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ESTHERVILLE FOODS, INC.
ESTHERVILLE, IOWA

NIOSH Investigators: Alexander Blair Smith, M.D., M.S.
Matthew A. London, M.S., Kenneth Wallingford, C.I.H, Gregory A. Ornella, M.D.
Gregory A. Ornella, M.D., Mary A. Newman, Ph.D.
University of Cincinnati College of Medicine:
David I. Bernstein, M.D., Joan S. Gallagher, Ph.D.
Centennial Health Center Moscow, Idaho: Susan Gelletly, M.D.

I. SUMMARY

On July 15, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposures to raw egg products at the Estherville Foods, Inc. plant in Estherville, Iowa. Workers at another egg processing facility had previously been documented to have IgE-mediated occupational asthma from airborne egg protein exposure. The intent of this evaluation was to replicate the original findings, and determine the risk for IgE-mediated occupational asthma among employees of the Estherville Foods plant. An initial site visit and walk-through survey were conducted by NIOSH personnel on September 12, 1986. A combined medical and industrial hygiene survey was undertaken during March 30-April 2, 1987.

Employees' exposures to chloride ions and acid gases were below applicable standards. Ambient air concentrations of chloride ions were less than 0.013 milligrams per cubic meter (mg/m^3). Ambient air concentrations of hydrochloric acid (HCL) were less than 0.06 mg/m^3. Ambient air concentrations of sulfuric acid (H_2SO_4) were non-detectable. There are no applicable exposure recommendations or standards specifically for ambient air total protein concentration. Ambient air concentrations for total protein were less than 1.2 mg/m^3. Ambient air concentrations of ovalbumin, ovomucoid, and lysozyme were less than 360 ug/m^3, 243 ug/m^3, and 40 ug/m^3, respectively. Over the course of a work shift, protein concentration in the sanitizer water from the egg washers increased from 0.27 mg/ml to 5.6 mg/ml.

Ten employees were determined to have IgE-mediated occupational asthma from egg protein exposure, based upon questionnaire responses compatible with occupational asthma, a physician's clinical history and examination suggestive of occupational asthma, and immunologic evidence of allergy to egg proteins (one or more positive skin-prick tests or radioallergosorbent tests (RASTs) to egg proteins). Three of the 10

also had peak expiratory flow rate (PEFR) measurements suggestive of bronchial lability. The estimated prevalence by job classification of IgE-mediated occupational asthma from egg exposures at this plant ranged from 8% among egg breakers, to 33% among candlers.

On the basis of these data, NIOSH investigators have determined that a health hazard existed among employees of the Estherville Foods, Inc., plant in Estherville, Iowa, from occupational exposure to airborne egg protein. Recommendations to reduce exposures to egg protein, and for screening of at-risk workers, are made in Section IX of this report.

KEYWORDS: SIC 2017, poultry and egg processing, egg protein, egg dust, occupational asthma, aeroallergens, chloride ions, acid gases

II. INTRODUCTION

On July 15, l986, NIOSH received a request from the president of Sonstegard Foods, Inc., to evaluate occupational exposures to raw egg products at Estherville Foods, Inc., Estherville, Iowa. An initial site visit and walk-through survey were conducted by NIOSH personnel on September l2, l986. A combined medical and industrial hygiene survey was undertaken during March 30 - April 2, l987. Each participant in the medical study was notified of the results of his or her medical examinations on July 27, l987. An interim report summarizing the results of the medical survey was distributed in October 1987.

III. BACKGROUND

In l986, NIOSH released a report of a health hazard evaluation among workers at Siouxpreme Egg Products, Inc., in Sioux Center, Iowa.[1] This plant processes up to a million and a half raw eggs each day, into powdered whole egg, powdered egg yolk, and liquid egg white. Workers at Siouxpreme Egg Products were complaining of "asthma-like" symptoms, including wheezing, shortness of breath, and chest tightness, which they believed were work-related. NIOSH investigators determined that five workers at Siouxpreme Egg Products had developed IgE-mediated occupational asthma from exposure to egg protein. This disease previously had not been described in the egg processing industry. Results of the study were reported in the Morbidity and Mortality Weekly Report, reprinted in the Journal of the American Medical Association, and published in the American Journal of Industrial Medicine and the Journal of Allergy and Clinical Immunology.[2-5]

On July l5, l986, representatives of NIOSH and the United Egg Producers Association met in Cincinnati, Ohio, to discuss the findings of the hazard evaluation conducted at Siouxpreme Egg Products. It was agreed that the results of the Siouxpreme Egg Products hazard evaluation should be replicated, to determine if the occurrence of five cases of IgE-mediated occupational asthma from egg protein exposures at this plant was an isolated incident, or if IgE-mediated occupational asthma to eggs is present among workers in other facilities. The president of Sonstegard Foods, Inc., attended this meeting, and requested an evaluation of workers at Estherville Foods, Inc., in Estherville, Iowa. Both Estherville Foods, Inc., and Siouxpreme Egg Products, Inc., are subsidiaries of Sonstegard Foods, Inc. Workers at the Estherville Foods plant break and separate raw eggs, but do not dry eggs. Thus, risks for developing occupational asthma among workers exposed only to raw, liquid egg products, and not to dried egg products, could be examined at this plant.

IV. PROCESS DESCRIPTION

Estherville Foods, Inc., has been in operation at its present site since 1976. Operations at the plant are typically structured around

two work shifts, from 6:00 A.M. to 2:30 P.M., and from 2:30 P.M. to 11:00 P.M. In accordance with U.S. Department of Agriculture (USDA) regulations, the process runs for 5 hours, after which the machines are cleaned for an hour. Thus, during a workday, the lines run from 6 A.M. to 11 A.M., 12 noon to 5 P.M., and 6 P.M. to 11 P.M. They are cleaned from 11 A.M. to 12 noon, from 5 P.M. to 6 P.M., and at the end of the workday. Approximately 150 employees typically work at the plant. Spring is peak employment time, and the work force may increase to approximately 200 workers.

Semi-trailer shipments of eggs on pallets are off-loaded in the "receiving" area using a propane-powered forklift. Each pallet holds 36 cartons of 30 eggs. From the receiving area, eggs are transported via forklift to the "transfer" area, to be washed and sanitized. There are 12 egg washing machines. Egg cartons are placed on the loading chutes of the washing machines, and are then picked up by suction cups and transferred (or loaded) onto conveyors that feed the machines. Broken eggs are evident around the washing machines and adjacent areas.

Eggs travel on conveyers through the washing tunnel of each egg washer. Within the washers, they are spray washed with a detergent solution of "Best Eggs Plus", which is a chlorinated egg washing detergent whose active ingredients are sodium metasilicate and sodium dichloroisocyanurate. The wash water is filtered and recirculated continually at approximately 100 degress Fahrenheit during a 5-hour cycle. Aerosolization of the recirculated wash water was evident during the walk-through survey. After passing through a clean water rinse, the eggs are sprayed with a chlorinated sanitizer, whose active ingredient is sodium hypochlorite. The eggs then pass over the candling table, where they are examined by a "candler". Eggs that are still dirty, cracked or broken, are removed from the conveyor. Otherwise, they pass through a window in a wall, into the breaking room.

Approximately 20 to 30 employees work in the transfer area. There is no rotation of employees in the transfer room. A worker either trays (loads) or candles throughout the workshift.

The washed and candled eggs enter the breaking room on the same continuous conveyors that transported them through the washing machines. They fall onto the continuous chains of the breaking machines. The eggs are gripped mechanically, the shells broken and separated, and the contents dropped into separating cups. The yolks are trapped in the cups, and the white flows through. As the cups pass by the breaking machine operator, the operator must make a decision on the thoroughness of each break. If the separation of yolk and white is clean, the operator lets the cup pass by, and the resulting product streams are the separated egg yolks and egg whites. If the separation is not good, or the yolk is broken, the operator tips the cup, which sends the whole egg product into another collection system. An air valve, located under the cup, blows air across the broken eggs while still in the cups, toward the nose of the operator. The operator, thus can both see and smell any rotten egg. If a rotten egg has gotten through the washing and candling process, the operator will stop the breaking machine and remove it. There are 12 breaking machines, with approximately 24 workers tending them.

Stainless steel pipes carry the egg products from the collection systems of the breaking machines to silos. Depending on the product, additives such as salt, sugar, and citric acid, may be blended into the liquid egg. About 20 to 25% of the product is pasteurized, and packed in the packaging room. The rest is shipped, unpasteurized, to other plants. The egg whites are shipped to Sonstegard Foods' plant in Howard Lake, Minnesota. The yolks and whole eggs are shipped to Siouxpreme Egg Products.

The breaking and packaging rooms are under positive pressure ventilation, per USDA requirements.

Inedible breakage is transported to the shellhouse, where broken shells are separated from the egg liquid. The liquid is sent to a pet food manufacture. The shells are loaded into a dump truck, and the shellhouse operator transports them to a field, where they are spread out to be used as lime.

A clean-up crew manually cleans the egg washers and the breaking machines. Workers on the clean-up crew may have other duties during the regular work shift. The machines are cleaned with water and sanitized with a chlorine rinse. Large tanks located in the breaking room are used to clean small parts. "Simbol", whose active ingredients are sodium hydroxide and sodium dichloro-s-triazine, is used as the cleaning agent.

The stainless steel pipes are cleaned automatically by a computerized "Clean-in-place" system, using a caustic wash ("Bril-Tak", whose active ingredient is sodium hydroxide), and an acid sanitizing rinse ("Servac", whose active ingredient is phosphoric acid). A foam cleaner, "Avid-L", whose active ingredients are potassium hydroxide and potassium hypochlorite, is used on all machines.

Neither pre-employment nor periodic medical examinations are performed. A local hospital is used for emergency situations. No medical records are maintained on site. Hearing protection is required in some areas (e.g., the breaking room). No audiometry program is provided.

V. METHODS

A. ENVIRONMENTAL

On March 31 and April 1, 1987, air sampling was conducted in the warehouse, the flat washing area, the transfer room, the breaking room, and the shellhouse. The sampling focused on the three most apparent agents in the workplace that could cause irritant respiratory symptoms or occupational asthma, namely, chloride ions and acid gases (HCl and H_2SO_4) from the sanitizer solutions, and egg dust from the product the plant produces.

Chloride ion: Two area samples were collected in the transfer area, using midget impingers containing 20 ml of $NaHCO_3$. One area sample was similarly collected in the Breaking Room. The samples were analyzed following NIOSH Method 7903, using a DIONEX 2010i ion chromatograph.[6]

Acid gases: Two area samples were collected in the transfer area, using silica gel solid sorbent tubes, and analyzed for acid gases (HCl and H_2SO_4) following NIOSH Method 7903,[6] using a DIONEX 2010i ion chromatograph.

Total protein: Personal (breathing zone) and area air samples were collected on 37 millimeter glass fiber filters, and analyzed for total protein by the Micro-Kjeldhal method.[7] Six samples were collected in the transfer area, three each from trayers (loaders) and candlers.

Four samples were collected in the breaking room from breaking machine operators. One sample each was obtained from the flat washer operator, and the shell house operator. One area sample for total protein was collected in the egg warehouse.

Bulk samples of clean and of dirty sanitizer water were obtained from the transfer area, and analyzed for total protein.

Aeroallergens: Personal and area air samples were collected on Teflon filters, total aerosol concentration determined gravimetrically, and analyzed for aeroallergen concentration (ovalbumin, ovomucoid, and lysozyme) by RAST inhibition.[8]

B. MEDICAL/EPIDEMIOLOGIC

The medical survey procedures were similar to those used previously at Siouxpreme Egg Products, Inc.[1] We administered a questionnaire to every available employee at the plant, to identify workers with symptoms suggestive of occupational asthma. These were, as demonstrated previously, episodic wheezing, shortness of breath, and/or chest tightness, occurring following specific activities or exposures at work, and occurring less frequently or not at all on days away from work and on vacations. We invited to participate in follow-up examinations, all respondents who reported wheezing, and/or shortness of breath and chest tightness, temporally related to work; and an approximately equal number of respondents with none of these chest symptoms. [Note: This criterion for inclusion in the follow-up examinations, differs from the criterion established for the hazard evaluation at the Ballas Food Products plant, HETA 86-461. At Ballas Foods, symptomatic respondents were invited to participate in the follow-up examinations regardless of the reported temporal relationship to work of their symptoms.] In the follow-up survey:

(1) A physician obtained a medical history and examined each participant. She was blinded to the questionnaire responses and the results of all other examinations. She rendered an opinion, based upon her clinical examination, whether the examinee had asthma, and if so, whether the asthma was occupational or non-occupational. She diagnosed occupational asthma if her clinical history elicited symptoms as outlined above. She diagnosed non-occupational asthma if there was a prior physician's diagnosis of asthma, preceding employment; or if there was a history suggestive of asthma, and the symptoms were not temporally related to work. She diagnosed irritant respiratory symptoms if an irritant exposure was easily identified by the subject, symptoms were present on initial exposure, symptoms generally began immediately with exposure, and intensity of symptoms appeared by history to correlate with concentration of exposure. She noted in her clinical evaluation report, that many of the individuals considered possibly to have occupational asthma, might be determined to have non-occupational asthma or irritant symptoms, depending on the results of the pulmonary function assessments and the immunologic testing; and conversely that many of the individuals considered possibly to have non-occupational asthma or irritant symptoms, might be determined to have occupational asthma, depending on the results of pulmonary and immunologic testing.

(2) Spirometry was performed toward the end of the work shift using an Ohio Medical Model 822 dry rolling sealed spirometer attached to a Spirotech 220B dedicated computer. If there was evidence of any abnormality on spirometric examination, the participant was requested to return the following morning, pre-shift, for another pulmonary function determination. We required as evidence of pulmonary function test abnormality, a forced expiratory volume in one second (FEV1) less than 80 percent of predicted, a forced vital capacity (FVC) less than 80 percent of predicted, or an FEV1/FVC ratio less than 0.7.[9]

(3) PEFRs were measured serially, using Wright's portable mini-peak flow meters, every three hours while awake for one week. Three exhalations were recorded each time, and the maximum of the three was accepted as the PEFR determination. Any wheezing, shortness of breath, or chest tightness experienced concurrently with each PEFR determination was also reported.

We diagnosed a participant to have "symptomatic bronchial lability" if the difference between the minimum and the maximum PEFR on at least one day exceeded 20 percent of the day's maximum PEFR,[10] and he/she reported wheezing, shortness of breath, or chest tightness at the time the PEFR reached the daily minimum.

(4) Skin-prick tests were administered and serum specific IgE levels were measured by the RAST method to a panel of egg allergens, including commercial egg white, yolk, and whole egg reagents (prick tests: Hollister-Steir (HS), Spokane, WA), extracts prepared from factory powdered egg white, yolk, and whole egg (prick tests and RASTs), and the egg fractions conalbumin, ovalbumin, lysozyme, and ovomucoid (prick tests and RASTs: Sigma Co., St. Louis, MO). A skin-prick test was considered positive if the wheal diameter measured at least three millimeters greater than the saline control, and the histamine control was positive. RAST results were expressed as counts per minute of 125I-labeled anti-IgE bound to allergen-coated discs, and were considered positive if the tests' sera binding was more than three standard deviations above the mean of non-exposed laboratory controls. Total serum IgE levels were measured by radioimmunoassay. The normal range was l0-l25 International Units (IU) per milliliter, where one IU equals 2.3 mg.

(5) Skin-prick tests were administered to a panel of common airborne allergens, including bluegrass, ragweed, timothy, cat hair, house dust, alternaria, hormodendrum, and house dust mites (Hollister-Steir). Negative and positive control skin tests included phosphate-buffered saline and histamine, respectively. Clinical atopy was determined by a positive response to two or more common allergens.

From our prior experience,[1,4] we developed survey-based diagnostic criteria for probable and possible occupational asthma, possible non-occupational asthma, and possible irritant respiratory symptoms. These are summarized in Table 6 and described as follows.

(1) Probable "egg asthma": We classified a participant as having probable "egg asthma" if (a) he/she had symptoms as described above, suggestive of occupational asthma, (b) the serial peak flow rate measurements demonstrated symptomatic bronchial lability on at least one day, and (c) there was evidence of IgE-mediated allergy to egg protein, i.e., there was at least one positive prick test or RAST to an egg protein. This definition potentially misclassifies individuals with "egg-asthma", who during the course of the one week survey, were not exposed to the situation(s) which typically precipitated their asthma. It also potentially misclassifies individuals with severe and unremitting bronchoconstriction, whose airways did not sufficiently dilate over the course of the survey, to demonstrate a 20% lability on any one day. We therefore classified as having "probable

egg-asthma", participants who had compatible symptoms and evidence of allergy to egg protein (criteria (a) and (c) above), who had a history of physician-diagnosed asthma, or who were taking medications for treatment of asthma at the time of our survey.

(2) Possible "egg asthma": We classified a participant as having possible "egg asthma" if he/she had symptoms suggestive of occupational asthma and evidence of IgE-mediated allergy to egg protein, but serial peak flow determinations did not yield evidence of symptomatic bronchial lability over the course of our 1 week survey. The absence of adequate PEFR data for analysis from a participant was treated as equivalent to adequate but negative data.

(3) Possible non-occupational asthma: We classified a participant as having possible non-occupational asthma if he/she had symptoms suggestive of asthma, apparently unrelated to work; he/she had symptomatic bronchial lability on serial PEFR determination; but he/she had no positive prick tests or RASTs to egg proteins.

(4) Possible irritant respiratory symptoms: We classified a participant as having possible irritant respiratory symptoms if he/she had episodic wheezing, and/or shortness of breath and chest tightness, apparently unrelated to work; he/she did not have symptomatic bronchial lability on serial PEFR determination or gave us insufficient data to analyze; and he/she had no positive skin prick test or RAST to egg proteins.

VI. EVALUATION 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 Recommended Exposure Limits (RELs),[11] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[12] and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[13] Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA PELs. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELs. The OSHA PELs also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELS, 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

A. CHLORIDE IONS

There are no applicable exposure standards for chloride ions. The OSHA PEL for exposure to chlorine is 3 mg/m^3 as a ceiling level, not to be exceeded at any time. The NIOSH REL is l.5 mg/m^3 as a 15-minute ceiling. The ACGIH has noted an intended change in the TLV from 0.3 mg/m^3 to l.5 mg/m^3 as a TWA and intends to add a STEL of 3 mg/m^3. Exposure to chlorine can cause coughing, shortness of breath, and itching or burning of the eyes, nose, and throat.[14]

B. ACID GASES

The OSHA PEL and ACGIH TLV for exposure to HCl is 7 mg/m^3 as a ceiling level, not to be exceeded at any time. There is not a NIOSH REL for HCl. Inhalation of HCl may cause throat irritation, gastritis and chronic bronchitis.[14]
The OSHA PEL, ACGIH TLV and NIOSH REL for H_2SO_4 are all l mg/m^3 as TWAs. Exposure to H_2SO_4 may cause tracheo bronchitis, inflammation of the mouth (stomatitis), conjunctivitis, and gastritis.[14]

The sampling and analytical methods utilized in this study were those recommended for use when sampling the air for the chlorine, HCl and H_2SO_4 in a gaseous state. After the contaminants are collected in a liquid or sorbent media, a specific ion in the desorption solution is quantified. The gaseous concentration is then calculated, assuming that the detected ion is representative of the total molecule. However, during this study the detection of specific ions cannot be used to calculate back to gas concentration because the specific ions are part of a different molecule. Since there are no standards for halogen organic complexes like those used in this plant, a straight-forward interpretation of the results is not feasible.

A worst case approach would be to consider that all of the contaminants were in a gaseous state and that their effects are additive. This concept has some merit in that these chemicals all have been shown to demonstrate irritant-type symptoms. This approach, which is also suggested in the ACGIH Threshold

Limit Values booklet for l987-88, utilizes the following formula:[12]

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = 1$$

where C_1 = concentration of chemical
where T_1 = TLV for chemical

As the formula implies, if the sum exceeds one, the calculated "mixture" TLV has been exceeded.

C. AEROSOL MASS

The OSHA PEL for nuisance dusts is l5 mg/m^3 for total dust and
5 mg/m^3 for the respirable fraction. The ACGIH TLV for total nuisance dust is l0 mg/m^3. Excessive concentrations of nuisance dusts in the workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears and nasal passages (Portland cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

D. Protein dust

There are no occupational exposure standards or recommendations specific for egg dust, and no standard for airborne dust of organic origin. Consequently the only workplace exposure standard applicable to the protein and aeroallergen concentrations measured in this study is that for airborne nuisance dust, which by definition has little adverse effect on the lungs. As noted by the ACGIH, however, the nuisance dust guidelines are not meant to "apply to those substances which may cause physiologic impairment at lower concentrations, and for which threshold limits have not yet been recommended."[14] Exposure to egg protein may lead to sensitization. Allergic reactions may develop in sensitive persons subsequently exposed to egg protein. Sensitized persons may react to allergens at low concentrations and the responses may be dose related. The ACGIH TLV for subtilisins, a proteolytic enzyme, thus, a dust of organic origin, illustrates the order of magnitude of the dust level that may be necessary to protect the worker from respiratory sensitization. The ACGIH recommends a ceiling limit of 0.06 ug/m^3 for proteolytic enzymes of Bacillus subtilis.[12]

VII. RESULTS

A. ENVIRONMENTAL

The three area samples had chloride ion concentrations (Table 1) of 0.011 mg/m^3, 0.013 mg/m^3, and 0.013 mg/m^3, with an average of 0.0l2 mg/m^3. The two area samples for acid gases (Table 2) were non-detectable (limit of detection 0.007 mg/m^3 for HCl and 0.044 mg/m^3 for H_2SO_4), except for one measurement for HCl of 0.06 mg/m^3.

Personal exposure samples for total protein concentration (Table 3, 12 samples collected) ranged from 0.44 to 0.73 mg/m^3 for trayers in the transfer room; from 0.39 to 1.2 mg/m^3 for candlers in the transfer room; and from 0.52 to 0.93 mg/m^3 for breakers. Personal exposure samples for the shell house operator and flat washer operator were 0.62 mg/m^3 and 0.23 mg/m^3, respectively. The average personal total protein exposure concentration was 0.64 mg/m^3.

Over the course of a work shift, protein concentration in the sanitizer water from the egg washers increased from 0.27 mg/ml to 5.6 mg/ml. (Table 4).

The three personal exposure samples for ovalbumin, ovomucoid, and lysozyme concentrations (Table 5) in the transfer room and in the breaking room ranged from non-detectable (0.03 ug/m^3 limit of detection) to 360 ug/m^3.

B. MEDICAL/EPIDEMIOLOGIC

(1) CASE HISTORIES

Data for each participant in the follow-up survey were summarized in tabular form in the interim report distributed in October, 1987. We determined that three participants in the study had "probable egg asthma", by our survey-based criteria (summarized in Table 6). Their case histories follow. ID numbers correspond to the data tabulated in the interim report.

ID 809l: This participant had been employed at Estherville Foods for approximately one year. He had approximately a four pack-year smoking history. He had a personal history of sinusitis and hayfever. By questionnaire he stated that approximately two months after he was hired, he began to experience wheezing, shortness of breath, and chest tightness which he believed occurred following workplace exposures, either during or within an hour after specific workplace activities. These symptoms, however, occurred with the same frequency on days away from work and on vacations, as on workdays. He had a daily itchy, runny, stuffy nose, with frequent sneezing at work; and itchy, watery, or tearing eyes several times a week while at work. The examining physician noted apparent conjunctival irritation, bilateral maxillary sinus tenderness, and slight diffuse inspiratory wheezing. Based upon clinical history, the examining physician diagnosed occupational asthma, with associated sinusitis. His pulmonary function tests (forced spirometry) were normal. His PEFR over seven days demonstrated symptomatic bronchial lability temporally related to work (Figure 1). Specifically, he was exposed to egg products on six of seven days, and on four of these seven days had bronchial lability greater than 20 percent. On the one non-exposed day, his bronchial lability was less than 20 percent. In addition, on two of the six days when he was exposed to egg products, his peak flow tracing yielded an apparent "U-shaped" pattern. Interestingly, this pattern occurred on the two days following a day off. He had positive skin-prick tests to factory whole egg, factory egg yolk, factory egg white, conalbumin, ovalbumin, ovomucoid, HS egg white, and HS egg yolk. His RASTs were all negative. He had five positive skin-prick tests to common airborne allergens, namely to ragweed, timothy, house dust, alternaria, and house dust mites. His serum total IgE level was elevated.

ID 8ll5: This worker had been employed at Estherville Foods for more than ten years. She was an ex-smoker, with a ten pack-year history of smoking. Less than one year prior to our survey, she had consulted a physician for breathing and chest tightness, and was taking a theophylline medication at the time of the survey. She denied any personal or family history of allergy or atopy. Approximately one and one half years after she was hired, she began to experience wheezing, and shortness of breath which she related to certain activities or exposures at work, and which occurred not at all on days away from work and on vacations. Approximately three years after the onset of wheezing and shortness of breath she similarily began to experience chest tightness. She reported an itchy, runny nose several times a week while at work, but denied nasal stuffiness, sneezing, and itchy, watery eyes while at work. The examining physician noticed mild diffuse bilateral wheezing on deep breathing, and based on her clinical history and examination, concluded she had irritant respiratory symptoms from workplace exposures, and occupational asthma. Her pulmonary function tests (forced spirometry) demonstrated an obstructive pattern. Her PEFR over seven days demonstrated symptomatic bronchial lability temporally related to work (Figure 2). Specifically, she reported exposures to egg products on six of seven days, and on each of these six days had bronchial lability of 20 percent or greater. On the one day when she was not exposed to work products, her bronchial lability was less than 20 percent. On each day during which she gave us PEFR determinations, she was taking a theophylline based medication. She had positive skin-prick tests to factory whole egg, factory egg white, conalbumin, ovalbumin, ovomucoid, lysozyme, HS whole egg, HS egg white, and HS egg yolk. She had positive RASTS to factory whole egg, conalbumin, lysozyme, and ovomucoid. She had no positive skin-prick tests to common airborne allergens. Her serum total IgE level was normal.

ID 8038: This participant had worked at Estherville Foods for approximately ten years. She had never smoked cigarettes. She denied ever having had asthma. However, at the time of the survey, she was taking oral theophylline, and a steroid preparation and albuterol by inhalation. She denied any personal or family history of allergy or atopy. Approximately four years after beginning work, she began to develop wheezing, shortness of breath, and chest tightness which she related to certain activities or exposures at work, and which occurred not at all on days away from work and on vacations. She denied nasal or ocular symptoms. The examining physician noted her to have conjunctival irritation, frequent coughing during the evaluation, a prolonged expiration time, and mild diffuse inspiratory and expiratory wheezing. Based upon her clinical history and examination, the physician concluded she had probable occupational asthma. Her pulmonary function tests (forced spirometry) demonstrated a combined restrictive and obstructive pattern on two days' testing. Her PEFR determinations demonstrated bronchial lability greater than 20 percent on all days, including the one day for which she reported no egg exposures (Figure 3). On all days she was taking her theophylline medication and steroid by inhalation. She took albuterol by inhalation on five of the seven days as well. She had positive skin-prick tests to factory egg yolk, conalbumin, ovomucoid, lysozyme, and HS whole egg. She had one positive RAST, to factory egg white. Her serum total IgE level was normal. She had no positive skin-prick test to common airborne allergens. Nine participants were classified as having possible "egg asthma". This determination was made because they reported on their questionnaire, work-related symptoms of wheezing, shortness of breath, or chest tightness, and had at least one positive skin test or RAST to egg proteins. It is important to review the history of one of these individuals, who had a history very suggestive of occupational asthma and immunologic tests demonstrative of egg allergy, yet whose serial peak flow determinations did not reveal the requisite 20% variability to be classified as probable "egg asthma". Upon review of her peak flow records, we determined that she was severely bronchoconstricted throughout the course of the survey. With ongoing egg exposures at work, she was never able sufficiently to open her airways toward baseline, to achieve the 20% variability criterion necessary to be recognized as having "probable" rather than "possible" egg-asthma, by our criteria. Her case history follows.

ID 8005: This participant had been employed at Estherville Foods for approximately six years. She was a non-smoker. She had a family history of asthma. By questionnaire, approximately three and a half years after she was hired, she began to experience wheezing, shortness of breath, and chest tightness which occurred following workplace exposures to steam in her job as a candler, usually about four hours after exposure. These symptoms occurred not at all on days away from work and on vacations. Approximately one year prior to our survey, she was diagnosed to have asthma by a physician, and at the time of our survey was taking a theophylline preparation orally, and albuterol by inhaler. The examining physician noted mild diffuse end-expiratory wheezing on deep breathing. Based upon clinical history, the examining physician diagnosed occupational asthma with possible associated occupational sinusitis. Her pulmonary function tests showed a restrictive pattern. Her daily variation in PEFR over seven days was from 8 to 16 percent of daily baseline. She was symptomatic throughout, and using both theophylline and albuterol daily. She had positive skin-prick tests to conalbumin and HS egg white. She had six positive RASTS, to factory whole egg, factory egg white, factory egg yolk, conalbumin, lysozyme, and ovomucoid. Her total serum IgE was elevated. She had no positive skin-prick tests to common airborne allergens.

Three participants in the medical follow-up, including two of the cases described above, had changes on their pulmonary function tests suggestive of severe restrictive lung disease. These three individuals were referred to the Mayo Clinic at NIOSH's expense, to undergo further examinations to rule out the presence of interstitial lung disease. All three individuals were diagnosed by the Mayo Clinic physician consultant to NIOSH, as having asthma, most likely occupational asthma. None of the three individuals had any evidence of interstitial lung disease.

(2) ANALYSIS OF MEDICAL SURVEY DATA

We administered the questionnaire to 92 of 107 (86%) current employees. Of the 15 non-respondents, 12 were unavailable for reasons unrelated to possible work-related respiratory disease, and 3 were not in the plant at the time of the survey. Responses to the screening questions, namely, work-related wheezing, and/or shortness of breath and chest tightness, are summarized in Table 7. Twenty-one respondents reported work-related wheezing, and/or shortness of breath and chest tightness. Six reported work-related shortness of breath or chest tightness, alone. Fifteen reported wheezing, shortness of breath, or chest tightness, that was not temporally related to work. Fifty denied wheezing, shortness of breath, or chest tightness.

We invited to participate in the medical follow-up examinations, all 21 respondents who reported work-related wheezing, and/or shortness of breath and chest tightness; and 22 of the 50 respondents who denied those symptoms. All 21 symptomatic, and 20 of 22 non-symptomatic respondents, participated in the follow-up.

The physician's clinical assessments, and the classifications of participants based upon the survey-based diagnositic criteria, are compared in Table 8. (Note that while the physician's assessment of occupational asthma has only one category, namely, "possible", the categorization of occupational asthma based upon questionnaire, PEFR data, and immunologic tests is divided into two categories, namely, "probable" and "possible". The Kappa statistic of 0.641 demonstrates moderate agreement[15] between the two physician examiner and the survey-based criteria for diagnosing occupational asthma.

We are reasonably certain that the 10 participants for whom there was diagnostic concordance by two independent, albeit imperfect, tests (physician's assessment and survey-based criteria) were correctly classified.[16] Tables 9 through 11 summarize by job category, the numbers of questionnaire respondents, participants in the follow-up examinations, and dually diagnosed cases of occupational asthma. The estimated minimum prevalence of occupational asthma in each job category is given in Tables 10 and 11. The estimated prevalences are minimum, since it is possible that one or more of the questionnaire respondents excluded from participation in the follow-up, may have had occupational asthma. The numerator of the estimated prevalence is thus a minimum count of occupational asthmatics within the plant, while the denominator is the total count of questionnaire respondents by job classification.

We note from Tables 10 and 11 that the estimated minimum prevalence of occupational asthma is 33% among candlers, 15% among loaders (trayers), and 8% among breakers. There were no dually diagnosed occupational asthmatics within other job classifications. In particular, none of the workers who described their duties primarily as "clean-up", and who may have had other responsibilities as well, were dually diagnosed to have occupational asthma.

Table 12 summarizes the relationship of atopy and occupational asthma. The prevalence odds ratio for atopy among dually classified occupational asthmatics, versus non-symptomatics, within the follow-up participants, is 3.9. The prevalence odds ratio for follow-up participants with work-related symptoms, not dually diagnosed as occupational asthma, versus non-symptomatics, is 1.8.

VIII. DISCUSSION

The original intent of this hazard evaluation, plus the similar hazard evaluation conducted at Ballas Egg Products (HETA 86-461) and the follow-up evaluation at Siouxpreme Egg Products, Inc. (HETA 86-446), was to attempt to replicate the original Siouxpreme Egg study (HETA 84-163-1657) and determine if cases of IgE-mediated occupational asthma due to airborne egg exposures could be found elsewhere in the egg processing industry. An additional goal of this evaluation was to determine the prevalence of IgE-mediated occupational asthma due to egg exposures at a plant where eggs were broken and separated, but not dried. We have demonstrated that IgE-mediated occupational asthma is present at each of three egg processing plants where we have conducted hazard evaluation surveys. We believe the evidence to be incontrovertible, that the risk for IgE-mediated occupational asthma among egg-exposed workers is generalized within the egg processing industry, and not just limited to the one plant that was the site of our initial evaluation.

Overall, by plant, the prevalence of egg asthma (by restrictive case criteria) varies from five to ten percent. By job classification within plant, the prevalence is as high as 33% (among candlers at the Estherville Foods plant). Thus, workers exposed to liquid aerosols of raw eggs develop IgE-mediated occupational asthma from egg exposures.

This study demonstrated the presence of airborne proteins and aeroallergens in areas where wet processes were being performed. There was no truly discernable trend in total protein exposure level by job or work area. It is important to note that the candlers appear most heavily to be subjected to the steam exposures from the egg washers, and that protein levels increased in the wash water, over the course of the workshift, from 0.27 to 5.6 mg/ml. This suggests the need to control exposures to egg protein as a consequence of aerosolization of dirty egg washer water.

Evaluating the employees' exposures to total and respirable protein and aeroallergens (ovalbumin, ovomucoid, and lysozyme) is difficult. There are no occupational exposure standards or recommendations specific for egg dust. Egg proteins can cause allergic reactions. Thus, the nuisance dust recommendations are not applicable. Control of occupational asthma among egg exposed workers will require adherence to exposure levels that are more restrictive than the closest prevailing standards.

There does not appear to be any direct correlation between any of the aeroallergens measured and total aerosol concentration.

Employees' exposure to chloride ions and acid gases were all below applicable recommendations and guidelines. The worst possible exposure scenario, considering simultaneous exposure to three contaminants, can be calculated as follows from data in Tables 1 and 2:

	Highest Concentration (mg/m^3)	Evaluation Criteria (ACGIH TLV) (mg/m^3)
Chloride	0.013	3
HC1	0.060	7
H_2SO_4	none detected	1

$$\frac{0.013}{3} + \frac{0.0600}{7} + \frac{0}{1} = \text{guidance value}$$

$$0.004 + 0.009 + 0 = 0.013$$

If the guidance value exceeded one, the exposure would be considered potentially hazardous. Since it is well below this value, it is unlikely that the exposures will cause adverse health effects unless these substances are playing a role in the sensitization process or if an individual is particularly sensitive.

IX. RECOMMENDATIONS

A. ENVIRONMENTAL

Recommendations have previously been made that are applicable to controlling airborne egg exposures at this plant. These recommendations were contained in the report of the first hazard evaluation, where "egg asthma" was first identified,[1] in the control technology report written in support of the follow-up evaluation at Siouxpreme Egg Products (HETA 86-446),[17] in the letter following the industrial hygiene walk-through survey at Ballas Egg Products, and in the interim report of the medical survey at Ballas Egg Products. The following recommendations are compiled verbatim from these original sources.

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, and personal protection. These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the source of the hazard, including engineering measures (material substitution, process/equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control both in terms of occupational and environmental concerns. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of isolate control rooms, isolation booths, fresh-air showers, improved work practices, and personal protective equipment.

In general, a combination of the above control measures is required to provide worker protection. Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use. Ongoing monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commitment of both workers and management to occupational health are also important ingredients of a complete, effective, and durable control program.

These principles of control apply to all situations but their optimal application varies from case to case. A discussion of the probable exposure sources as well as the application of the above principles are discussed in the following sections for each processing area.

Transfer room: Visible aerosol escaped from the freshly washed eggs, from the conveyor entrance and exit to the washer. Since the wash water is contaminated by broken eggs and is recirculated for the five-hour production run, this mist may be an important source of exposure to egg protein. The breaking room is maintained under positive pressure. Therefore, any mist generated during egg breaking escapes through the transfer/breaking windows into the transfer room. The control strategy addresses the two major aerosol sources (the washer and the transfer window) and the lack of fresh air supply to the area.

Although the halogen (chloride or iodide) ions in the egg washing area do not appear to be the cause of the asthmatic symptoms, the ventilation system from the washing machines could be connected directly to a roof mounted fan. This would provide more positive removal of the decontamination mist.

Ideally, all the mist sources in the breaking room could be controlled, thus eliminating the transfer/breaking windows as an exposure source for the workers in the transfer room. Because of the difficulty involved in accomplishing complete control in the breaking room, exhaust hoods should be placed directly above the transfer/breaking windows to contain the air leaving the breaking room.

To prevent localized cold/hot spots, and to avoid drafts, the air exhausted from the transfer room should be replaced with clean, tempered air. This make-up air should be distributed within the transfer room. To receive the maximum benefit from this clean air, it should be introduced directly above the candler and loader work stations in the form of a low velocity air shower.

Breaking room: The control strategy for the breaking room has three elements: minimizing the generation of egg-containing aerosol, containing the escape of the generated aerosol, and diluting any aerosol that may escape.

The egg breaking machines utilize compressed air to remove egg shells and/or yolk. Pressure gauges should be installed on each machine and the pressure reduced to the minimum necessary to accomplish the task of shell and/or yolk removal. Venturi type nozzles are available which use a small quantity of compressed air to induce motion of the ambient air. This type of nozzle operates at much lower pressures resulting in more air movement at lower air velocity, thereby reducing the probability of atomization, and lowering noise levels.

The egg breaking machine should be enclosed as much as possible. Local exhaust ventilation in the breaking room should be provided to contain the mist generated by the egg breaking machines. Exhaust hoods should be installed over the transfer room windows.

To receive the maximum benefit from the clean makeup air, it should be introduced directly above the breaking machine operators.

B. Medical

Every worker with asthma related to workplace exposure to egg proteins should be offered a work assignment that will minimize inhalational egg exposure. Each worker should be assessed by a physician conversant in the management of the asthmatic patient, and receive optimal therapy for treatment of asthma.

Each worker who develops episodic wheezing, shortness of breath, and/or chest tightness, or other symptoms compatible with asthma, should be evaluated for workplace-related asthma. The diagnosis requires a compatible history, with documentation of reversible episodic airways obstruction. If occupational asthma is diagnosed, then the preceding recommendation would apply.

Persons in whom IgE-mediated hypersensitivity reactions have been documented should not receive immunizations with vaccines grown in eggs. The vaccine most likely to be offered to an adult is the influenza vaccine. Yellow fever vaccine is also manufactured in eggs, and would be contraindicated.

X. REFERENCES

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XI. ACKNOWLEDGMENTS

Originating Office:	Medical Section, Hazard Evaluation and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations, and Field Studies
Report prepared by:	Alexander Blair Smith, M.D., M.S. Mary A. Newman, Ph.D.
Field Survey Team:	
Coordinator:	Matthew A. London, I.H.
Physical examinations:	Susan Gelletly, M.D.
Skin tests:	Gregory A. Ornella, M.D.
Peak flow rate determinations:	Thomas Sinks, Ph.D.
Spirometry:	Jim Collins
Phlebotomy:	Marian Coleman
Laboratory Services:	David I. Bernstein, M.D. Joan S. Gallagher, Ph.D. Division of Immunology, University of Cincinnati College of Medicine
	Mark C. Swanson Mayo Clinic
Industrial hygiene:	Ken Wallingford, C.I.H.
Referrals for further medical evaluation:	Charles E. Reed, M.D. Mayo Clinic, Rochester, MN
Report Typed by:	Toni Frey

XII. Distribution and availability of report

Copies of this 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 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Estherville Foods, Inc., Estherville, Iowa
2. NIOSH, Region VIII
3. OSHA, Region VII
4. Grading Branch, Poultry Division AMS, U.S. Department of Agriculture, Washington, D.C.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calandar days.

Table 1

Area Chloride Ion Sampling Results

Esthervile Foods
Estherville, Iowa
HETA 86-447

April 1, 1987

Sample Description				
Area	Job Description/Location	Time	Volume (m^3)	Chloride Ion Concentration (mg/m^3)
Transfer room	Candling area - line no.3	0756-1450	0.81	0.013
Transfer room	Traying area - line no. 1	0751-1447	0.81	0.011
Breaking room	Breaking machine - line no. 3	0801-1454	0.79	0.013

Analytical Limit of Quantitation: 0.0076mg/sample (approximately 0.0095 mg/m^3)
Limit of Detection: 0.002 mg/sample (approximately 0.0025 mg/m^3)

Table 2

Area Acid Gases Sampling Results

Estherville Foods
Estherville, Iowa
HETA 86-447

March 31, 1987

Sample Description				Acid Gas Concentration (mg/m^3)	
Area	Job Description/Location	Time	Volume (m^3)	Hydrochloric Acid	Sulfuric Acid
Transfer area	Candling area - line no. 4	0817-1431*	0.058	ND	ND
Transfer area	Traying area - line no. 1	0814-1429*	0.057	0.060	ND
OSHA**				7.0 (ceiling)	1.0 TWA

Analytical Limit of Detection: for hydrochloric acid 0.0006 mg/sample (approximately 0.01 mg/m^3)
for sulfuric acid 0.004 mg/sample (approximately 0.07 mg/m^3)

= Non-Detectable Concentration
= Sampling discontinued during cleanup
= Evaluation criteria is the Occupational Safety and Health Administration (OSHA) permissible exposure limit as a ceiling or time-weighted average (TWA) concentration.

Table 3

Personal and Area Protein Sample Results

Estherville Foods
Estherville, Iowa
HETA 86-447

March 31-April 1, 1987

Sample Description					
Area	Job Description/Location	Type	Time	Volume (m^3)	Protein Concentration (mg/m^3)**
Egg warehouse	On readout at weighing station	A	0800-1432	0.90	0.25
Flat washing area	Flat washer operator	P	0712-1420*	0.87	0.23
Shell house	Shell house operator	P	0730-1142	0.58	0.62
Transfer room	Candler - line no. 8	P	0732-1436*	0.83	0.39
Transfer room	Trayer - line no. 5	P	0740-1435*	0.78	0.44
Transfer room	Trayer - line no. 4	P	0743-1416*	0.74	0.60
Transfer room	Candler - line no. 7	P	0717-1423*	0.80	0.63
Transfer room	Candler - line nos. 1 and 2	P	0722-1512*	0.92	1.2
Transfer room	Trayer - line no. 1	P	0721-1513*	0.92	0.73
Breaking room	Relief breaker - all lines	P	0748-1422	0.75	0.70
Breaking room	Breaker - trainee	P	0755-1424*	0.67	0.69
Breaking room	Breaker - line no. 4	P	0737-1518*	0.90	0.93
Breaking room	Breaker - line no. 8	P	0735-1418*	0.76	0.52

Analytical Limit of Quantitation: 0.10 mg/sample (approximately 0.10 mg/m^3)

P = Personal Sample
A = Area Sample
* = Sampling discontinued during lunch break
** = Total aerosol mass fraction

Table 4

Bulk Sample Protein Results

Estherville Foods
Estherville, Iowa

HETA 86-446

April 1, 1987

Sample Description	Protein Concentration
Clean sanitizer water from transfer area	0.27 mg/ml
Dirty sanitizer water from transfer area	5.6 mg/ml

Table 5

Personal Aeroallergen Sampling Results

Estherville Foods
Estherville, Iowa
HETA 86-447

March 31-April 1, 1987

Sample Description				Aeroallergen Concentration (ug/m³)			Total Aerosol Concentration (mg/m³)
Area	Job Description/Location	Time	Volume (m³)	Ovalbumin	Ovomucoid	Lysozyme	
Transfer room	Trayer - line no. 2	0725-1514	0.91	77	92	0.49	1.0
Transfer room	Candler - line no. 6	0729-1418*	0.77	161	38	ND	0.71
Breaking room	Breaker - line no. 5	0751-1421*	0.74	360	243	40	1.3
Analytical Limit of Detection: (approximate)				1.0	1.0	0.03	0.01

ND = Non-Detectable Concentration
* = Sampling discontinued during lunch break

Table 6
Survey-Based Diagnostic Criteria
Derived from Questionnaire Responses, Peak Flow Data,
and Immunologic Tests
Estherville Foods
Estherville, Iowa
HETA 86-447

	Probable Egg Asthma	Possible Egg Asthma	Possible Non-Occup. Asthma	Possible Irritant Symptoms
Work-related symptoms	YES	YES	YES	YES
Symptomatic bronchial lability	YES	NO	YES	NO
One or more positive prick tests or RASTs to egg proteins	YES	YES	NO	NO

Table 7
Numbers of Respondents to Questionnaire,
by Reported Symptoms, and Temporal Relationship of Symptoms to Work
Estherville Foods, Estherville, Iowa, HETA 86-447

	Number	Participated in Follow-up
Work-related symptoms		
W, SOB, and CT	15	15
W and SOB	1	1
W and CT	0	0
W only	4	4
SOB and CT	1	1
Sub-total (invited to participate in follow-up)	21	21
SOB only	3	0
CT only	3	0
Sub-total (excluded from follow-up)	6	0
Symptoms not work-related		
W, SOB, and CT	2	0
W and SOB	1	0
W and CT	1	0
W only	6	0
SOB and CT	0	0
SOB only	1	0
CT only	4	0
Sub-total (excluded from follow-up)	15	0
Non-symptomatic		
Invited for follow-up	22	20
Excluded from follow-up	28	
Sub-total	50	

W = Wheezing
SOB = Shortness of breath
CT = Chest tightness

TABLE 8

Estherville Foods
Estherville, Iowa

HETA 86-447

PHYSICIAN DIAGNOSIS	SURVEY-BASED CLASSIFICATION: PROBABLE OCCUP. ASTHMA	POSSIBLE OCCUP. ASTHMA	POSSIBLE NON-OCCUP. ASTHMA	POSSIBLE IRRITANT SYMPTOMS	OTHER INCLUDING NO SX.	TOTAL
POSSIBLE OCCUP. ASTHMA	3	7	3	2	0	15
POSSIBLE NON-OCCUP. ASTHMA	0	0	1	1	0	2
POSSIBLE IRRITANT SYMPTOMS	0	1	0	1	0	2
OTHER INCLUDING NO SX.	0	1	1	0	19	21
TOTAL	3	9	5	4	19	40

KAPPA = 0.641
VAR(K) = 0.006
S.E.(K) = 0.079

Sx = symptoms

TABLE 9
Respondents to Questionnaire, and Numbers of Symptomatic and Asymptomatic Respondents
Estherville Foods
Estherville, Iowa

HETA 86-447

Job	Number of Respondents to Quest.	Number of Asymptomatic Respondents	Number of Asymptomatic Respondents In Follow-up	Number of Respondents with Eligible Sx.*	Number of Respondents with Ineligible Sx.**
Office	4	3	1	1	0
Warehouse	1	1	0	0	0
Candling	12	0	-	8	4
Traying	26	15	3	6	5
Breaking	25	13	7	5	7
Maintenance & Clean-up	17	14	7	1	2
Packing	4	2	1	0	2
Shell house	2	1	0	0	1
Other	1	1	1	0	0
Total	92	50	20	21	21

* Eligible symptoms (Sx) were wheezing, and/or shortness of breath and tightness, temporally related to work.

** Ineligible symptoms were wheezing, shortness of breath, and/or chest tightness, not temporally related to work; or shortness of breath or chest tightness alone, regardless of temporal relationship to work. These respondents were excluded from the follow-up examinations.

Table 10
Asymptomatic Respondents: Estimated Minimum Prevalence of Occupational Asthma

Estherville Foods
Estherville, Iowa

HETA 86-447

	Number of Asymptomatic Respondents In Follow-up	Number of Asymptomatic Respondents with Dual Dx. of OA	Estimated Minimum Prevalence of OA	Number of Atopics*
Office	1	0	0%	0
Warehouse	0	-		-
Candling	-	-		-
Traying	3	0	0%	0
Breaking	7	0	0%	1
Maintenance & Clean-up	7	0	0%	1
Packing	1	0	0%	0
Shell hse.	0	-		-
Other	1	0	0%	0
Total	20	0	0%	2

* Two or more positive skin tests to common airborne allergens

Dx = diagnosis
OA = occupational asthma

TABLE 11
Symptomatic Respondents: Estimated Minimum Prevalence of Occupational Asthma
Estherville Foods
Estherville, Iowa
HETA 86-447

	Number* of Respondents with Eligible Sx.	Number of Respondents with Eligible Sx. with Dual Dx. of OA	Estimated** Minimum Prevalence of OA	Number of Atopics***
Office	1	0	0%	0
Warehouse	0	-	-	-
Candling	8	4	33%	0
Traying	6	4	15%	3
Breaking	5	2	8%	1
Maintenance & Clean-up	1	0	0%	1
Packing	0	-	-	-
Shell house	0	-	-	-
Other	0	-	-	-
Total	22	0	10%	5

* All respondents with eligible symptoms participated in the follow-up.

** To the extent that questionnaire respondents with ineligible symptoms for participation in the follow-up actually had occupational asthma, but went undiagnosed because of their exclusion from the follow-up examinations, this estimated prevalence of occupational asthma is an underestimate. This estimate minimizes the size of the numerator (the number of dually diagnosed occupational asthmatics) and maximizes the size of the denominator (the number of questionnaire respondents in each job classification), and thus is a minimum estimate of the prevalence of occupational asthma in each job classification.

*** Two or more positive skin tests to common airborne allergens

Sx = symptoms

Dx = diagnosis

OA = occupational asthma

TABLE 12

Atopy

Estherville Foods
Estherville, Iowa

HETA 86-447

	YES	NO	Total	Odds Ratio*
Dual Diagnosis of OA	3	7	10	4.1
Symptomatic, Not Dual Diagnosis of OA	2	9	11	1.9
Non-symptomatic	2	17	19	
Total	7	33	40	

* The odds ratio is calculated with respect the non-symptomatics.

OA = occupational asthma

FIGURE 1

PEAK EXPIRATORY FLOW RATE
CASE NO. 1, ID 8091

Estherville Foods
Estherville, Iowa

HETA 86-447

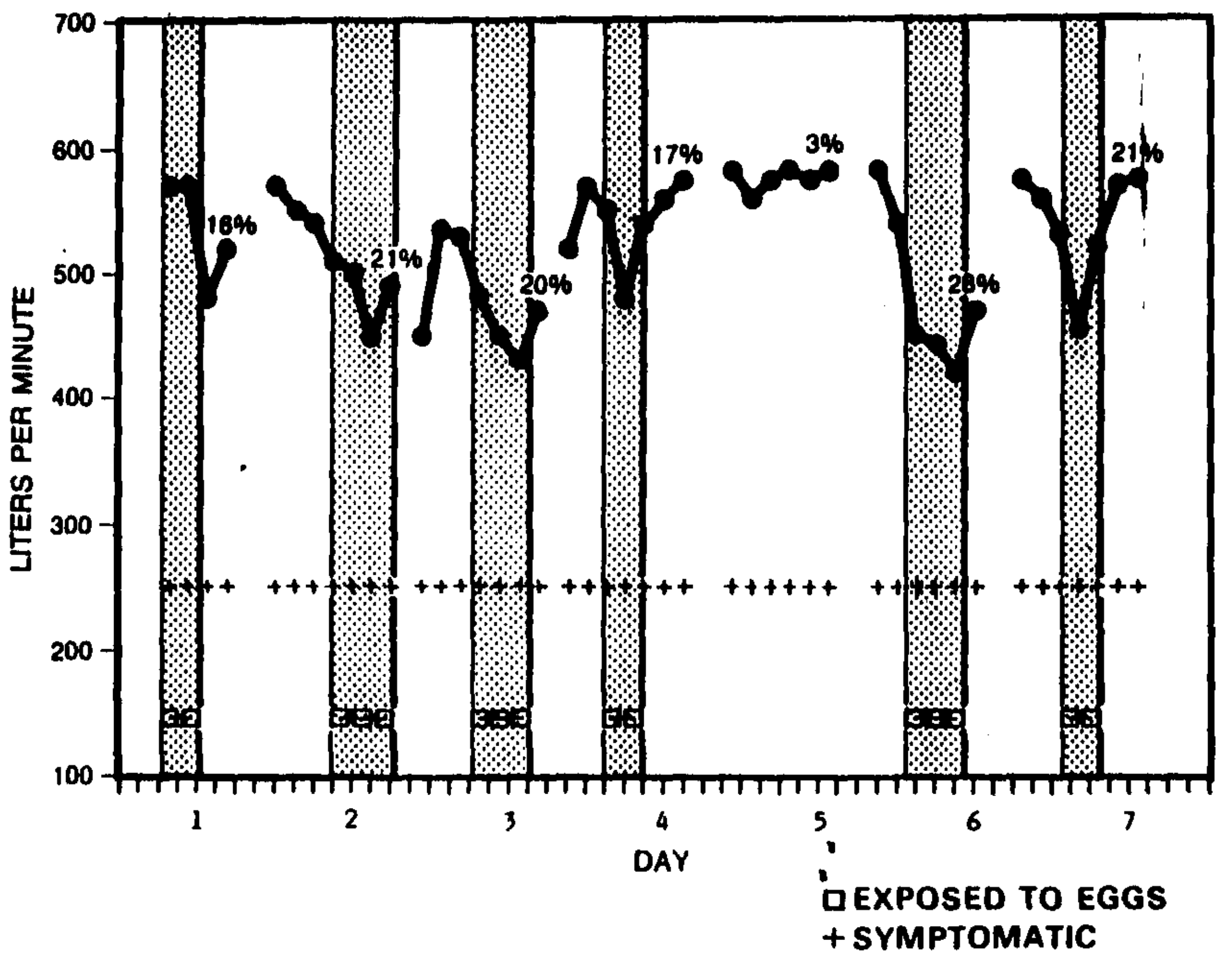

FIGURE 2

PEAK EXPIRATORY FLOW RATE
CASE NO. 2, ID 8115

Estherville Foods
Estherville, Ohio

HETA 86-447

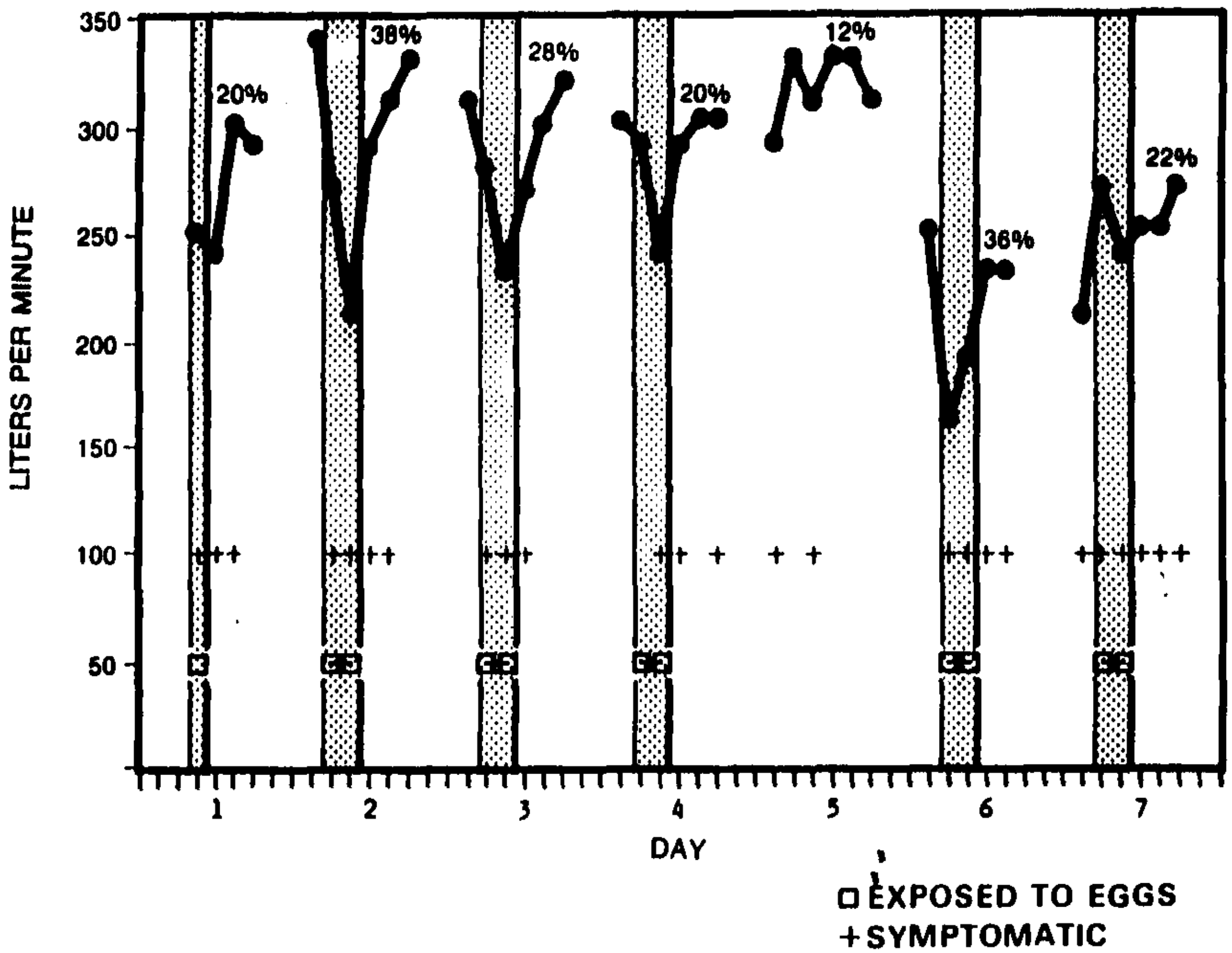

FIGURE 3

PEAK EXPIRATORY FLOW RATE
CASE NO. 3, ID 8038

Estherville Foods
Estherville, Iowa

HETA 86-447