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SUMMARY

On February 1, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at the Gwinnett Medical Center (GMC) in Lawrenceville, Georgia. The request asked NIOSH to determine if workplace exposures are related to health problems reportedly experienced by some GMC employees working in the In–Patient Surgery (IPS) and Day Surgery (DS) departments at this hospital. Health problems described in the request included dermatitis, burning and itching eyes, respiratory irritation, headache, and cough. Potential exposures included construction dust and debris, volatile contaminants from new carpet and paint, disinfectants, common cleaning chemicals, and waste anesthetic gases.

On March 1, 1999, NIOSH investigators conducted an initial site visit at GMC. The purpose of this site visit was to review the current status of the health complaints with GMC personnel, inspect the IPS and DS departments and observe work practices, and assess the ventilation system supporting these two areas. A follow–up site visit was conducted on April 20–21, 1999. During this follow–up site visit, eight area air samples for natural rubber latex (NRL) allergen were collected in the IPS and DS departments. Bulk and surface samples for NRL allergen analysis were obtained from ceiling plenums (ventilation return air pathways) in both departments. Because of concerns regarding latex allergy, GMC had previously implemented a powder–free latex glove policy and cleaned both the DS and IPS departments. In response to cases of clinically confirmed latex allergy in the DS department, the ventilation duct work was also cleaned. No workers in the IPS department were found to be latex–allergic and the ventilation duct work in this area was not cleaned. NRL monitoring was conducted to compare the two areas. At the time of the NIOSH site visits, the health concerns in the DS department were associated with poor indoor environmental quality (IEQ), and monitoring for standard IEQ parameters (temperature, relative humidity [%RH], and carbon dioxide [CO_2]) was conducted in this area.

No NRL allergen was detected on any of the air samples collected from the IPS or DS departments. However, NRL allergen was not detected on two quality control sample filters spiked with known concentrations of NRL. Therefore, a meaningful comparison of airborne NRL allergen between the DS and IPS cannot be made from these results. Regulatory standards for acceptable levels of NRL allergen in air have not been established.

The bulk and surface dust samples indicated the presence, at various concentrations, of NRL allergen in the return air (RA) plenums from the IPS and DS departments. NRL allergen in bulk samples from the RA plenum in IPS ranged from 21,070 nanograms per gram sample (ng/gm) to 52,800 ng/gm. The two samples from the RA plenum in DS contained 21,067 ng/gm and 39,301 ng/gm of NRL allergen. Regulatory criteria for NRL allergen in surface or dust samples has not been established, although guidelines have been suggested (Mayo Clinic) for bulk dust

samples. The suggested recommendations for bulk dust are: Low, < 10,000 ng/gm; Low–Moderate, 10,000–100,000 ng/gm; High, >100,000 ng/gm. Although only limited samples were collected, there did not appear to be any appreciable difference in NRL concentrations in dust between the DS and IPS departments. The temperature, RH, and CO_2 monitoring found all measured parameters to be within acceptable ranges.

Inspection of the air handling units (AHUs) providing ventilation to the IPS and DS departments found the units to be clean and well–maintained. The units are equipped with efficient filtration that should effectively prevent most dust particles from entering the supply side of the air handlers. As such, dispersion of latex containing particles from supply ducts into occupied areas is unlikely. However, because a reservoir of NRL was identified in the plenum spaces, episodic dispersion of latex–containing particles is a possibility, and actions should be implemented (e.g., proper work practices, particularly during maintenance activities) to control the potential release of NRL–containing dust into occupied areas. Humidification of supply air to the operating rooms is accomplished by direct injection of boiler steam, and there is the potential for introducing boiler water treatment chemicals into the system, and subsequently into the work environment.

No obvious environmental explanations for the reported symptoms and complaints were identified. Although some improvements are warranted, the ventilation system supporting both the DS and IPS departments was clean and operating properly. Some employees may have experienced latex–related problems; however significant steps have been taken by GMC to reduce the potential for exposure to latex and this probably does not account for most of the currently reported health complaints. Recommendations to address employee health concerns include eliminating the use of boiler steam for humidification, ensuring accurate diagnosis of latex allergy, improving the ventilation provided to the X–Ray room, and ensuring precautions are taken to prevent latex allergen–containing dust from entering occupied areas.

Keywords: SIC 8062 (General Medical and Surgical Hospitals), natural rubber latex, latex allergy, indoor environmental quality, IAQ, dermatitis, respiratory irritation.

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INTRODUCTION

The National Institute for Occupational Safety and Helath (NIOSH) received a management request from the Gwinnett Medical Center (GMC) on February 1, 1999, to evaluate health complaints among some employees who work in the In–Patient Surgery (IPS) and Day Surgery (DS) departments. Health complaints in IPS included dermatitis, hives, burning and itching eyes, respiratory irritation, headache, and cough. Health complaints in the DS department were non–specific in nature and associated with general indoor environmental quality (IEQ). Specific complaints in DS included transient eye irritation, stuffy nose, and headaches. Potential exposures included natural rubber latex (NRL) allergen, construction dust and debris, volatile contaminants from new carpet and paint, disinfectants, and common cleaning chemicals. Prior to the NIOSH site visit, GMC had instituted a number of measures to address the health complaints, including implementing a powder–free latex glove policy, conducting a thorough cleaning of the DS and IPS departments, and cleaning the ductwork in the DS department.

An initial site visit to GMC was conducted on March 1, 1999, to review work practices in the areas of concern, inspect the ventilation system, and develop an environmental evaluation strategy. On April 20–21, 1999, a follow–up site visit was conducted to monitor for NRL allergen in both the DS and IPS and for standard IEQ parameters (temperature, relative humidity [RH], and carbon dioxide [CO_2]) in the DS department. An interim report with findings and recommendations from the initial site visit was issued on March 21, 1999.

BACKGROUND

Facility

The GMC in Lawrenceville, Georgia, was established in 1984 and is a full–service hospital employing approximately 2500 workers. The hospital provides comprehensive in–patient services, including surgical and obstetrical care to the community. In November 1996, construction began to remodel existing areas and provide additional patient and emergency care facilities. At the time of the NIOSH site visits, the construction was essentially complete, with some final work being conducted in a few areas.

The IPS department is located on the second floor of the main building and employs approximately 70 workers across all shifts. The area is serviced by air handling units (AHUs) located on the third floor mechanical room. This department contains operating rooms (OR), a minor procedures (MP) section, recovery (PACU) area, an intensive care unit (ICU), and various work areas, administrative stations, and waiting rooms. The MP area was being relocated and was not in operation at the time of the NIOSH survey.

The DS department is located on the first floor of an attached building and employs approximately 100 workers. The DS department operates from 6:00 a.m. to 7:00 p.m. In addition to patient waiting and administrative areas, the DS contains ORs, staff lounges, recovery and post–recovery areas, and nurses' stations. The AHUs servicing this area are located on the roof of the building housing the DS department.

Health Complaints at GMC

Employee complaints of dermatitis, itching, flushing, and respiratory irritation in the IPS and DS departments were reported in the Summer–Fall of 1997. Most of the complaints were among the health care worker staff; one member of the housekeeping department had previously reported problems but is now working in a different area of the hospital and was reportedly not experiencing any problems. Because of the proximity of a major facility expansion, some of the employees attributed their symptoms to the ongoing construction. A number of attempts to identify and resolve the health complaints were initiated by GMC, and medical evaluations of affected personnel, including tests

(radioallergosorbent [RAST]) for NRL allergy, were conducted. In both areas, affected individuals reported they did not experience any symptoms when away from work. Monitoring for waste anesthetic agents has been conducted by GMC and this exposure was reportedly found to be well controlled.

In response to at least four reported cases of latex allergy in DS, GMC prohibited the use of powdered latex gloves in the DS department beginning in August 1998. The use of powder–free latex gloves was subsequently implemented hospital–wide in October 1998. Non–latex gloves are also available for use if preferred by the health care provider.

In IPS, the areas associated with the health complaints were the OR Station, PACU, and the Pre–OP areas. No complaints were recorded from the ICU. Although 5 workers in the IPS department were among those reporting health symptoms they attributed to an allergic reaction, no cases of latex allergy were reported. After the use of powdered latex gloves was eliminated, the areas were thoroughly cleaned. Because of the previous finding of latex allergy in the DS department, the ventilation ducts supporting this area were cleaned. The ventilation ducts in the IPS department were not cleaned.

In the DS department, the reported health complaints included headaches, stuffy nose, and watery eyes. Odors from construction activities (e.g., asphalt paving project) have been detected in DS. No further cases of latex allergy been reported since the August 1998 ban on powdered latex gloves.

METHODS

On March 1, 1999, after meeting with GMC management and employee representatives from the Safety and Health Department, Engineering, DS, and IPS, a limited walk–through inspection of the IPS and DS departments was conducted. During this inspection informal discussions were held with employees regarding potential contaminants that may be present in their work areas. The status of construction activities, materials in use in each department, and glove use practices in each area were reviewed. The heating, ventilation, and air–conditioning (HVAC) system supporting the IPS and DS departments was inspected. No environmental monitoring was conducted during this site visit.

On April 20–21, 1999, a follow–up site visit to monitor environmental levels of NRL allergen in the DS and IPS departments was conducted. During this site visit, area air samples for NRL were collected at various work stations. Additionally, surface and bulk samples of dust were collected to assess NRL in the return air pathways (ceiling plenums) of the ventilation systems serving the areas evaluated. In DS, monitoring for standard indoor environmental quality parameters (temperature, %RH, and CO_2) was also conducted. Specific sampling and analytical methodology for this monitoring was as follows:

Natural Rubber Latex (NRL)

Environmental monitoring was conducted to measure airborne and surface dust (from the back surfaces of ceiling tiles and return air grilles) concentrations of NRL proteins at GMC. Bulk samples of loose dust from the back surfaces of ceiling tile (adjacent the area where a surface sample was collected) were also obtained. All samples were sent to the Mayo Clinic, Rochester, Minnesota, for analysis by an inhibition assay technique using IgE antibodies from latex sensitive individuals.[1]

Air Sampling

To evaluate airborne concentrations of NRL proteins, full–shift (approximately 8 hours) area air samples were collected in the IPS department on April 20, 1999, and in the DS department on April 21, 1999. The air samples for NRL aerosol were collected using bilaminate filters (glass fiber and polytetrafluoroethylene [PTFE] membrane filters) provided by the Mayo clinic. Monitoring was

conducted with high–volume air samplers to maximize sample volume. All pumps and sampling trains were calibrated to verify flow rate and ensure accurate collection volumes were determined. One sampling pump provided by the Mayo clinic used a filter that was approximately 100 square centimeter (cm^2) which was mounted in the pump under an air inlet cover that was circular in shape and sieved to provide for uniform distribution of airflow over the filter face.

To calibrate the Mayo Clinic sampler, airflow rate was measured (with new filters in–line) using a recently factory–calibrated TSI VelociCalc® Model 8360 thermoanemometer. The 8360 was first programmed to measure air flow in units of liters per second. To calibrate the sampler, a 61 centimeter (cm) length of round schedule 40 PVC duct pipe 3" (7.6 cm) in diameter was connected to a flange on top of the sampler using a standard circular PVC connector sleeve. The pipe was attached to the sampler only temporarily for use as an extended intake plenum so that an accurate airflow measurement could be obtained. Airflow was measured at two 1.3 cm ports placed 90 degrees apart in the plenum. To minimize turbulence effect in the duct, the ports were located 2.5 duct diameters from the end of the plenum and 5.5 duct diameters from the filter. The tip of the VelociCalc® was inserted in each port and five flow measurements were made across the diameter of the plenum. The ten flow measurements were averaged to determine the nominal flow rate of the sampler in liters per second.

The other air samples were collected using filters mounted in standard 37 millimeter (mm) 3–piece polystyrene cassettes and secured using cassette sealing bands (SKC, Inc.). The filter cassette was connected to the sampling pump via tygon® tubing; all samples were collected with the cassette cover removed (open–face sampling). A Gilian Gilibrator® with a 30 liter volumetric cell was used to measure pre– and post–monitoring flow rates on these pumps. The Gilibrator® is an electronic bubble flow meter that provides instantaneous air flow readings and a cumulative average of multiple readings. The time interval necessary for a soap bubble, stretched across a cell, to travel a known volume is calculated to determine the flow rate. The system is considered a primary standard airflow measurement device as all values are absolute; a known and fixed volume divided by time provides the airflow. To calibrate, the open–face cassette was mounted inside a 1–gallon jar with a modified cover equipped with sampling ports. The ports were connected via tubing to the sampling pump (outlet) and Gilibrator® (inlet). The total air volume sampled is the product of the flow rate and the sampling time.

After collection, the samples were shipped to the Mayo Clinic for analysis. As a quality control measure, four field blanks and six spiked samples (containing known quantities of latex allergen) were included with the sample shipment to the analytical laboratory. The spike samples were prepared by sequential dilution with a phosphate buffer solution using stock non–ammoniated latex protein (Greer Labs, Lenoir, North Carolina). The inlet cap of the sampling cassette was removed and the prepared latex allergen was added through the inlet and then the cassette was re–capped. The field blanks and spiked samples were submitted blind to the laboratory.

Surface and Bulk Sampling

The surface dust samples were collected from the backs of ceiling tile adjacent from the return air grille (the area above the false ceiling functions as a return air plenum), or in ORs with a ducted return air system, from the inside of the return air duct. The samples were collected using the American Society for Testing and Materials (ASTM) micro–vacuuming method D 5755–95 with several modifications.[2] The area to be sampled was masked using 100 cm^2 disposable clear plastic masking templates to demarcate an area on the back of a ceiling tile. Dust was collected using 37–mm sampling cassettes connected in line with Tygon® tubing to a high–volume sampling pump operating at approximately 28.3 liters per minute (L/min). A 1.5 inch piece of Tygon tubing cut to a 45° angle was

connected to the face of the cassette to act as a nozzle. Surface dust was collected by micro vacuuming within the area of the masking template up, then down, then back and forth, for a period of two minutes, or as the method states, until no visible dust remains on the surface of the sampling area. After the surface dust sample was collected, the cassette was inverted and the pump was shut off. The nozzle was capped with a plug, and the sampler was packaged to prevent separation of the nozzle from the cassette and sealed upright in a plastic bag.

The bulk samples were collected from above the false ceiling in the return air plenum adjacent the area where the surface sample was obtained. Loose dust was placed in labeled, wide–top polyethylene containers and sealed. The bulk samples were shipped to the analytical laboratory separately from the air samples.

Carbon Dioxide (CO_2) Monitoring

Instantaneous measurements of CO_2 concentrations in the DS department were obtained using a Gastech Model RI–411A portable (direct reading) CO_2 monitor. The principle of detection is non–dispersive infrared absorption. The instrument was zeroed (zero CO_2 gas source) and calibrated prior to use with a known CO_2 source (span gas). The monitor provides CO_2 concentrations in 25 parts per million (ppm) increments with a range of 0–4975 ppm. Measurements were obtained at various intervals and locations in the art rooms and adjacent hallways. Outdoor readings were taken to determine baseline CO_2 levels.

Temperature and Relative Humidity (RH)

Dry bulb temperature and RH levels were measured at the same times and locations as the CO_2 readings. Instrumentation consisted of a factory–calibrated TSI, Inc. model 8360 VelociCalc® meter with a digital readout. This unit is battery operated and has humidity and temperature sensors on an extendable probe. The temperature range of the meter is 14 to 140° F and the humidity range is 20 – 95%.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 even though 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 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),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] NIOSH encourages employers to follow the OSHA

limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. Employers are legally required to meet 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 (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term.

Latex Allergy

NRL contains a number of different proteins that can induce an allergic reaction. A wide variety of products contain latex, and routes of exposure can include dermal, mucosal, parenteral, and inhalation. There are three types of reactions that can occur from the use of latex products:[6]

- **Irritant contact dermatitis:** the most common reaction, which typically results in dry, itchy, and irritated skin, often on the hands.

- **Allergic contact dermatitis:** which results from exposure to chemicals added to latex during production. Skin reactions are similar to those caused by poison ivy, and usually manifest 1–2 days after contact.

- **Latex allergy:** also called an immediate hypersensitivity, a result of exposure to certain proteins in the latex. Once a person is sensitized (from repeated exposure), reactions generally occur within a short period after exposure.

The symptoms associated with latex allergy can vary in type and severity. Rhinoconjunctivitis (nasal congestion and red, itchy eyes), urticaria (hives), asthma, and anaphylactic shock (a severe allergic reaction) have also occurred as a result of latex–related allergic reactions.[7,8,9,10] One prevalence study found 7.4% of physicians and 5.6% of nurses working in operating rooms to have rubber contact urticaria.[11] Another study where 224 medical center employees were skin tested with extracts of four different latex gloves and one synthetic glove found positive reactions to the latex extracts in 17% of the test subjects, while there were no reactions to the non–latex glove extract.[12] Time periods between exposure to latex allergens and onset of symptoms have been reported to range from 6 months to 5 years.[9]

Latex is not a pure chemical, but a complex mixture. Latex gloves contain approximately 2–3% protein.[11] Gloves from different manufacturers vary widely in their ability to elicit allergic reactions. One study found that the rate of positive responses to skin prick tests (SPTs) using latex gloves from 19 different manufacturers ranged from 8% to 100% among those tested.[11]

A number of studies have shown that latex allergen becomes airborne, primarily when powdered latex gloves are used.[13,14,15] There is evidence that the cornstarch powder used with latex gloves will bind with allergenic proteins in the latex.[6,13] The resultant airborne particles can present a significant hazard to latex sensitive persons, and mucosal exposures may be more apt to result in anaphylactic reactions.[11] One study showed that when a latex–sensitive laboratory technician's coworkers switched to powder–free latex gloves, her symptoms resolved.[14]

Protection for latex–sensitive workers can be accomplished by substituting synthetic (e.g., vinyl) gloves, or when such gloves alone would not be adequately protective, wearing synthetic gloves underneath the latex gloves. Providing a latex–free environment, identification of high–latex use areas, and providing latex allergy assessments for employees should also be part of a health and safety plan for responding to this issue. In some cases, it may be necessary for workers to move to other areas or assume different job duties. The NIOSH Alert*: Preventing Allergic Reactions to Natural Rubber*

Latex in the Workplace was provided at the opening conference during this project and should be referenced for additional information on latex allergy.[6]

Because of the wide range in dose response for allergens in general, it is difficult to determine a safe threshold concentration below which sensitized individuals would not experience reactions, or to prevent unsensitized individuals from developing allergic sensitization. The concentration of airborne NRL allergens which can cause sensitization or elicit allergic symptoms is unknown.[16]

Neither NIOSH, OSHA, or ACGIH have established numerical exposure limits for latex exposures. Some individual studies, however, have suggested some exposure criteria. One researcher suggests an estimate of airborne concentrations of total latex protein less than 10 nanograms per cubic meter (ng/m^3) poses a "low" risk for latex sensitization.[17] Another researcher from Germany reported that within a range of airborne latex concentrations from 0.6 to 205 ng/m^3, a concentration of 0.6 ng/m^3 of latex appeared to be the lowest threshold likely to induce rhinitis, conjunctivitis, dyspnea, and in some cases, the presence of latex specific antibodies.[16] Although the majority of airborne latex concentrations in that study appeared to lie in a range of 5 to 15 ng/m^3 and those concentrations were reported to be measured in rooms without ventilation systems. A recent NIOSH study found that the geometric mean concentration of NRL in clinical areas (emergency department, labor and delivery, and several laboratories) of one hospital was 0.52 ng/m^3 (the samples were in a range of not–detected to 3.3 ng/m^3). In the non–clincal areas of the hospital the geometric mean NRL concentration was 0.10 ng/m^3 (range was not detected to 0.26 ng/m^3)[18]

Regulatory criteria for NRL allergen in surface or dust samples has not been established, although guidelines have been suggested (Mayo Clinic) for bulk dust samples. The suggested recommendations for bulk dust are: Low , <10,000 nanograms per gram (ng/gm); Low–Moderate, 10,000 – 100,000 ng/gm; High, >100,000 ng/gm.

Well developed protocols and standardized analytical methods for collecting and quantifying NRL allergen in air samples have not been established. Parameters such as air sampling technique, collection efficiency, sample recovery, precision, analytical sensitivity, and specificity may differ among methods or may not be well characterized. As such the comparability of data from one study to another may not be valid, and any limitations of the sampling and analytical method must be considered when interpreting the results.

Standards defining "acceptable" levels of surface contamination have not been established. However, surface and bulk samples can provide information regarding the effectiveness of housekeeping practices, the potential for exposure to contaminants from other exposure routes (e.g., surface contamination on a table that is also used for food consumption), the potential for contamination of worker clothing and subsequent transport of the contaminant, and the potential for non–process related activities to generate airborne contaminants (e.g. maintenance activities).

Indoor Environmental Quality (IEQ)

Most scientists investigating indoor environmental problems believe that there are multiple factors contributing to building occupants' complaints.[19,20] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[19,20,21] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts are beneficial.[22] However, in some studies rates lower than these amounts appear to be associated with increased rates of complaints and symptoms.[23] Design,

maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. As demonstrated by the reports of odors from outdoor construction activities or testing the emergency generator, indoor environmental pollutants can arise from either indoor or outdoor sources.

Problems that NIOSH investigators have found in the non–industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, office machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and RH conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job–related psychosocial stressors. In most cases, however, no environmental cause of the reported health effects could be determined.

Measurement of indoor environmental contaminants in non–industrial settings has rarely proved to be helpful in determining the cause of symptoms and complaints, except where there is an identifiable source, or a dose–related association between a contaminant and a building–related illness. However, measuring ventilation and comfort indicators such as CO_2, temperature, and RH is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

Additional information on IEQ can be obtained from the NIOSH/Environmental Protection Agency (EPA) documents provided at the opening conference.[27]

RESULTS

In–Patient Surgery (IPS)

The IPS was clean and orderly. The MP area was being renovated and had been relocated at the time of the NIOSH site visit. The MP and OR areas were not inspected during this visit. A review of activities in the IPS indicated that there had been no changes in janitorial practices, laundry service, soaps (Acute–Kare®) or cleaners, glove manufacturer, equipment, or pest control practices in the last several years. Glutaraldehyde use is primarily restricted to Endoscopy and is not used in areas where health complaints have been reported. There is a limited amount of 10% formalin that is used under very controlled conditions (restricted to a specific area). A quarternary ammonium–based disinfectant (Virex®) has been in use hospital–wide since 1991 and is used by hospital staff to wipe down surfaces, including floors (daily) and gurneys. Because of concern that the disinfectant may be contributing to some of the health complaints, a procedural change to eliminate the spray application of Virex® was implemented. The use of cloth surgical masks was also implemented in an effort to resolve complaints of facial irritation. Several brands of both latex and non–latex surgical gloves were available in the supply storage room. All gloves were powder–free.

In the X–Ray developing room, a louvered vent (it was not determined if this was a room exhaust or a return air vent) had been blocked. Smoke tests to evaluate air flow indicated the X–Ray developing room was positive with respect to the OR hallway (air flow direction was from the X–Ray room into the hallway).

Informal discussions with several workers in IPS indicated that some are still experiencing problems with itching, rash, and flushing, primarily on the face, neck, and arms, with a sudden onset. Personnel interviewed indicated that the problems resolve when they are away from the hospital. Some of the workers have sought medical treatment and are using an antihistamine on a routine basis. All are using either powder–free or latex–free gloves.

Day Surgery (DS)

DS is located on the first floor of an adjacent building and appears to have different concerns than

IPS. According to GMC representatives, since the use of powdered latex gloves was eliminated and the area cleaned in August 1998, there have been no new cases of latex allergy reported, and the number of general complaints has also decreased.

Housekeeping in the Recovery and Post–Recovery departments was, with one exception, good. Because of a lack of storage space, janitorial supplies, including open mop buckets of the Virex® solution, were placed in an open area near the Recovery room. The OR was not inspected during this site visit. Occasional odors are experienced in the DS (e.g., when the emergency diesel generator is tested).

Heating, Ventilation, and Air–Conditioning (HVAC)

The IPS is serviced by AHU #5 (PACU, Pre–Op, OR [rooms 3, 4, 5, 6], ICU) and AHU #4 (MP, OR [rooms 1, 2, 7]). These are single duct, variable–air–volume (VAV) systems equipped with reheat units near the terminal VAV boxes for each thermostat zone. The AHU supplies air at a constant temperature (to maintain a discharge air temperature of 48°F) through the duct system to the VAV boxes located in the ceiling plenum. Hot water is used for the AHU heating coils and VAV reheat units. Chilled water is used for cooling. Return air (RA) is obtained through ceiling mounted louvers and is conveyed back to the AHU via a common RA plenum (the space above the false ceiling). The AHUs operate continuously and are equipped with economizers designed to allow more outside air (OA) into the system if outside conditions are favorable. The OA dampers will modulate to allow additional OA if the outside temperature is less than 57°F. GMC Engineering representatives indicated that the OA dampers have a minimum stop set at 20% OA. OA is obtained from louvers located on the 3rd floor mezzanine. A series of exhaust vent stacks from a hospital laboratory are located approximately 75 feet from the OA intakes. No other sources of potential contaminants were noted. The majority of the AHU's that support the rest of the hospital are located on this mezzanine. Each AHU is equipped with a prefilter, bag filter, and 95% efficiency terminal filters (Vari–cel®) that are treated by the manufacturer with an antimicrobial agent (Intersept®).

Direct injection of boiler steam ("live" steam) for humidification is utilized for humidity control in the operating rooms. A humidistat controls the steam injection, which occurs downstream of the VAV boxes. Humidification only occurs during the heating season. Potassium hydroxide and diethanolamine are used as sludge and corrosion inhibitor chemicals in the boiler. A metering system is used for systematic injection of these chemicals into the boiler water.

The IPS operating room is designed to operate under positive pressure, with the direction of air from the OR into the PACU and hallways. HVAC design calls for a range of 6–12 air changes per hour (ac/h) in IPS. The design temperature and RH in IPS is 68–72°F and 50% RH.

A limited visual inspection of AHU #5 found the unit to be in good condition. The mixing chamber (RA and OA) was clean; the OA damper was in the minimum open position as outside temperatures were greater than 57°F. The condensate drain pan was free of standing water, which was expected as it was not the cooling season. As such, drainage efficacy could not be assessed. The bottom of the drain pan was potentially deteriorating – rust or flaking of the pan was observed. An inspection schedule for the humidifiers to ensure proper function has not been established.

The DS area is supported by rooftop constant volume AHUs (AHU #1, Pre–Op, AHU #3, and Recovery and Post–Recovery) that utilize fluorocarbon cooling systems and thermostat controlled electric reheat. OA is obtained at the AHU, each of which is equipped with an economizer. GMC Engineering indicated the minimum OA damper setting is 20%. The units have prefilters installed in the AHU, and terminal 95% efficiency bag filters (also treated by the manufacturer with Intersept®). As with the IPS, the

operating rooms in the DS department are equipped with humidifiers that utilize boiler steam. Air is returned to the AHUs via a common plenum (area above the false ceiling).

In August 1998, duct cleaning to remove accumulated dirt and debris in the AHUs and associated duct work was conducted on AHUs supporting the DS. The cleaning included all surfaces within the HVAC systems such as turning vanes, dampers, coils, and fans. The cleaning included the use of high pressure air to dislodge residue and the use of a high efficiency particulate air (HEPA) filtered vacuum system, as well as manual cleaning of grills and registers. The contract specified that the work should meet the requirements of the National Air Duct Cleaners Association (NADCA).

Inspection of AHU #3 indicated the system was clean and operating properly. The condensate pan was dry and the filters appeared clean.

The supply duct work inspected in all areas appeared clean. The HVAC filtering efficiency and maintenance schedule are such that extensive particulate contamination of the supply duct is unlikely. There was no evidence of filter bypass in the AHUs inspected. No signs of moisture damage, mold growth, or water incursion were observed in the IPS or DS areas during the walkthrough inspection.

Natural Rubber Latex (NRL) Sampling

Activity in both the IPS and DS departments was considered normal on the days of the monitoring. All operating rooms were in use during the sampling except when being cleaned and prepared for the next patient.

Air Sampling

The results of the air sampling conducted for NRL allergen are shown in Tables 1 and 2. As noted, no NRL was detected on any of the air samples, at a laboratory reported limit of detection (LOD) of 20 nanograms per sample (ng/sample). The less–than values were calculated using the reported LOD and the air volume collected for that sample.

No NRL was detected by the laboratory on any of the blank or spiked samples (LOD = 20 ng/sample). Two of the blinded spiked samples contained 50 nanograms (ng) of NRL allergen (2.5 X the reported LOD). The analytical laboratory did not detect any NRL allergen on these samples. Two spiked samples contained 5 ng of latex protein, and two contained the phosphate buffer solution (used as the diluent in the preparation of the spike samples), but no NRL allergen. After informing the analytical laboratory, the spiked samples were re–analyzed; no NRL allergen was detected on the re–analysis. However, there are potential explanations for the failure to detect NRL allergen on the spiked sample (e.g., sample loss due to hydrophobic nature of the filter, different capabilities for measuring ammoniated vs non–ammoniated latex).

Bulk and Surface Sampling

The results of the bulk and surface sampling are shown in Tables 3 and 4. Latex allergen was detected in all of the samples collected from IPS. In IPS, the bulk samples containing the highest concentration of latex allergen were collected on the top surfaces (plenum side) of ceiling tiles adjacent the RA grille in PACU (52,849 ng/g) and the OR corridor (52,734 ng/g). The concentration detected in the RA plenum in the Pre–Op area contained 21,071 ng/g. As previously noted, surface samples were collected adjacent the area where the bulk samples were collected. The surface sample concentrations ranged from 17 ng/100 square centimeter surface area (ng/100 cm^2) and 562 ng/100 cm^2. The lowest surface concentrations (17 and 61 ng/ 100 cm^2) were from samples collected inside the floor level RA grille in OR # 4 and # 5. There does not appear to be any correlation between the concentration of latex allergen detected in the surface samples and the concentration detected in the corresponding bulk samples

Latex allergen was detected in both bulk samples collected from the RA plenum in DS and two of the three surface samples. The highest concentration detected was 39,301 ng/g from the sample collected in the Pre–Op area. No latex allergen (< 0.2 ng/100 cm^2) was detected on the surface sample collected from the RA grille in OR #3; the highest concentration (152 ng/100 cm^2) of latex allergen was detected in the sample collected from the RA plenum in the Pre–Op area adjacent the Nurses' Station.

Temperature, Relative Humidity (RH), and Carbon Dioxide (CO_2) Monitoring

The results of the temperature, RH, and CO_2 measurements from the DS department are shown in Table 5. The measurements were collected at three different times during the work day (8:00 a.m., 12:30 p.m., and 2:30 p.m.) at various locations in the DS department and outside. All CO_2 concentrations except one were below the 1000 ppm guideline established by the American Society of Heating, Refrigeration and Air–conditioning Engineers (ASHRAE).[24] Two measurements, collected at 10:00 a.m. were at or above the proposed criteria of 800 ppm.[25] However, levels exceeding 800 ppm were not consistently measured and this finding may have been due to the number of people in the area at the time the measurement was made. Temperature measurements indicated levels to be within acceptable ranges, although there were fluctuations of 4–5 F° in some areas. Excessive variations in temperature may cause more discomfort than maintenance of higher or lower temperatures with less variation, and can exacerbate complaints.

DISCUSSION

No obvious environmental explanations for the reported health problems in the IPS and DS departments were identified during this evaluation. GMC has taken a number of appropriate actions to investigate and control potential contributors to the problems, however, reports of skin and respiratory irritation and other symptoms were still occurring. Construction activities were very limited and the renovations were near completion during the NIOSH site visit; construction was not found to be a likely contributor to the currently reported problems experienced by some employees. The effect of past construction activities on air quality in these areas could not be determined.

Even though quarternary ammonium compounds such as the disinfectant (Virex®) used at GMC could potentially cause skin irritation, observation of work practices and past history of use suggest that this is an unlikely cause of the reported problems. There may have been some specific incidents during the hospital expansion that resulted in construction–related contaminants entering the IPS or DS. However, these activities are no longer ongoing and are not considered a likely contributor to the current symptoms.

Actions taken by GMC to eliminate the use of powdered gloves and the facility cleaning were important steps in controlling exposure to latex allergen. Although the threshold of latex allergen necessary to provoke sensitization or symptoms is unknown, eliminating the use of powdered gloves will reduce aeroallergen levels in the work environment.[14,26]

Although the HVAC system in the IPS was not cleaned, the potential for residual latex allergen from the supply ductwork is considered remote as the filtration system is efficient and well–maintained. This system should effectively prevent particulate from being re–distributed to occupied areas. As such, similar duct cleaning as that performed in the DS HVAC system is unlikely to result in significant benefit. There was considerable dust that contained latex allergen present in areas adjacent the return air grille in the return air plenum. This dust could be disturbed and possibly enter occupied areas when ceiling tile is removed for maintenance, or other activities which involve entry into the ceiling plenum area. Some hospitals have developed specific

guidelines and plans for accessing ceiling plenum areas in hospitals.

The use of steam humidifiers for OR humidity control is not specific to the areas investigated during this survey, and it is likely that humidification is not frequently required because of the climate. However, the use of boiler steam that contains additives (e.g., corrosion inhibitors) for humidification can potentially result in occupant exposure to these water treatment chemicals. Steam humidifiers should utilize clean steam, rather than treated boiler water.[27] Although only a limited number of samples were collected, similar quantities of NRL allergen were detected in the bulk and surface samples collected from the RA plenum in both the DS and IPS departments. This is not surprising as the non–air duct areas above the false ceiling in DS were not included in the duct cleaning project. The concentrations of latex allergen detected in the bulk samples were in the low–moderate range suggested by the Mayo Clinic as a recommended guideline.

The air samples for NRL allergen provide only limited data. There are however, potential explanations for the failure to detect NRL allergen on the spiked samples. For example, because the sample filter is hydrophobic and the spike was delivered in a liquid form, the NRL allergen may have failed to adhere to the filter and was subsequently lost during transfer. Despite the potential explanations, the air sampling data must be interpreted cautiously. As such, no meaningful comparison can be made regarding the relative levels of airborne NRL allergen in the DS and IPS departments. Certainly, the hospital's policy of using powder–free gloves will result in less NRL–containing powder to be present in the hospital's indoor environment. Using powder–free gloves is believed to be the single most important intervention in reducing airborne concentrations of NRL–containing dusts, where use of gloves is the prime source of this allergen.

The health complaints reported in the DS department are similar to those NIOSH has encountered during investigations in other non–industrial settings. These complaints are generally not suggestive of any particular medical diagnosis or associated with a causative agent. Symptoms generally include headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory symptoms. Typically, the workplace has been implicated because workers report that their symptoms lessen or resolve when they leave the building. While it is difficult to identify concentrations of specific contaminants that are associated with the occurrence of symptoms, many researchers in the field believe that symptoms among building occupants can be lessened by providing a properly maintained interior environment. Adequate control of temperature and RH is a particularly important aspect of employee comfort.

CONCLUSIONS

Ongoing health concerns about the working environment have been reported by some employees working in the IPS department at the GMC. The predominant symptoms (dermatitis, burning and itching eyes, respiratory irritation, headache, and cough) were initially reported in the summer of 1997. Health concerns reported in the DS department appear to have been resolved. Following a facility inspection, observation of work practices, review of materials in use, and limited environmental monitoring, no obvious environmental explanations for the reported health problems were identified.

Although some areas for improvement were noted, the ventilation systems supporting both the DS and IPS departments were found to be clean, well maintained, efficiently filtered, and operating properly. Sufficient outside air is being provided to occupied areas.

Some employees may have experienced latex–related allergic problems or may be sensitized to latex allergen; however, significant steps have been taken by GMC to reduce the potential for

exposure to latex and this probably does not account for most of the currently reported health complaints.

RECOMMENDATIONS

1. Eliminate the use of boiler steam for humidification. If a system to humidify supply air is necessary, it must be carefully planned and properly maintained to assure that indoor environmental quality is not adversely affected. Steam humidification is the preferable method for commercial spaces, since the heating of the water kills nearly all of the microorganisms. Steam humidifiers should have a separate water supply which is free from potentially irritating anti–corrosion agents such as diethanolamine (DEA). Chemicals such as DEA, in sufficient concentrations, are irritants of the skin, mucous membranes, and eyes.

2. The diagnosis of latex allergy should be based on symptoms and clinical findings consistent with an immunoglobulin E (IgE) – mediated allergic reaction following exposure to latex protein. Various serologic tests for antibodies to these proteins, glove use tests, and skin prick tests can be used to support or challenge the diagnosis. Serologic tests are often used for prevalence surveys of latex sensitization, but should not be the sole basis for diagnosing either the presence or absence of latex allergy.

3. Improve storage conditions in the DS department. Mop solutions containing disinfectant should be covered when not in use.

4. Evaluate the condition of the AHU condensate drain pans. Replace or repair them if they are found to be deteriorating and ensure that during the cooling season the pans drain properly. The likelihood of re–entrainment from the laboratory exhaust stacks into the outside air intakes was not assessed during our site visit and should be evaluated.

5. Review the ventilation system supporting the X–Ray developer room in IPS and ensure the room is adequately ventilated to control developer emissions. Direct exhaust to the outside and maintaining the room under negative pressure with respect to the OR will help ensure any emissions of developer chemicals are contained and adequately ventilated.

6. Implement procedures to ensure precautions are taken to prevent dust from the return air plenum from entering occupied areas and to protect personnel working in the return air system. Activities entailing removing ceiling panels, repairing ceiling–mounted fixtures, pipe maintenance, etc., are tasks that should be reviewed to ensure appropriate precautions are taken.

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Table 1
Latex Allergen Area Air Sampling Results
Gwinnett Medical Center: In–Patient Surgery
HETA 99–0090–2744
April 20, 1999

Sample # and Description	Sample Time (min)	Flow Rate (air sample volume in liters)	Latex Allergen (ng/m^3)
LAS #2: Operating Room Desk	09:26–17:19 (473)	15.8 lpm (7473.4)	< 2.7
LAS #3: Pre–Op Hallway Between Rooms 4 and 5	09:44–17:24 (460)	9.2 lpm (4232)	< 4.7
LAS #4: Pre–Op Hallway Above Pre–OP Nurses Station	09:44–17:24 (460)	9.6 lpm (4416)	< 4.5
LAS #7: PACU Nurses Station	09:11–17:10 (479)	8.35 lps (239,979)	< 0.08

Table 2
Latex Allergen Area Air Sampling Results
Gwinnett Medical Center: Day Surgery
HETA 99–0090–2744
April 21, 1999

Sample # and Description	Sample Time (min)	Flow Rate (air sample volume in liters)	Latex Allergen (ng/m^3)
LAS #8: DS–Recovery Between Suite 4 and 5	08:21–15:39 (438)	15.8 lpm (6920)	< 2.9
LAS #10: Pre–Op Nurses Station Adjacent Secretary Office	08:37–15:43 (426)	9.2 lpm (3919.2)	< 5.1
LAS #11: Above Pre–Op Nurses Station, Opposite LAS #10	08:37–15:43 (426)	9.6 lpm (4089.6)	< 4.9
LAS #14: Post–Recovery Nurses Station	08:11–15:32 (441)	8.35 lps (220,941)	< 0.09

Notes:
ng/m^3 = nanograms of latex allergen per cubic meter of air sampled
< = less than. Based on a laboratory reported limit of detection of 20 nanograms per sample
lpm = liters of air sampled per minute
lps = liters of air sampled per second

Table 3
Latex Allergen Bulk and Surface Sampling Results
Gwinnett Medical Center: In–Patient Surgery
HETA 99–0090–2744
April 20, 1999

Location	Sample #	Results	
		ng/gm	ng/100 cm^2
Pre–Op: Top of ceiling panel in return air plenum, adjacent return air grille (above false ceiling)	B–1	21, 070	
	S–1		194.8
OR Corridor: Top of ceiling panel in return air plenum, adjacent return air grille (above false ceiling)	B–2	52,734	
	S–2		562.5
PACU: Top of ceiling panel in return air plenum, adjacent return air grille (above false ceiling). Surface sample collected from interior of open lined duct connected to return air grille	B–3	52,849	
	S–3		205.6
OR #5: Inside floor level return air grille.*	S–4		61
OR #4: Inside floor level return air grille.*	S–5		17.1

Notes:
ng/gm = nanogram of latex allergen detected per gram sample
ng/100 cm^2 = nanogram of latex allergen detected per 100 square centimeters of surface area sampled using micro–vacuum technique.
*** = Surface area sampled is an estimate only**
Sample Sets S–1, B–1; S–2, B–2; S–3, B–3; S–4, were obtained from areas serviced by air handler unit (AHU) # 5. Sample # S–5 obtained from area served by AHU #4. Observation of OR #4 return air grille showed less visible dust.

Table 4
Latex Allergen Bulk and Surface Sampling Results
Gwinnett Medical Center: Day Surgery
HETA 99–0090–2744
April 21, 1999

Location	Sample #	Results	
		ng/gm	ng/100 cm^2
Pre–Op: Top of ceiling panel in return air plenum, adjacent return air grille (above false ceiling) by Nurses Station	B–4	39,301	
	S–6		151.7
Pre–Op: Top of ceiling panel in return air plenum, adjacent return air grille (above false ceiling), opposite end of Pre–Op (adjacent Endoscopy)	B–5	21,067	
	S–7		58.8
OR#3: Inside floor level return air grille.*	S–8		< 0.2

Notes:
ng/gm = nanogram of latex allergen detected per gram sample
ng/100 cm^2 = nanogram of latex allergen detected per 100 square centimeters of surface area sampled using micro–vacuum technique.
*** = Surface area sampled is an estimate only**

Table 5
Temperature, Relative Humidity, and Carbon Dioxide Monitoring Results
Gwinnett Hospital, Gwinnett, Georgia
HETA 99–0090–2744
April 21, 1999

Location	Carbon Dioxide (PPM)			Relative Humidity (%)			Temperature °F		
	8:00 a.m.	12:35 p.m.	2:30 p.m.	8:00 a.m.	12:35 p.m.	2:30 p.m.	8:00 a.m.	12:35 p.m.	2:30 p.m.
Post–Recovery	575	600	675	37	39	41	69	76	75
Recovery	550	575	650	39	39	41	68	73	73
Main Corridor	575	625	675	39	41	45	69	72	72
Pre–Op Nurses Station	950	725	700	40	42	45	71	71	71
Pre–op Area	1025	750	725	40	43	45	71	71	71
Waiting Room	675	625	650	41	43	47	71	71	71
OR Corridor	425	600	675	41	44	47	70	71	71
OR Corridor	325	575	625	40	45	47	70	70	71
OR Corridor	300	525	650	40	45	47	70	70	71
Business Office	575	700	825	40	44	47	70	70	73
Outside	250	350	375	41	48	39	79	70	82

ppm = parts of gas or vapor per million parts of air

National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation (HHE) at the Gwinnett Medical Center

In March and April 1999, NIOSH representatives conducted a HHE at the (GMC) Gwinnett Medical Center in response to a request from GMC Management. We looked into concerns about health problems possibly associated with working in the (IPS) In–Patient Surgery and (DS) Day Surgery departments. This sheet summarizes our evaluation and findings.

What NIOSH Did

We reviewed the health complaints with GMC personnel and management, inspected the IPS and DS work areas and observed work practices.

We evaluated the ventilation system that supports these two areas. We inspected filters, air flow, and cleanliness.

We measured levels of latex allergen from latex gloves in both areas and evaluated general air quality in DS.

What NIOSH Found

The ventilation system in both the DS and IPS departments was clean, well maintained, and operating properly.

No latex allergen was found in any air samples; however, analytical problems limited our ability to draw conclusions.

We found latex allergen in dust samples collected from the area above the false ceiling in both the DS and IPS departments. This is in the return–air path for the ventilation system.

General air quality was found to be within established guidelines in DS.

Steps have been taken by GMC to reduce exposure to latex and this probably does not account for most of the reported health complaints.

We were unable to find an obvious environmental source for the reported complaints

What GMC Managers Can Do

Prevent return air plenum dust from entering occupied areas.

Make sure the X–ray room is properly ventilated to control X–ray developer emissions.

Don't use boiler–steam for humidifying the operating rooms.

Improve methods for diagnosing latex allergy.

What GMC Employees Can Do

Follow all company policies regarding the use of non–powdered latex gloves.

Promptly report any suspected work–related health problems.

Follow proper precautions when using disinfectants or other cleaning materials.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1–513–841–4252 and ask for HETA Report # 99–0090–2744

NIOSH

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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