invited to participate. The proportion participating cannot be determined since the total number of persons with potential exposure to poultry confinement houses is not known.

Persons with a history of exposure to poultry confinement houses were asked to come to a central location on the morning of Monday, October 24, 1983. They were asked to postpone entering the confinement

houses until after being tested if possible. Each person was to have spirometric measurement of lung function prior to any exposure that day and then later that day after exposure. Spirometry was performed on an Ohio 822 waterless spirometer using the technique recommended by the American Thoracic Society (11). A questionnaire (attached as Appendix A) was administered to obtain information about acute symptoms and environmental exposures occurring on the day of the study and chronic symptoms or exposures. Personal samplers were also used to measure total dust concentration in the breathing zone while in the poultry houses, for persons who entered the houses during the day of the study.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations; 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's are usually based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the

feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Limits appearing in Table 1 are the lowest found among these sources, and the current OSHA limits.

Table 1 - Evaluation Criteria for Chemicals Assayed in the Poultry Houses

Substance	Ceiling Limit or STEL (ppm)	8-hour Time Weighted Average (ppm)	Source	OSHA Standard (14)
Ammonia	35	25	ACGIH (12)	50
Carbon Monoxide	200	35	NIOSH (13)	50
Carbon Dioxide	15,000	5,000	ACGIH (12)	5,000

Samples were also taken for the contaminants listed below. These are not included in Table 1 because all were less than the limit of detection, given in parenthesis for each substance, of the sampling method used.

H_2S (1 ppm)	Mercaptan (2 ppm)
NO_2 (0.5 ppm)	Formaldehyde (0.5 ppm)
NO_x (0.5 ppm)	Hydrocarbons (0.1%)
	CH_4 (0.5%)

There are no exposure limits for respirable or total particulates in air specifically for poultry houses. The OSHA permissible exposure limits for nuisance dust are 5 and 15 milligrams/cubic meter (mg/m^3) for respirable and total dust, respectively (14), and the ACGIH recommended TLVs are 5 and 10 mg/m^3, respectively (12). Both OSHA and ACGIH limits are intended for "inert" dust, so their application to dust in poultry houses may be inappropriate.

There are no published limits or standards for a "safe" level of exposure to endotoxins or to airborne bacteria and fungi in poultry houses.

B. Medical

1. Literature Review

The literature on human health effects of working in poultry environments is scanty, as documented in a recent doctoral dissertation on the subject (8). There has been much more interest in studying the effects of air contaminants on the chickens' health. A North Carolina Extension Service publication states that "Dust, ammonia, and stale air irritates the birds' throats, lungs, and air sacs. Good ventilation is the key to fewer colds and respiratory ailments" (15). Poultry growers are exposed to a wide variety of organic respirable dusts derived from the wood shavings used as bedding material, from soil, chicken feed, and the secretions and excretions of the chickens. Components of this respirable aerosolized dust may include bacteria, viruses, fungi, chlamydiae, rickettsiae, dander (desquamating cells), feather dust, and endotoxins, in addition to a variety of plant materials (8). Endotoxins are lipopolysaccharide protein complexes contained in bacterial cell walls which may cause fever and a variety of hypersensitivity and respiratory responses when inhaled. There are several zoonotic infectious diseases known to be transmitted by exposure to domestic fowl including chlamydiosis, Q fever, Newcastle disease (viral illness; most common symptom is conjunctivitis) (16), Mycobacterium avium infection, aspergillosis, salmonellosis, histoplasmosis, coccidioidomycosis, and several other rare diseases (8,17,18). However, the greatest potential for worker respiratory disease is from a variety of hypersensitivity responses rather than from invasive infectious diseases. These allergic responses include the syndromes of extrinsic allergic bronchiolo-alveolitis, allergic rhinitis, and bronchial asthma.

Extrinsic allergic 'alveolitis' (or hypersensitivity pneumonitis) is a generic term for a common manifestation from a variety of causes. "Animal handlers' lung" and "Bird fanciers' lung" are two well known types of this syndrome, due to inhalation of dander, bird droppings and feathers (18). It is defined as a clinical disorder due to the inhalation of particulate antigenic organic material and is characterized in its acute phase by constitutional

symptoms, the presence of specific precipitins in many cases and by lymphocytic infiltration and sarcoid-type granulomas in the walls of the alveoli and small airways; and, in its chronic phase, by an irreversible and often progressive diffuse intrapulmonary fibrosis (18). Evidence for hypersensitivity pneumonitis in poultry workers was found in a study of 205 workers involved in raising or processing turkeys. Of these workers, 69% described respiratory symptoms occurring within one hour after working with the birds, and when compared with the non-symptomatic workers, they had a significantly higher prevalence of precipitating antibodies, positive skin tests, elevated IgE levels, and atopic histories (19).

Allergic rhinitis is an inflammation of the nasal mucosa initiated by an immunologic reaction in sensitized individuals. While a variety of allergens may produce the disease, common ones include mold spores, animal danders, and bacterial antigens. Allergic rhinitis is characterized by sneezing, rhinorrhea, obstruction of the nasal passages, conjunctival and pharyngeal itching, and lacrimation (20).

Asthma is defined as "a disease characterized by an increased responsiveness of the trachea and bronchi to various stimuli and is manifested by a widespread narrowing of the airways that changes in severity either spontaneously or as a result of therapy" (21). "Occupational asthma," also called extrinsic or reagenic asthma, is said to occur "when a person becomes specifically sensitized to a chemical or biological factor in his work environment if he was not actually suffering from asthma at the time he began the work in question" (22).

2. Health Status

Criteria for evaluation of health status are (a) comparison of results of the health screening history and respiratory history questionnaire responses of the exposed growers (Appendix A) with those of a demographically similar group of workers who are not exposed, and (b) judgment of the examining physicians.

VI. RESULTS AND DISCUSSION

Three site visits were made. The first visit, March 11, 1983, was largely a walk-through survey of several poultry houses. One total and one respirable dust sample were taken and ammonia concentrations were measured in several houses. On the basis of results, an extensive sampling survey was conducted June 15-16, 1983, during which air concentrations of total and respirable dust, endotoxins, microorganisms and a variety of gases were assayed. On the third survey, October 24, 1983, pre- and/or post- exposure pulmonary function tests were performed on 25 growers. For some growers, personal dust exposures were measured. Area dust and ammonia samples were also taken in two poultry houses.

A. Environmental

1. Particulates

a. Total and Respirable Dust

Dust concentrations as measured by area samples are reported in Table 2. Houses 1, 2 and 3 are described in Figure 1. Dust concentrations tended to be higher during March and October, when both natural and induced ventilation were minimal, and in houses with adult birds. About 4 to 12% of the airborne dust was respirable in active areas; and nearly all dust in unused areas was respirable.

During the second survey (June), the dust levels (both total and respirable) were higher in House 3 than House 2. Since all variables except age of litter were the same in these houses, it is possible that the old litter (which contains more dried manure) may be more friable than new wood chips. A worker walking through the house may create more airborne dust where old litter is in place. It was observed that when the birds are large, the grower's mere walking from one end of the house to the other results in the chickens flapping their wings and stirring up considerable amounts of dust.

In one of the houses surveyed June 15-16, 1983, the birds were 30 days old and occupied the entire house. Several fans (set to turn on when the temperature inside reached 81°F) were located along the center line of the house, as shown in Figure 4. The fans operated continually during the air sampling survey because the temperature ranged between 83 and 87°F. Relative humidity was 50-60% and winds were light and variable. Large doors, 8'x10', at both ends of the building, as well as all windows, were open during the survey to aid ventilation. Smaller doors 3'x4' located in the sidewalls of the house were closed during the survey.

The size distribution of the dust in Houses 1, 2 and 3 was quite similar; mass median aerodynamic diameter (MMAD) of about 15 μm and geometric standard deviation of about 2.2. Therefore, most of the mass of this dust consisted of particles that are non-respirable, as was indicated also by total and respirable dust sample results.

The concentrations of total dust (Table 2) found in occupied areas ($\bar{x}$ = 5.6 mg/m^3 in summer and 12.4 mg/m^3 in cold weather) are intermediate when compared to those reported in 2 previous studies reported on dust levels in poultry confinement houses in Sweden. Carlsson (23) found total dust levels of 9-17 mg/m^3 in the broiler houses he surveyed. Clark, et al., (24) investigated houses where the birds were raised "on wire" (in suspended wire cages), as opposed to "on litter." The average total airborne dust concentration found in that study was 2.3 mg/m^3.

Table 2 - Total and Respirable Airborne Dust and Ammonia Concentrations in Poultry Houses

House Description and Month of Survey		Location Within House	Dust Concentration, mg/m^3		Ammonia Concentration, ppm	
			Total	Respirable	Tubes, Long-term	Tubes, Short-term
doors June & windows open	House #1 30-day old birds	Front	11.4	0.62	13.1	7-10
		Middle	9.2	0.39	9.2	3
		Back	7.6	0.42	-	3
	House #2 new litter 7-day old birds	Front	2.5	0.11	-	2
		Middle	1.4	0.04	6.0	2
		Back[a]	0.02	0.02	-	<2
	House #3 old litter 7-day old birds	Front	2.8	0.11	-	6-7
		Middle	4.6	0.31	75[b]	18-20
		Back[a]	0.14	0.11	169[b]	>150
doors Mar. & windows closed Oct.	42-day old birds	Front	24.8	3.5	-	80
	35-day old birds	Front	-	-	-	40-50
	7-day old birds	Front[c]	-	-	-	40
	4-day old birds	Front[c]	1.69	0.15	-	15
	28-day old birds	Front[c]	10.9	0.73	-	40
		Middle[c]	12.2	1.07	-	18

[a]Windows and doors closed; no ventilation; unoccupied.

[b]Mean value of 7 measurements taken for experimental purposes.

[c]Endotoxin concentrations for total and respirable dust samples for October survey are shown below.

Average Endotoxin Concentration

House Description		Total Dust		Respirable Dust	
		Dust (ng/mg)	Air (ng/m^3)	Dust (ng/mg)	Air (ng/m^3)
4-day old birds	Front	48.75	77.02	10.84	1.63
28-day old birds	Front	291.01	3172.01	18.24	13.32
	Middle	3.03	37.09	13.09	14.00

Dust exposures were measured with personal samplers for 11 growers on October 24. These are reported in Table 3. Samplers were operated only during periods when the growers were inside poultry houses. Total dust concentrations ranged from 0.07 to 7.8 mg/m^3. Growers spent from 45 minutes to 3 hours in the houses, with an average of 1.7 hours. It should be noted that "personal" dust samples are collected with a sampler worn by a person and measures the actual dust exposure of that person. By contrast, "area" dust samples measure airborne dust concentrations at a location within a house and represents the potential exposure of anyone near the location.

Four of the area total dust samples exceeded the ACGIH (12) recommended limit of 10 mg/m^3 for nuisance dust. No personal total dust samples or area respirable dust samples exceeded nuisance dust recommended limits. A qualification that should be made is that the "respirable" dust sampler was designed to preferentially sample that fraction of a dust which can contribute to the development of pneumoconiosis; i.e., the fraction of the dust which is able to penetrate and remain in the alveolar region of the lung. The biological activity of poultry house dust may be quite different and larger particles may be able to elicit a response. The application of both the respirable and the total "inert" dust exposure limits to poultry house dust are thus qualified.

b. Endotoxins

Table 4 gives the results of the endotoxin analysis on the area total and respirable dust samples. Endotoxin concentrations are expressed both in terms of the amount of endotoxin per unit of dust on the filter (ng/mg) and in terms of air concentration (ng/m^3).

All filters analyzed contained quantifiable amounts of endotoxins, but the degree of contamination varied between houses. Average endotoxin levels in the total dusts ranged from 6.4 to 16 ng/mg. The average endotoxin contamination of the respirable dust fractions was higher, ranging from 20 to 40 ng/mg. The highest concentrations of endotoxin per unit of dust for both total and respirable dust was measured in House #2. When endotoxin is expressed in terms of air concentration the pattern is reversed and higher concentrations are recorded in total dust (24 to 59 ng/m^3) compared to respirable dust (3.8 to 9.8 ng/m^3). This is simply due to the much higher concentrations of total dust than respirable dust found at these facilities.

Endotoxin was found in each size fraction of the aerodynamically fractioned dust (Table 5). Both impactor samples show the same trend of rather uniform endotoxin contamination in the size fractions within the 3.5 to 20 μm range. Dust collected on the back-up filter, representing particles <3.5 μm, contained a greater amount of endotoxin per mg of dust than did the other size fractions. However, because the fraction of dust collected on the back-up filter constituted the lowest amount of dust, it had the lowest concentration of endotoxins when expressed as concentration in air. This is consistent with the endotoxin analysis on the total and respirable dust samples.

Table 3 - Dust and Endotoxin Exposure to Growers
Measured by Personal Samples
Survey Date: October 24, 1983

Age of Birds; (Activity)	Time in Houses (min)	Total Dust Concentration mg/m^3	Average Endotoxin Concentration[a] ng/mg	Average Endotoxin Concentration[a] ng/m^3
25-day old birds (adjust water lines)	(50)	1.19	8.15	9.70
18-day old birds (adjust feed lines; culled birds)	(75)	5.52	12.72	70.19
14-day old birds (moving birds to back)	(92)	7.79	1130.58	8807.41
11-day old birds (old litter, exhaust fan on occasionally)	(120)	4.52	6.44	1.43
6-day old birds (watering & feeding)	(152)	3.83	9.06	34.68
4-day old birds (feeding & watering)	(82)	1.58	7.89	12.46
4-day old birds (filled water troughs)	(45)	0.98	12.16	11.91
4-day old birds (litter old, adjusting vent & heater)	(180)	0.91	5.82	5.29
1-day old birds (delivered in AM)	(64)	2.76	1.07	2.94
No birds (setting up; moving curtains & heaters)	(161)	2.66	1.02	2.71
No birds (setting up water & feed troughs)	(85)	0.07	20.50	1.44
Average:	100	2.9		
Range	45-180	0.07-7.8		

[a] Reported as U.S. Reference Endotoxin

Table 4 - Endotoxin Concentrations of Total and Respirable Airborne Dust in Poultry Houses
Survey Date: June 15 and 16, 1983

House #	No. of Samples (n)	Average Endotoxin Concentration[a]			
		Total Dust		Respirable Dust	
		Dust (ng/mg)	Air (ng/m^3)	Dust (ng/mg)	Air (ng/m^3)
1 30-day old birds	3	6.4	59	20	9.8
2 (new litter) 7-day old birds	1	16	24	40	4.5
3 (old litter) 7-day old birds	3	12	36	30	3.8

[a] Assayed in duplicate and reported as U.S. Reference Endotoxin

Table 5 - Endotoxin Concentrations in
Aerodynamically Fractionated Dusts
Survey Date: June 15 and 16, 1983

House #	Impactor Stage	Effective Cut Diameter (μm)	Dust Weight (mg)	Endotoxin Concentration[a] Dust (ng/mg)	Endotoxin Concentration[a] Air (ng/m^3)
1-	1	20	1.49	6.46	21.10
30-day old birds	2	15	0.83	5.49	10.00
	3	10	0.90	6.18	12.19
	4	3.5	0.99	5.82	12.63
	BF[b]	-	0.20	12.60	5.53
3-	1	20	1.32	6.86	13.84
7-day old birds	2	15	0.63	5.79	5.58
(old litter)	3	10	0.78	6.72	8.01
	4	3.5	1.02	9.67	15.08
	BF[b]	-	0.16	15.25	3.73

[a] Reported as U.S. Reference Endotoxin

[b] Back-up filter

Endotoxin concentrations found in these houses are lower than those reported for poultry confinement units in the southern part of Sweden. Clark, et al. (24) reported average endotoxin concentrations of 310 ng/m^3 in total airborne dust of three poultry confinement units, whereas the concentrations reported here are approximately 44 ng/m^3 (Table 3). Likewise, the airborne dust from the units studied by Clark contained endotoxin contamination of 120 ng/mg, and the airborne dust from the units in this study contained an overall mean of 10 and 27 ng/mg for total and respirable dust respectively. By comparison with another aspect of the poultry industry, that of poultry processing, Olenchock, et al. (25) reported endotoxin concentrations of 24 to 108 ng/mg for total dust and 25 to 65 ng/mg for respirable dust. A single sample of settled dust from a poultry confinement house yielded a concentration of 11.4 ng/mg in a study reported by Thedell, et al. (26).

A wide range of reported endotoxin concentrations is expected in such a non-standardized industry. Variables such as type and age of litter, geographical location, age and type of birds and ventilation would all be expected to affect both dust and endotoxin concentration.

Airborne endotoxins have been implicated as a causative agent for respiratory disease in cotton workers (27) and have been associated with symptoms including cough, headache, nausea, chest tightness, diarrhea and fever (28,29). Although there are no regulatory or recommended "safe" limits for endotoxin exposure, Rylander and Haglind reported a reaction threshold of about 0.5 µg/m^3 for decreases in FEV_1 measured over a 4-hour exposure period (30), in students exposed to cotton dust in an experimental card room. That threshold is approximately 10 times the highest average endotoxin concentration observed in this study.

2. Gases

The ammonia concentrations in air measured with long-term indicator tubes in occupied areas of the houses ranged from 6.0 to 13.1 ppm, with two exceptions (Table 2, June survey). The highest concentration (169 ppm) was found in the back area of House #3, an area unused, closed, and unventilated. The concentration of 75 ppm was found 10 feet from an opening in the canvas partition in this house, through which air from the unused section (with higher ammonia concentrations) was being drawn by the exhaust fans. Growers usually spend little time in unused portions of the houses. Summertime ammonia concentrations were lowest in House #2; this was expected since the ammonia is produced from decomposing manure, and the litter in this building was essentially clean new wood chips.

Short-term ammonia indicator tube measurements were also made in the air of the poultry houses during the June survey (Table 2). Eight ammonia samples in the general working area of the House #1 with 30-day old birds ranged from 3 to 10 ppm, with a mean of 5.9 ppm. With 7-day old chicks and new litter, House #2 had 2 ppm of ammonia (with four samples taken). With the same age chicks on old litter, two samples from House #3 indicated 6 and 7 ppm ammonia. Two samples taken in this same house 25 feet from the partition indicated 18 and 20 ppm ammonia. The surveyor reported air movement through the partition from the unused area of the house, with higher concentrations of ammonia entering the area monitored. The ammonia concentration in the unused area was found to be >150 ppm.

Similar short-term measurements made in March and October with house windows and doors closed (Table 2) showed air concentrations of ammonia to be from 15 to 80 ppm. These much higher concentrations show the effect of ventilation rate on ammonia buildup in the houses.

Carbon dioxide concentrations in the houses ranged from 500 to 1000 ppm, well below the recommended limit of 5000 ppm (12). Samples were also taken for the contaminants listed below but all were less than the limits of detection given in parenthesis for each substance.

CO (5 ppm)	CH_4(0.5%)
H_2S (1 ppm)	Mercaptan (2 ppm)
NO_2 (0.5 ppm)	Formaldehyde (0.5 ppm)
NO_x (0.5 ppm)	Hydrocarbons (0.1%)

Of the gases investigated, only ammonia was found in concentrations approaching the recommended exposure limit of 25 ppm (12). Ammonia concentrations in excess of the recommended limit were observed in occupied houses in cool weather, when windows were closed, and in unused (closed, unventilated) sections of houses. Some concentrations exceeded even the recommended short-term exposure limit for ammonia (35 ppm) (12).

Several samples were taken using short-term indicator tubes one inch from the floor to determine the concentaration at the source. House #1 with litter at least 30 days old indicated 12 and 27 ppm ammonia. House #2 with new litter had 3 ppm ammonia, and House #3 with old litter had 10 and 30 ppm ammonia.

3. Microbial

Concentrations of airborne bacteria and fungi in poultry houses are presented in Table 6. Fungi concentrations were similar in Houses #1 and #3 and higher in House #2.

Table 6 - Concentrations of Airborne Microorganisms in Poultry Houses (Levels Reported in CFU/m^3)[a]
Survey Date: June 15 and 16, 1983

House #	Bacteria		Fungi	
	N6[b]	A6[c]	N6[b]	A6[c]
1 (30-day old birds)	360000	360000	4500	2500
2 (7-day old birds; new litter)	120000	70000	23000	24000
3 (7-day old birds; old litter)	74000	-	2500	2500

[a] CFU/m^3 - colony forming units per cubic meter of air.

[b] N6 - Modified sampling method where only the last stage of the Andersen sampler is used to collect microbes directly onto a single culture plate.

[c] 6 - Andersen 6-stage sampler.

Airborne bacterial concentrations were highest (360,000 colony forming units per cubic meter of air, CFU/m^3) in House #1. This may be due in part to the higher dust concentrations measured here since these organisms tend to be associated with particulate matter. The majority of bacteria as well as fungi collected in the 6-stage Andersen impactor were deposited on the upper (1-4) stages. Although bacteria species were not identified, gram staining revealed that >90% of the bacteria in Houses #1 and #3 were gram positive cocci. In House #2, >90% were gram negative rods.

Both sampling procedures gave comparable results for both bacteria and fungi, except that in some cases the N6 sampler yielded higher values. This has been observed in other side-by-side comparisons of the two methods. The reason may be due to fewer wall losses of viable particulates with the N6 method, since the organisms are impacted directly onto a single culture plate.

As with endotoxins, there are no specific standards or recommended exposure limits for "safe" levels of exposure to airborne bacteria and fungi. The concentrations of airborne fungi measured in this study ($x \simeq 10{,}000$ CFU/m^3), were much higher than those reported by Clark, et al. (24) ($x \simeq 700$ CFU/m^3). This may be due to the fact that in this study the birds were raised on litter (wood chips) while in Clark's study the birds were raised in wire cages. Concentrations of bacteria in air were in closer agreement for the two studies, with a range of 74,000-360,000 CFU/m^3 measured in this study compared to 120,000-680,000 CFU/m^3 in Clark's study. The variable percentage of gram negative bacteria found in this study (low in Houses #1 and #3; high in House #2) was also observed previously. In most of the poultry confinement houses surveyed by Clark, the percentage of gram negative bacteria was an average of approximately 8%, but in one house it was estimated to be about 80%. Perhaps there is a biological succession occurring within these facilities which could account for these variables results.

B. Medical

1. Results

Twenty-five persons participated in the study and performed at least one spirometry session. Characteristics of these poultry workers are given in Table 7. Seventeen of these workers performed a second spirometry session allowing assessment of the change in pulmonary function during the day of the study. Three of these seventeen had entered a poultry house for over 15 minutes prior to the first spirometry session (30, 60, and 60 minutes, respectively) and have been excluded from the analysis of acute responses to exposure. One worker was a "catcher" who had worked the entire night prior to the first spirometry session; he was also excluded from the analyses.

Table 7 - Characteristics of 25 Poultry Growers
Who Performed at Least One Spirometry Session
October 24, 1983

Men	21 (84%)	
White	19 (76%)	
Mean Age (years)	44.7	(Range 24-64)
Mean Years of Poultry Raising	6.3	(Range 2-15)
Mean Days Per Week Entering Poultry House	6.2	(SD = 1.7)[a]
Mean Hours Per Day Spent in Poultry House	3.2	(SD = 1.9)[a]

[a] SD denotes standard deviation

Spirometry assesses ventilatory mechanics of the lungs by a rapid and complete emptying of the lungs. Several parameters can be measured from this simple maneuver. The tests and what they measure are briefly summarized below:

a. FVC (Forced Vital Capacity): The FVC measures the ability of the lung to fully expand. Reduction of this ability could be caused by such things as diffuse interstitial fibrosis of the lung ("restrictive" lung disease) from whatever origin (e.g., asbestosis, silicosis, talcosis), left heart failure, and impairment of full movement of the chest wall (polio). FVC can be reduced in obstructive syndromes as well.

b. $FEV_{1.0}$ (Forced Expiratory Volume in 1 Second): The $FEV_{1.0}$ is a widely used test for the measurement of airways obstruction. The $FEV_{1.0}$ is in fact a complex measurement of lung function which is determined by effort exerted by the subject, the cross-sectional area of the large airways (determining resistance to air flow in the large airways), and the elastic recoil pressure of the lung. The [$FEV_{1.0}$/FVC x 100] ratio (or FEV%) has also been used to indicate obstruction. Thus, if FEV% is below normal, then some degree of obstruction is occurring.

   The $FEV_{1.0}$ may not be a good measure of early chronic obstructive airways disease for several reasons. Peripheral (or small) airways are the major sites of resistance in obstructive lung disease. The resistance in small airways could double or triple without having an appreciable effect on total airways resistance - or therefore on the ventilatory maneuvers that for the most part reflect changes in the large airways. Until recently, most epidemiological studies of industrial lung disease relied heavily on Spirometry (FVC, FEV) for assessing lung function.

c. FEF_{25-75} (Forced Expiratory Flow at Given Percentages of FVC): This is the average flow over the middle half of the vital capacity (between 25% and 75% of vital capacity; 0% is maximal inspiration). This test may be a better measure than FEV of the ventilatory function of "small airways." As the lungs become more deflated, the resistance of smaller airways becomes increasingly important. Changes in FEV_{25-75} are not as clear as in $FEV_{1.0}$.

Table 8 compares the eight growers who spent at least one hour in the poultry houses between spirometry sessions to the five who spent less than one hour. The spirometric variables ΔFVC(%), ΔFEV_1(%), and ΔFEF_{25-75}(%) are the percentage change between sessions in the forced vital capacity, the forced expiratory volume in one second, and the forced expiratory flow from 25 to 75 percent of the exhaled vital capacity. These are calculated by subtracting the value obtained in the first session from that obtained in the second session, dividing by the first session value and expressing

Table 8 - Comparison of 8 Poultry Growers Who Spent at Least One Hour in Poultry Houses between Spirometry Sessions to 5 Who Did Not (see text for definition of terms)

Time in Poultry Houses between Spirometry Sessions	≥60 minutes	<60 minutes
Number of Growers	8	5
Mean Minutes in Poultry Houses between Sessions ±SEM[a]	124 ± 15	19 ± 12
Mean ΔFVC% ±SEM	-1.8* ± 0.6	+ 3.5 ± 2.7
Mean ΔFEV_1% ±SEM	-2.1 ± 2.3	-1.5 ± 2.7
Mean ΔFEF_{25-75}% ±SEM	+2.7 ± 4.1	-1.3 ± 8.6
Number with ≥5% fall in FVC	0	1
Number with ≥5% fall in FEV_1	1	2
Number with symptoms occurring between sessions		
chest symptoms	5	1
upper respiratory symptoms	2	0
eye irritation	2	0

* $p<.05$ compared to those with shorter exposure

[a] SEM denotes standard error of the mean

the result as a percentage. Negative values mean a drop in capacity occurred during the day of the study. Only the FVC showed a decrement which was significantly larger in those with longer exposures. Four growers experienced a 5% or greater fall in FVC or FEV_1; three of these were in the shorter exposure-time group.

The number of growers reporting symptoms which developed between spirometry sessions is also given in Table 8. Chest symptoms include chest tightness, cough, wheezing, phlegm production, or shortness of breath. Upper respiratory symptoms include sneezing, nasal discharge, and throat soreness. Although a larger proportion of those with longer exposure had symptoms of each type, none of these proportions was statistically significantly greater than those for growers with shorter exposures. Only one grower had any other environmental exposures on the day of the study which might have been associated with the respiratory symptoms; this person was in the longer poultry exposure group. Two of the growers with longer exposure wore some type of respiratory protective mask during the time they spent in the poultry houses while none of those with shorter exposure did. Two growers in each acute exposure duration category were current cigarette smokers and all except one (in the longer exposure group) smoked between spirometry sessions.

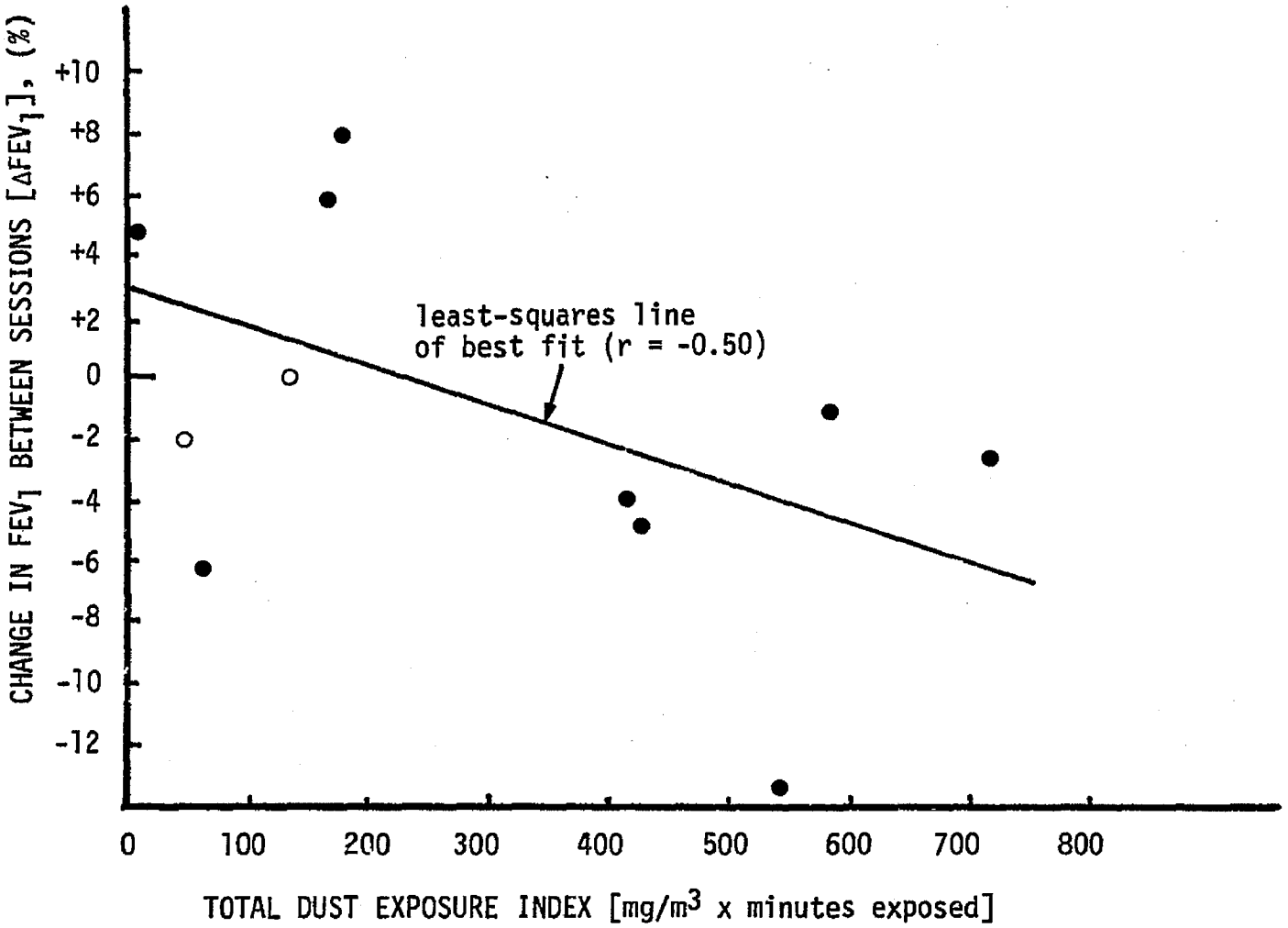
Table 9 compares growers who developed chest symptoms between spirometry sessions to those who did not, for only those growers who spent less than 15 minutes in the poultry houses before the first session but at least 15 minutes in the houses between sessions. Thus, these growers are those with potential for developing symptoms between sessions which were related to their exposure to poultry on the day of the study. Those who developed chest symptoms had spent approximately twice as long in the poultry houses as those who did not develop symptoms. Those with symptoms had a larger fall in FEV_1 between sessions that those without symptoms, but this was not statistically significant due to the large standard errors. As shown in Table 9 fewer growers with chest symptoms showed 5% or greater decrements in FVC or FEV_1 between sessions than those without chest symptoms. Similar results were obtained when all 16 growers with 2 spirometry sessions were compared regardless of the amount of time spent in poultry houses before the first session or between sessions.

Eleven growers wore personal dust samplers during the time spent in poultry houses on the day of the study. Total dust concentrations measured during the time spent in the poultry houses multiplied by that time provide an "index" of total dust exposure between sessions. Figure 6 shows the change in FEV_1 between sessions as a function of this index. Two growers had spent 60 minutes in the poultry houses prior to the first spirometry session. This may have influenced any subsequent response to dust exposure between sessions. The values for these growers are indicated on Figure 6 and the fitted least squares (linear) regression line shown does not include these two points. Although there is a trend toward larger decrements in FEV_1 with larger total dust exposure indices ($r = -.50$) the correlation

Table 9 - Comparison of Poultry Growers With and Without Chest Symptoms Developing Between Spirometry Sessions, for Only Those Growers Who Spent <15 Minutes in Poultry Houses Before the First Session and >15 Minutes Between Sessions

	With Chest Symptoms	Without Chest Symptoms
Number of Growers	5	5
Men	4	4
White	5	5
Age mean	40	43
median	42	42
Current Cigarette Smokers	0	3
Mean Minutes in Poultry Houses Between Sessions ±SEM	153 (±10)	65 ± 8
Mean ΔFVC% ±SEM	-1.5 ± 0.7	-1.5 ± 1.9
Mean ΔFEV_1% ±SEM	-3.6 ± 3.1	-0.1 ± 2.8
Mean ΔFEF_{25-75}% ±SEM	+4.3 ± 6.3	+0.6 ± 4.5
Number with ≥5% Decrease Between Sessions		
FVC	0	1
FEV_1	1	2

FIGURE 6 - CHANGE IN FEV_1 BETWEEN SPIROMETRY SESSIONS AS A FUNCTION OF DUST EXPOSURE INDEX



○ Growers with 60 minutes exposure before first spirometry session; not included in least-squares regression line determination.

is not statistically significant. Including the two omitted points results in a small reduction in the magnitude of the correlation coefficient ($r = -.46$).

For analysis of possible chronic effects of exposure to poultry confinement houses, an index of cumulative exposure was calculated for each grower as the number of years they had raised poultry times one-seventh the number of days per week they usually entered the poultry houses times the hours per day they usually spent in the houses. A grower with 5 years of poultry raising who spent an average of three hours per day seven days per week in the houses would have an index of 15. Table 10 presents a comparison of growers with exposure indices of over 15 to those with lower indices. The proportion of current and ex-smokers was similar in the two groups but those with lower poultry indices had more pack-years of smoking. Mean values of FVC, FEV_1, and FEF_{25-75} obtained at the first session expressed as a percentage of the predicted value from the equations of Knudson* and co-workers (31) were similar for the two groups. In each case the mean value for growers with the higher exposure index was greater than that for growers with the lower poultry exposure index. The proportion of growers with values of FEV_1 less than 80% of predicted was also similar for the two groups. Only one grower in the lower exposure index group and two growers in the higher exposure index group had spent more than 15 minutes in poultry houses prior to the first spirometry session and thus had potentially reduced first session lung function from any acute effects of exposure. The person who worked as a catcher had worked for 15 years, five days per week, approximately eight hours per day in the poultry confinement houses. His FVC was 107% of predicted, FEV_1 94% of predicted, and FEF_{25-75} 62% of predicted.

Table 11 presents symptom prevalences for growers with "low" and "high" poultry exposure indices. Similar proportions of each group were current or ex-cigarette smokers and had a history of other occupational exposures to potential respiratory hazards. Non-specific symptoms were defined from questions 1-22 on the questionnaire (Appendix A). Chronic cough and chronic phlegm were defined by presence for three months each year. Dyspnea was graded as 0 if question 12 was answered "no" with grades 1, 2, and 3 corresponding to "yes" answers for questions 12, 13, and 14 respectively. Prevalences of these symptoms were similar for the two exposure groups. Although wheezing was more prevalent in the high exposure index group, the difference was not statistically significant.

Poultry related symptom prevalence was obtained from the answers to the final questions on the questionnaire. Three-quarters of the growers complained of one or more of the lower respiratory symptoms

* The predicted values from Knudson and co-workers for whites were multiplied by 0.9 for blacks.

Table 10 - Comparison of Poultry Growers With "High" and "Low" Indices of Exposure* to Poultry Confinement Houses

	Exposure Index ≤15	Exposure Index >15
Number of Growers	11	13
Men	10	11
White	9	10
Current Cigarette Smokers	3	3
Ex-Smokers	2	4
Mean Pack Years of Cigarette Smoking	45.9	36.2
Mean Age (years)	45.7	42.7
Mean FVC (% predicted) ±SEM	90.4 ± 5.3	92.2 ± 2.0
Mean FEV_1 (% predicted) ±SEM	87.6 ± 6.8	91.0 ± 3.0
Mean FEF_{25-75} (% predicted) ±SEM	78.0 ± 8.8	85.6 ± 10.0
Number with FEV_1 <80% predicted	5	4
Number Who Spent >15 Minutes in Poultry Houses Before First Spirometry Session	1	2

* Index of Exposure = Number of Years Raising Poultry x $\frac{1}{7}$ Days per Week With Exposure x Usual Hours Per Day of Exposure

Table 11 - Symptom Prevalence for Poultry Growers
With "High" and "Low" Poultry Exposure Indices

	Exposure Index ≤15		Exposure Index >15	
Number of Growers	11		13	
Number with History of Other Exposures to Respiratory Hazards	5	(45%)	5	(38%)
Current or Ex-Cigarette Smokers	5	(45%)	7	(54%)
Non-specific Symptoms				
Chronic Cough	4	(36%)	4	(31%)
Chronic Phlegm	5	(45%)	3	(23%)
Ever Chest Tightness	8	(73%)	6	(46%)
Ever Wheezing	3	(27%)	6	(46%)
Dyspnea > Grade 1	2	(18%)	1	(8%)
Poultry-related Symptoms				
Lower Respiratory				
Cough	7	(64%)	7	(54%)
Phlegm	5	(45%)	4	(31%)
Wheezing	4	(36%)	4	(31%)
Chest Tightness	3	(27%)	6	(46%)
Dyspnea	5	(45%)	6	(46%)
Upper Respiratory and Eye				
Stuffy Nose	3	(27%)	6	(46%)
Sore Throat	0	(0)	3	(23%)
Eye Irritation	4	(36%)	9	(69%)
Systemic				
Chills	0	(0)	1	(8%)
Fever	0	(0)	1	(8%)
Muscle Aches	0	(0)	2	(15%)

listed and felt that these symptoms had begun or had become worse since they began raising poultry. However, prevalence for these symptoms was similar for the two exposure groups. The most prevalent single non-respiratory symptom was eye irritation, which was reported by 54% of the growers. Those with the higher exposure index had a higher prevalence but this was not statistically significant. Systemic symptoms of chills, fever, or muscle aches were reported by four growers in the higher exposure group. Further questioning did not provide a strong suggestion that these growers were experiencing episodes of hypersensitivity pneumonitis.

2. Discussion

Three-quarters of those participating in the study reported lower respiratory symptoms which they believed had begun or had become worse since they started raising poultry in confinement houses. However, those with higher cumulative exposure to the confinement house environment did not have a higher prevalence of symptoms than those with lower cumulative exposure. Lower respiratory symptoms occurring on the day of the study tended to occur in those with longer exposures on that day. However, these symptoms were not clearly associated with acute decrements in pulmonary function. In turn, decrements in lung function were not clearly associated with a longer duration of exposure nor higher indices of exposure based on total dust concentrations from personal samplers. There was a trend toward larger declines in FEV_1 to be associated with higher total dust indices ($r = -.50$) but this was not statistically significant.

Time spent in the buildings varies considerably among growers and is dependent on the particular tasks necessary at a given stage of bird development. It was not possible to observe growers directly at work, so their own estimates of the time spent in the houses on the day of the study were accepted. Only large inaccuracies in these estimates would obscure any association between exposure and acute response. It also was not possible to control the time between exposure and repeat testing, which may have further lowered the ability to detect responses. Due to the small number of growers who underwent spirometry prior to entering the confinement houses and who returned for spirometry after exposure, results must be interpreted cautiously.

A previous poll of growers, and published figures (7), indicate that growers spend 1.7 hours per day per house inside the poultry houses, and that some growers operate up to 4 houses. On the day of the spirometry tests, growers wearing personal samples spent an average of 1.7 hours inside (range of 45 minutes to 3 hours). This may not have been a typical day because of the time spent participating in the testing.

Acute responses may also vary depending on composition and concentration of airborne materials in the houses. These in turn depend, among other things; the age of the birds, confinement house ventilation rate, and the state and composition of the litter material covering the house floor. As demonstrated in this study, concentrations of ammonia in air can vary greatly among houses between occupied and unoccupied areas of a single house. Exposure to excessive levels of ammonia is very likely to cause eye irritation, a commonly reported symptom. Whether this agent may also contribute to the other respiratory symptoms is not clear. Concentrations of endotoxin measured earlier in this study were generally lower than those reported to be associated with acute changes in pulmonary function in experimental textile dust exposures (30). Acute symptoms and pulmonary function changes have been associated with exposure to relatively inert particles (32) and thus would not be unexpected with exposure to high concentrations of airborne total particulates (dust). The significance of such non-specific responses is not clear. Of concern is the potential for chronic, i.e., irreversible impairment resulting from repeated acute insults. However, even for organic dusts (such as cotton dust) thought to produce bronchospasm via stimulation of mediator release in the airways, the relationship between acute and chronic responses is not established (33).

Chronic bronchitis (chronic cough and phlegm) has been associated with many environmental and industrial exposures (34). However, significant loss of ventilatory function is not necessarily associated with these symptoms (35). One third of the growers in this study complained of chronic cough and/or phlegm production. Although approximately two-thirds of those with these complaints were non-smokers, the prevalence of these complaints was not greater in those with higher indices of cumulative exposure to the poultry confinement environment. Likewise, pulmonary function results did not show lower mean values (% predicted) in those with more cumulative exposure. Also, approximately the same proportion of those with "high" and "low" cumulative exposure indices had "abnormal" values of the FEV_1; that is, values below 80% of the predicted value.

The lack of a dose-response relationship between exposure and chronic symptom prevalence or impairment of pulmonary function suggests that the poultry confinement environment has not been a major cause of chronic respiratory impairment in these growers. However several important limitations of this study must be recognized. The number of growers studied was small and was a non-random sample from an unknown target population of exposed growers. The length of time these growers have been exposed to the poultry confinement environment is relatively short (approximately 6 years on average) and the intensity of exposure may vary importantly between individuals. There was no way to evaluate this latter factor beyond the growers' own estimates of the amount of time spent in the confinement houses each day. Thus, the power of this study to detect an association between exposure and effect was low.

VII. CONCLUSIONS

1. The primary exposures to poultry growers was found to be airborne dust and ammonia. The source of the ammonia appeared to be decaying chicken droppings and litter. The source of the airborne dust appeared to be dried chicken droppings, litter, and other material.

2. Four of 13 area measurements of total dust and 6 of 17 measurements of ammonia in the air in occupied areas of the houses were in excess of the recommended exposure limits for inert dust and ammonia. No personal dust samples or area respirable dust samples exceeded recommended exposure limits. Concentrations were higher in winter when confinement house ventilation was minimal and in houses with adult birds. Carbon dioxide concentrations were well below recommended limits and other gases and vapors assayed were not detected. Analysis of the dust indicated that it was not merely "inert" dust, so the recommended limits for inert nuisance dust may not apply. See Conclusion 3.

3. Endotoxins, bacteria, and fungi were found in the airborne dust in the poultry houses, in quantities roughly comparable to those observed in other studies of poultry houses. Portions were of particle sizes small enough to reach the alveoli of the lung (respirable). There are no regulatory or recommended "safe" exposure limits for these agents in air. Exposure to endotoxins has been associated with respiratory symptoms and disease, headache, nausea, diarrhea and fever. No assays were made for bacterial or fungal species. Fungi concentrations in air were higher than found in studies of poultry raised on wire mesh floored cages; possibly the wood chip litter is a fungi source.

4. Twenty-five growers with exposure to poultry confinement houses were studied with spirometry and questionnaires for respiratory symptoms. Although a high prevalence of respiratory symptoms was found, no clear association between acute symptoms or acute changes in pulmonary function on the day of the study and indices of exposure was found. There was a trend for those with more exposure to have a higher incidence of lower respiratory symptoms and decrements in FEV_1 but these did not reach statistical significance. Chronic symptoms and chronic levels of pulmonary function were also not clearly related to estimates of cumulative exposure to the poultry confinement environment. Due to the small number of growers studied and other limitations the power of the study to detect such associations was probably low. Based on environmental sampling results, airborne ammonia concentrations may reach levels associated with eye and upper respiratory irritation. The potential for long term irreversible effects on the respiratory system under conditions now prevailing cannot be determined from this study.

VIII. RECOMMENDATIONS

Recommendations focus on achieving reductions in exposure to ammonia and to airborne dust, which contains endotoxins, bacteria and fungi.

1. Adequate ventilation to reduce ammonia and total particulate concentrations to the lowest feasible levels is recommended to prevent acute irritative effects. Consideration should be given to the recommended ventilation rates of North Carolina State University (0.1 to 0.2 cfm/chicken) cited in this report.

2. Unused, unventilated spaces should be thoroughly aired out before work is performed inside (highest ammonia concentrations found were in these spaces).

3. Consideration should be given to use of combination dust/ammonia respirators when inside the houses. Several companies manufacture NIOSH-approved half-mask respirators with replaceable combination dust/ammonia removal cartridges. Similar respirators are also available with full face masks to provide eye protection as well as respiratory protection.

4. Further studies need to be conducted at the broiler houses to document environmental conditions as a function of seasonal changes as well as age of chickens and age of litter.

5. Only twenty-five growers with exposure to poultry confinement houses were studied with spirometry and questionnaires for respiratory symptoms. A larger population of growers should be studied to determine if there is an association between acute symptoms or acute changes in pulmonary function and indices of exposure during times where exposure of the growers to adverse conditions is most likely to be highest.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

The cooperation of Mr. David Mayer, Ms. Ronda Mayer and other poultry producers in the Hobgood, NC area, and the assistance of Ms. Anne Stone, UNC pulmonary function technician, Mr. Jonathan L. Sheline, UNC medical student, Dr. Jerry J. Tulis, Clinical Professor of Parasitology and his graduate students of the UNC School of Public Health, and Ms. Kathy L. Morring of the NIOSH Appalachian Laboratory for Occupational Safety and Health are hereby acknowledged.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this Determination report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

(a) Mr. David Mayer, Hobgood, NC
(b) U.S. Department of Labor, OSHA, Region IV
(c) NIOSH Region IV
(d) North Carolina Department of Human Resources
(e) North Carolina Department of Labor
(f) N.C. State University, Office of Extension Poultry Science

APPENDIX A - Questionnaire Used in Study of Poultry Growers

Name_____ Date_____

Address_____

Phone_____ Private MD_____

DOB_____ Age_____ Race_____ Sex_____ Height_____ Weight_____

Highest Grade of School Completed_____

Chronic

1. Do you usually cough first thing in the morning?_____
2. Do you usually cough during the rest of the day or night?_____
3. If yes for 1 or 2 --Do you cough like this on most days for as much as 3 months a year?_____
4. If yes to 3 -- how long have you had this cough?_____
5. Is your cough worse on any particular day of the week?_____ If yes, which _____

Phlegm

6. Do you usually bring up any phlegm from your chest first thing in the morning?_____
7. Do you usually bring up any phlegm from your chest during the rest of the day or night?_____
8. If yes for 1 or 2 -- do you bring up phlegm like this on most days for as much as 3 months each year?_____
9. If yes -- how long have you had this phlegm?_____
10. Do you bring up more phlegm on any particular day of the week? _____ If yes which_____

Chest Illness

11. During the past 3 years have you had any chest illness which has kept you off work, indoors, at home, or in bed for as long as 1 week?_____

Breathlessness (Sequential)

12. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?_____
13. Do you get short of breath walking with other people of your own age on level ground?_____
14. Do you have to stop because of shortness of breath when walking at your own pace on level ground?_____
15. How long have you had shortness of breath?_____
16. Is your shortness of breath worse on any particular day of the week?_____ If yes which_____

Wheezing

17. Does your chest ever sound wheezy or whistling?_____
    a. When you have a cold?_____
    b. Occasionally apart from colds?_____
    c. Most days or nights?_____
18. How long have you had this wheezing?_____
19. Is this wheezing worse on any particular day of the week?_____ If yes, which_____

Chest Tightness

20. Does your chest ever feel tight or your breathing become difficult?_____
21. How long have you had this chest tightness?_____
22. Is this chest tightness worse on any particular day(s) of the week?_____ If yes, which_____
23. Do you smoke cigarettes?_____
24. If no, did you ever smoke cigarettes regularly?_____

If yes to 23 or 24

25. How old were you when you started smoking regularly?_____
26. If you have stopped smoking how old were you when you stopped_____
27. How many cigarettes do you smoke each day now?_____
28. How many cigarettes did you smoke each day on average over the period of time you have smoked?_____
29. Do you smoke a pipe or cigars regularly?_____

Past Illnesses

30. Have you ever had
    a. Tuberculosis_____
    b. Pneumonia_____
    c. Asthma_____
    d. Allergies_____
    e. Hay Fever_____
    f. A serious chest injury or operation_____
    g. Any lung trouble before age 16
    h. Heart trouble_____

Family History

31. Has anyone in your family had asthma?_____

32. Have you ever worked in

    a. A textile mill_____
    b. A mine or mineral processing plant_____
    c. A shipyard_____
    d. Any job with exposure to dust, smoke, chemicals, or gases?
       List job_____# years_____
       # years ago_____

33. Do you have any hobbies which involve exposure to dust, smoke, chemicals or gases? List_____

Poultry Related Questions

34. How long have you raised poultry?_____

35. How many days per week do you enter the poultry houses?_____

36. How many hours per day do you spend in the poultry houses?_____

37. What job do you usually do in the poultry houses?_____

38. Do you usually wear a dust mask while in the poultry houses?____

Have you noticed any of the following since starting to raise poultry (or if present before have they become worse) since you started raising poultry?

	N	Y	Occasionally	Most days	While in poultry house	After out of poultry houses	any improvement on days when you don't go into poultry house
coughing							
phlegm							
wheezing							
chest tightness							
shortness of breath							
stuffy nose							
eye irritation							
sore throat							
chills							
muscle aches							
fever							

SPIROMETRY QUESTIONS

Name:_____ Date:_____

Birthdate:_____ Height:_____

Race/Sex:_____ Weight:_____

Temperature before first spirometry session:_____

1. Do you have a chest cold today? Yes No.
2. Did you smoke any cigarettes today? Yes No
   If so, how many? Number:_____
3. Did you work in poultry houses yesterday? Yes No
4. Have you been in a poultry house today? Yes No

Temperature before second spirometry session:_____

1. How long did you spend in the poultry houses today? Hours:_____
2. Did you wear a dust mask during that time? Yes No
3. How many cigarettes since the first test? Number:_____
4. Did you have any of the following today? Circle if you did.

   Chest tightness/cough/wheezing/phlegm/shortness of breath/

   sneezing/runny nose/sorethroat/eye irritation/

   other_____
5. What sort of job did you do today?

   a. Feeding:_____
   b. Cleaning:_____
   c. Other:_____
6. Did you work in an area other than poultry houses today. Yes No

   If so, were you exposed to gas, smoke, chemicals or other dust? Yes No

   If yes, then what_____ where_____