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HETA 99-0294-2775
Exempla St. Joseph's Hospital
Denver, Colorado

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PREFACE

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

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Eric J. Esswein of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Denver Field Office. Analytical assistance was provided by the generous assistance of Robert G. Hamilton, Ph.D., D. ABMLI, Associate Professor of Medicine and Pathology, The Johns Hopkins University DACI Reference Laboratory. Desktop publishing was done by Joyce Woody. Review and preparation for printing were performed by Penny Arthur.

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**Health Hazard Evaluation Report 99-0294-2775
Exempla St. Joseph's Hospital
Denver, Colorado
January 2000**

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SUMMARY

A health hazard evaluation (HHE) was requested by management at the neonatal intensive care unit (NICU) at Exempla St. Joseph's Hospital in Denver, Colorado. The request concerned possible exposures to natural rubber latex (NRL) proteins. Employees reported rhinitis, sneezing, rash, watery eyes, and aggravation of allergic symptoms.

A reservoir of dust was found within the NICU; exhaust from the central vacuum cleaning system was leaking into the ceiling plenum of an area adjacent to the NICU. The system exhausted vacuumed carpet dust into the ceiling plenum, rather than to the outside, as designed. The use of pressure measurements and carbon dioxide tracer gas demonstrated that a potential pathway existed for the movement of airborne dusts from the affected plenum to the adjacent plenum over the NICU.

Two air samples, six surface samples, and two bulk dust samples were collected. Concentrations of NRL ranged from below the limit of detection [<1 allergy units (AU) per milliliter of extracted sample] to 4.2 AUs. Eight of the ten samples were in a range considered to be trace concentrations. The two NRL air samples were reported at less than the limit of detection and 1.8 AU. No mechanical or maintenance deficiencies and no visible microbiological contamination were identified in the air handling unit serving the NICU. A water leak in the NICU was identified, and remediated by hospital personnel.

While no occupational health hazard related to exposure to NRL in the NICU was identified, a cause for the employee complaints of rhinitis, sneezing, and aggravation of allergic symptoms was identified, i.e., airborne dust caused by a broken central vacuum exhaust. Recommendations were provided to repair the broken central vacuum exhaust pipe, clean the accumulated dust within the plenum, and improve housekeeping.

Keywords: SIC Code 8062 (General Medical and Surgical Hospitals) Hospital, Neo-natal Intensive Care Unit, NICU, dust, vacuum cleaners, carpets, natural rubber latex, NRL

Highlights of the NIOSH Health Hazard Evaluation

Allergy Symptoms in Hospital Employees

This NIOSH Health Hazard Evaluation (HHE) was requested by the management of the neonatal intensive care unit (NICU) at Exempla St. Joseph's Hospital in Denver, Colorado. It was conducted on July 19-20, 1999, and covered employee concerns about symptoms (rhinitis, sneezing, rash, watery eyes, and aggravation of allergic symptoms) they thought might be related to natural rubber latex (NRL) exposure.

What NIOSH Did

- # We gathered information from employer and employee representatives about the timing of their symptoms relative to specific events that occurred in the hospital.
- # We visited the NICU to conduct a visual and environmental investigation of conditions.
- # We analyzed air and dust samples taken in the NICU for NRL proteins.
- # We conducted pressure and carbon dioxide tracer gas studies in adjacent plenums above the NICU and a neighboring area.

What NIOSH Found

- # Dust moving from a broken central vacuum cleaner exhaust pipe in an adjacent ceiling plenum to the NICU may have caused employee symptoms.

- # Concentrations of NRL in air and dust samples were very low, and thus were not a hazard for workers in the NICU.
- # There were no mechanical or maintenance deficiencies and no visible microbiological contamination in the air handling unit serving the NICU.
- # A source for a previously unidentified water leak in the NICU was identified, and repaired by hospital personnel.

What Exempla/St. Joseph Hospital Managers Can Do

- # Improve housekeeping to prevent the build-up of dust in the NICU.
- # Repair the broken central vacuum exhaust pipe, and remove the accumulated dust from the plenum.



What To Do For More Information:
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INTRODUCTION

A health hazard evaluation (HHE) was requested by management at the neonatal intensive care unit (NICU), Exempla St. Joseph's Hospital in Denver, Colorado. Employees in the NICU reported rhinitis, sneezing, rash, watery eyes, and aggravation of allergic symptoms. The request originated because employees had concerns about possible exposures to environmental dust that was believed to contain natural rubber latex (NRL) proteins. Early in 1999, phone cables were installed in the plenum space above the NICU. Staff reported upper respiratory irritation and allergic symptoms when the work was underway and after it was completed.

BACKGROUND

Approximately 70 staff members work in the NICU. The NICU director reported that health symptoms were first reported in 1995, approximately one year after the NICU underwent extensive remodeling. During 1995, quiescent sampling using settling plates (petri dishes) was performed by hospital infection control personnel to determine if bioaerosols of concern (*Aspergillus* species) were present after construction and remodeling. Sampling did not reveal the presence of *Aspergillus* species according to NICU management.

Recent events reported to be temporally related to complaints of poor indoor environmental quality (IEQ) in the NICU included a broken exhaust pipe for the central in-wall vacuum system which occurred in 1996. This system is dedicated for use in the NICU. The location of the break was inside the ceiling plenum above the environmental services closet, in the NICU. A chronic rainwater leak was also reported on an interior wall near the main entrance to the NICU. Water was reported to leak from the wall where a transparent plastic cover was mounted over a quilt displayed on the wall. The vacuum exhaust line was reported to have been repaired in 1996, but the reason for the leak in the wall had not been identified.

Some staff reported experiencing "allergy-like" symptoms while working in isolation room 4 and near bed space 24 (both locations are adjacent). Other staff reported allergic rhinitis and other allergic symptoms whenever working in the NICU,

regardless of the specific location. One staff member reported experiencing a rash on both arms which spread to the legs. Staff also reported upper respiratory symptoms whenever the carpet was vacuumed or cleaned. Carpeting is vacuumed with a Vacu-Flo® in-wall central vacuum system and spot-cleaned with a rotary carpet burnisher.

Staff reported irritant dermatitis with glove use but did not report allergic contact dermatitis with latex glove use. Powderless natural rubber latex (NRL), vinyl, and polyvinyl chloride gloves (PVC) were reported to be the only gloves used in the NICU, and since 1998, the hospital has required the use of powderless gloves in the NICU. Two unopened boxes of powdered gloves were in the NICU during the investigation. The NICU manager reported that the gloves were sent to the NICU by mistake and were to be returned to central stores.

In 1998, Exempla St. Joseph's Hospital contacted NIOSH and requested an HHE to investigate occupational exposures to NRL.¹ NIOSH investigated clinical and non-clinical areas of the hospital. The NICU was not chosen as part of the study because the NICU had made a recent change in the type of gloves used (use of all powderless) and NIOSH chose to investigate areas where glove use had remained constant prior to the HHE. NIOSH found that current or past occupational use of latex gloves was not associated with latex sensitization but was associated with work-related rhinoconjunctivitis, hand urticaria, and hand dermatitis. Airborne latex levels were very low. Geometric mean concentrations of 0.52 nanograms of NRL per cubic meter of air (ng/m³) was identified in clinical areas, and 0.10 ng/m³ in non-clinical areas.¹

METHODS

An opening conference was held on the morning of July 19, 1999. Blueprints of the heating, ventilating, and air conditioning (HVAC) system for the NICU were reviewed followed by a discussion of work activities, work practices in the NICU, types of medications in use, and other issues related to the request for the HHE. Following the opening conference, a walk through inspection of the NICU area was conducted.

Smoke traces were used to evaluate pressure differences in the NICU area and at doors leading into the NICU. Housekeeping in the NICU, the central vacuum system, and the NICU HVAC system (AC-8), were visually inspected. A hand-held battery operated TSI Model 8551 Q-Trak™ IAQ Monitor was used to measure pressure differentials, carbon dioxide, and to screen for temperature and relative humidity (RH).

Samples for airborne NRL proteins were collected using a high volume Aircon® air sampling pump and bilaminant [glass fiber and polytetrafluoroethylene (PTFE)] membrane filters in 37-millimeter polystyrene sampling cassettes. The sampling train was calibrated using a BIOS Dry Calc® flowmeter. The sampling train operated at a flow rate of 30 liters per minute. NRL samples were analyzed at the Johns-Hopkins Reference Laboratory for Dermatology, Allergy, and Clinical Immunology.

Surface dust samples were collected using 100 square centimeter (cm²) disposable masking templates, and micro-vacuuming techniques according to ASTM method D5755 using PTFE filters and 37-millimeter sampling cassettes.²

A CO₂ tracer gas investigation was performed to test a hypothesis that the plenum above the environmental service closet was connected with the plenum above the main NICU area, possibly through small visible gaps in a firewall separating the two areas. Small spaces were present where the top of the firewall met the subflooring and/or support structures from the floor/roof above the NICU. These spaces were suspected to be the pathway for movement of airborne dust from the plenum where dust was blown from the broken pipe to the plenum above the NICU work area. If vacuumed and accumulated dust were agitated from the force and volume of air that would be blown into the plenum (from the disconnected pipe), the increased pressurization would likely act to move airborne dust into the plenum area above the main NICU area through the gaps in the firewall. To evaluate plenum pressurization, a digital manometer was used to measure pressure change when the vacuum was on, and when it was off. To evaluate air movement (as a surrogate for the migration of fine airborne dusts), two five-pound charges of carbon dioxide from a fire extinguisher were released into the plenum at the location of the pipe break. CO₂ concentrations were

then monitored in plenum areas above the NICU occupied area.

EVALUATION CRITERIA

Because of the wide range in dose-response for allergens in general, it is difficult to determine a safe threshold exposure concentration below which sensitized individuals would not experience reactions, or unsensitized individuals would not experience allergic sensitization with exposure to environmental dust which could contain a wide variety of allergens including NRL allergens. Neither NIOSH, nor the Occupational Safety and Health Administration (OSHA), nor the American Conference of Governmental Industrial Hygienists (ACGIH) has established numerical exposure limits for natural rubber latex exposures, or mixed allergens in environmental dust.

RESULTS

The main NICU area had a slight negative pressure relative to the Labor and Delivery (L&D) area as determined with the use of chemical smoke. Static pressure in the NICU ceiling plenum outside the nurses' station was 0.0002 inches water gauge with the vacuum off and 0.0005 inches water gauge with the vacuum on. Pressure was slightly increased when the vacuum motor operated. In another test, pressure in the plenum inside the nurses station was measured at 0.0002 inches water gauge with the vacuum off and -0.0001 inches water gauge with the vacuum on. This measurement was taken close to a return air grill which might explain the slightly negative pressure. After the CO₂ was released into the plenum directly at the broken pipe, CO₂ concentrations increased from 377 parts per million (ppm) to 623 ppm in the occupied area and from 412 ppm to 530 ppm in the plenum near the nurses' station over a 15 minute period. Later, another 5-pound charge was released at the pipe break and CO₂ was monitored in the plenum above Isolation Room 4. In a 15 minute period, CO₂ increased from 462 ppm to 502 ppm. Occupancy remained constant during the investigation, so increases in CO₂ could not be attributed to occupancy changes. This evaluation suggests that fine, respirable dusts can be dispersed within the plenum above the NICU when the vacuum was operated with a broken exhaust connection. Fine dusts could be distributed into the

occupied areas of the NICU when the plenum becomes slightly pressurized.

Inspection of HVAC system (AC-8) revealed that the 30-40% efficient pad prefilters were all in place and were slightly dusty, which is an indicator of appropriate filter performance. The final filters were all in place and were dry. There was no evidence of filter bypass. The coil was clean, and there was no visible evidence of mold or biological growth. The main drain pan held a small amount of water but no biofilm was evident nor were fungi visibly present in the condensate pan. Condensate pan slope and drainage were confirmed by pouring one liter of water into the pan and observing the water rapidly flow toward the central drain. The pan was configured with the drain tube lower than the bottom of the pan to prevent water from accumulating in the pan. In the final chamber of the HVAC unit, the large ductwork was free to the touch of accumulated dust and particles.

NRL sample results in Table 1 are in allergy units (AU). AU is a unit of measure which is referenced to a Food and Drug Administration (FDA) standard preparation of non-ammoniated latex. The results are expressed as the mean of a duplicate analysis for each sample. The current FDA standard (undiluted) latex extract is known as E8. E8 has been assigned a value of 10,000 AU per milliliter (mL) by a consensus of FDA scientists. In the previous NIOSH investigation at Exempla St. Joseph Hospital, NRL airborne and surface sampling results were analyzed by a different laboratory that reports results in units of nanograms of latex per cubic meter of air (ng/m³) for air samples, and nanograms of latex per 100 square centimeters for surface samples. Results from the investigation reported here are expressed in different units because the laboratory at Johns Hopkins uses a slightly different immunoassay technique and reports their results in AUs per milliliter of extracted sample. While the sampling results of this investigation are not directly comparable with the previous investigation at Exempla St. Joseph Hospital, the results are interpretable considering the limit of sensitivity of the assay (<1 AU) as the lowest value reportable, and 143,715 AUs (latex glove extract used as a positive control) as the highest value reported for the data set, and 10,000 AU/ml as the E8 NRL reference extract. NRL values for this sample set are also comparable relative to each other within the range of values reported for the individual samples.

Concentrations of NRL from all samples was very low and ranged from less than the limit of detection (LOD) to slightly more than four times the LOD. For chemical analyses, NIOSH considers the limit of quantitation (LOQ) to be a three fold difference from the LOD. Values which fall between the LOD and LOQ are reported as “trace” or non-numerical concentrations. The majority (80%) of the values for NRL in the samples from this investigation were in a range which could be considered a trace concentration. Concentrations of NRL ranged from <1 to 4.2 AUs. The three samples with the highest NRL concentrations (4.2, 3.3, and 2.9 AUs) were dust collected from the back of the ceiling tile in the environmental services closet, settled dust from the wall light in isolation room 4, and dust from the pre filter of air handling unit AC-8, respectively. These samples were all collected from “reservoir locations,” that is, areas where dust had visibly accumulated. The air samples were <1 AU and 1.8 AU, a trace concentration.

A thunderstorm occurred late in the afternoon of July 20 and water began spurting from the wall where the previous water leaks had been reported. Water came through a hole in the wall where a toggle bolt went through the drywall to secure the acrylic cover in place over the decorative quilt. Hospital maintenance staff removed several small pieces of the wet drywall and a pipe for the roof drain was visible and was identified as the source of the water. Apparently, when the holes were drilled in the drywall for the toggle bolts, the drill bit pierced the pipe. The pipe would leak only when sufficient water pressure was present in the pipe to force water out of the small hole. The hole in the drain pipe was temporarily patched then completely repaired the following day. Mold was not visible growing on the back of the drywall near the leak, nor was a moldy smell apparent, thus the presence of mold growth in the interstitial space was not likely.

Temperatures on the first and second days of the investigation were 74 and 72 degrees Fahrenheit, respectively. Relative humidity was 50.4, 47.8% and 53.5 and 50.5%, respectively. Indoor CO₂ concentrations ranged from 395 ppm to 535 ppm during the non-CO₂ tracer gas evaluation portion of the HHE.

DISCUSSION

A reservoir of dust was found in the ceiling plenum above the environmental services closet where an exhaust pipe for a central vacuum system had broken. Vacuum cleaner dust which normally would have been exhausted from the building was instead being discharged into the ceiling plenum. Pressure measurements and a CO₂ tracer gas study showed that the plenum where the pipe break occurred was not isolated (by a firewall) from the ceiling plenum above the work area of the NICU. The pressure measurements, and the CO₂ tracer gas (which was used as a surrogate for fine airborne dust), demonstrated a pathway and a driving force for airborne dusts to move from the area where the pipe was broken to the plenum above the NICU, and into the occupied area of the NICU.

Inspection of the NICU identified exposure to vacuum cleaner dust as a probable cause for the upper respiratory symptoms reported by NICU staff. Vacuum cleaner dust contains both inert and biologically active components which can cause sneezing, upper respiratory irritation, and aggravation of pre-existing allergic conditions.

In the opening conference, the NICU manager said that NICU staff voiced concern about the possibility that NRL-containing dusts might be entering the NICU through the hallway from the L&D area. Powdered NRL gloves are used in L&D. It is unlikely that airborne NRL-containing dust (cornstarch from powdered gloves) would reach the NICU and present a health hazard to sensitized employees, or a sensitization hazard to non-sensitized employees. Cornstarch particles are relatively large (greater than ten microns) and settle out of the air quite quickly. Additionally, areas where gloves are most often used in the L&D areas are the individual patient rooms which are contained. Because the HVAC system for L&D is not connected to the HVAC system for the NICU, airborne dust could not reach the NICU by that pathway.

Poor housekeeping could contribute to the symptoms reported by staff in the NICU. Settled dust was present on horizontal surfaces such as the sills on the glass partitions above the NICU bays, on ceiling-mounted return air grills in the NICU, and the horizontal wall lighting fixtures. Stains were visible on the carpeting (presumably from spills) in many areas of the NICU. A large stain on the carpeting

was present in Isolation Room 4, and a dry dust-like odor was noticed in that room.

CONCLUSIONS

This HHE identified a contaminant source (vacuum cleaner dust), and a potential pathway (ceiling plenums) and driving force (pressure from the central vacuum in the plenum space) which could explain movement of fine airborne dust to the NICU work area where employees reported upper respiratory irritant and allergic symptoms. A plausible explanation for the reported symptoms in the NICU is exposure to vacuum cleaner dust that contained low levels of NRL and likely contained other allergens that could also act as respiratory irritants.

RECOMMENDATIONS

The following recommendations are offered to improve indoor environmental quality in the NICU.

1. All isolation rooms should be maintained under a negative pressure relationship to the main NICU area. Isolation rooms should have self-closing devices on all room exit doors.³ The minimum pressure necessary to achieve and maintain negative pressure that will result in airflow into a room is reported to be 0.001 inch of water gauge.⁴
2. Housekeeping should be improved in the NICU, especially more frequent and effective cleaning of horizontal surfaces which can gather dust and the return air grills in the patient treatment area. Prevent dust accumulation by damp-dusting horizontal surfaces on a daily basis and by cleaning ceiling tiles and return air grills that appear to be visibly discolored. All visible settled dusts on all the wall light fixtures in the isolation rooms should be cleaned. Care should be taken to minimize the creation of airborne dusts while cleaning.⁵ Do not use a carpet burnisher to clean the carpet; this will generate dust in the occupied environment. If carpet is replaced, choose a low-pile material, with a non-jute-backed construction. Choose a replacement product with low volatile organic emissions. The State of Washington and the Carpet and Rug Institute have developed guidelines and specifications for acceptable emissions from carpeting.

3. Do not use the vacuum until it has been repaired and tested for leaks. A pipe hanger should be used to support the pipe from above. The pipe should be checked for integrity by daubing a dilute solution of dish detergent or another bubble-forming solution around the repair while the motor is operating. If bubbles develop, the leak has not been completely repaired. Periodic checks above the plenum should be made to confirm the integrity of the exhaust pipe.

4. The carpet in Isolation Room 4 should be cleaned and thoroughly vacuumed. Use a high efficiency particulate aerosol (HEPA) vacuum if the central vacuum has not been repaired and tested.

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Table 1
 Exempla St. Joseph's Hospital
 Denver, Colorado
 Air and Environmental Dust Sampling for Latex
 July 19-20, 1999

Sample #	Sample Description	NRL allergy units (AU)
SJH-NICU 1	settled dust, wall light on right side of Isolation Room 4	3.3
SJH-NICU 2	surface dust from ceiling air diffuser in Isolation Room 4	<1 (below LOD)
SJH-NICU 3	surface dust from 100 cm ² area from back of ceiling tile in Isolation Room 4	<1 (below LOD)
SJH-NICU 4	loose bulk dust from back of ceiling tile environmental services closet	1.0
SJH-NICU 5	fine dust from 100 cm ² area from back of ceiling tile in environmental services closet	4.2
SJH-NICU 6	surface dust, 100 cm ² area back of ceiling tile in front of bed # 27	<1 (below LOD)
SJH-NICU 7	surface dust, 100 cm ² area on back of ceiling tile in nurses station	1.6
SJH-NICU 8	air sample collected near bed 24 (volume = 5430 L)	<1 (below LOD)
SJH-NICU 9	filter dust from prefilter on air handling unit AC-8	2.9
SJH-NICU 10	air sample collected outside Isolation Room 4 (volume = 4440 L)	1.8
Negative control	vinyl glove	<1 (below LOD)
Positive control	latex glove extract	143,715

Notes:

LOD = limit of detection of the assay

AU = allergen units. Referenced to the FDA E8 non-ammoniated NRL extract of 10,000 AU/mL (undiluted).

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