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CINCINNATI, OHIO

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I. SUMMARY

In April 1987, the National Institute for Occupational Safety and Health (NIOSH) was requested by Joseph T. Luttmer, D.D.S. to assess the potential health hazard of occupational mercury exposure at his dental office in Cincinnati, Ohio.

On May 13, 1987, NIOSH investigators conducted an industrial hygiene walk-through survey and medical evaluation of the employees. A follow-up industrial hygiene survey of the office was conducted on June 15-16, 1987. The medical evaluation consisted of medical interviews, urine mercury measurements, and in one case, a detailed neurological examination. The industrial hygiene surveys consisted of full shift airborne mercury level samples for each employee in the office as well as instantaneous mercury vapor samples obtained with a direct reading instrument. In addition to mercury sampling, office work practices were evaluated.

Mercury exposures ranged from 0.016 to 0.022 mg/m^3 for the personal breathing zone and area full shift samples. Instantaneous airborne mercury levels measured with the direct reading instrument ranged from 0.048 to 0.066 mg/m^3. Mercury vapor levels measured directly over surfaces with the direct reading instrument were found to be between 0.027 and 1.216 mg/m^3. While some of the surface values were relatively high, they were generally observed in areas which were obviously contaminated with dental amalgams. These areas include the tables where the amalgamators were located and a carpeted wall immediately adjacent to an amalgamator in which small droplets of dental amalgam were visible. The other surfaces in which high values were observed were the vacuum cleaners used to sweep the office carpeting. The airborne mercury samples were all well below the current NIOSH recommended exposure limit of 0.050 mg/m^3. The instantaneous air samples were also below the current Occupational Safety and Health Administration (OSHA) regulation of 0.100 mg/m^3 as a ceiling value not to be exceeded.

The medical evaluations revealed no symptoms suggestive of mercury toxicity in the dental office personnel. The urine mercury levels measured in three of the personnel ranged from 6.9 to 20.0 ug/l of urine. These levels of urine mercury are in a range where no signs or symptoms of mercury toxicity would be expected.

Based on these results, NIOSH investigators determined that a current health hazard did not exist for the dental personnel at this office. Measured mercury levels were below current guidelines and regulations for inorganic mercury exposure levels. Recommendations are made in this report in Section VIII to improve mercury handling techniques and for initiating a medical monitoring program for mercury.

KEYWORDS: SIC 8021 (Offices of Dentists), inorganic mercury, mercury hygienic techniques, medical monitoring.

II. INTRODUCTION

In April 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at a dental office located in Cincinnati, Ohio. The request was submitted by the dentist and was concerned with potential inorganic mercury exposure to the office personnel. A dental assistant, who had worked in the office but was no longer there at the time of the hazard evaluation, had been told by her personal physician that she had a high level of urine mercury.

NIOSH made visits to the dental office on May 13-14, 1987 to conduct a walk-through survey of the office and to do the medical evaluation of the staff. An industrial hygiene survey for mercury exposure was conducted on June 15-16, 1987. Interim reports were sent to the requestor in June 1987 describing some of the initial findings and making recommendations on how to improve the work practices for the handling of mercury in the office.

III. BACKGROUND

The dental facility is situated on the second floor of an older office building overlooking a town square in the eastern side of Cincinnati, Ohio. The dentist has been located in this building since 1966, and moved to this current dental suite in 1979. The carpeting in the office during the time of the NIOSH survey was installed just prior to this move.

The office is staffed by one dentist, 2 - 3 dental assistants and hygienists, and 1 - 2 receptionists and bookkeepers. The number of persons in the office depends on the day of the week because most of the assistants only work part-time for this dentist. The office suite has six patient examining rooms, an x-ray room, office areas, and patient reception area. A diagram of the office layout is shown in Figure 1. The typical day's schedule is from 8:00 a.m. to 5:00 p.m. with a one-hour lunch period. However, the dentist will often see patients before and after this scheduled time frame.

Inorganic mercury is a component of the material used to fill cavities in patients' teeth. The filling material, or amalgam, is made by adding mercury to a pre-measured alloy in a capsule, placing the capsule onto a vibrating device, called an amalgamator, and shaking it for a few seconds. The mixed material is removed from the capsule for use by the dentist. The dentist was unable to estimate the annual amount of mercury used in his practice. However, the office staff did estimate that they can make up to 15 - 20 amalgams per day.

IV. MATERIALS AND METHODS

The mercury vapor surface readings and the instantaneous airborne readings were obtained with a direct reading Jerome Gold Film Mercury Vapor Analyzer (Model 411). Full shift air samples were acquired with hopcalite sorbent tubes connected via tygon tubing to battery-powered pumps calibrated at 0.05 liters of air per minute (lpm). As air is pulled through the tubing, the hopcalite collection media chemically reacts with the mercury vapor.

The samples collected on the hopcalite sorbent tubes were sent to the NIOSH contract laboratory for analysis. The hopcalite media was transferred to 50 milliliter (ml) volumetric flasks and ashed with nitric and hydrochloric acids. After dissolution was complete, the samples were diluted with deionized water and nitric acid. Mercury was reduced by the addition of stannous chloride and analyzed by means of cold vapor atomic absorption spectroscopy.

The surface readings were collected with the direct reading analyzer with a 12" hollow metal tube connected to the input port of the device. The end of the tube was placed within 2" of the surface being analyzed. The instrument was allowed to sample in its 10 second (sec) operation mode. For instantaneous airborne levels, the instrument was held in the center of the room being sampled, approximately 3' from the floor. The 10 sec operation period was used for these samples also. However, the tube was removed from the input port for airborne samples.

The medical portion of the study consisted of medical interviews, urine mercury measurements, and in one case, a neurological exam. The dentist and two dental assistants were available on the day of the medical study. The medical interviews emphasized neurological symptoms, particularly tremor, balance disturbance, memory loss, and personality change, and constitutional symptoms such as fatigue, weight loss, loss of appetite, and weakness. The three participants provided late morning urine specimens in urinalysis containers. The dental assistant who no longer worked in the office and who was told by her personal physician that her urine mercury levels were high was also interviewed at NIOSH Hamilton Laboratories at a later date.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the

occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

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

Mercury occurs as elemental mercury and as inorganic and organic compounds. Each form has different toxicological properties. Organic mercury compounds are the most widespread and potentially dangerous. The release of 30,000-150,000 tons per year of mercury from the earth's crust and oceans is a natural occurrence. Some 20,000 tons of mercury are added to the environment each year by human activities. The mercury in fish, a major source of mercury ingested by humans, is predominantly methylmercury, an organic form. Aquatic methylmercury is produced microbially from inorganic mercury arising from natural or man-made sources. The average daily intake of methylmercury from fish has been estimated to vary between 1 and 20 ug/day, depending on diet, the type of fish consumed, and level of aquatic contamination The daily intake of inorganic mercury is not thought to exceed 10 ug in the absence of occupational exposures.[13]

NIOSH currently recommends that exposure to inorganic mercury be limited to 0.050 milligrams per cubic meter (mg/m^3) as an 8-hour time weighted average (TWA)[1]. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that mercury vapor exposure be limited to a TLV of 0.050 mg/m^3 as an 8-hour TWA [2]. The current Occupational Safety and Health Administration (OSHA) standard for inorganic mercury is 0.100 mg/m^3 as a ceiling level.[3]

B. Medical Criteria

Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive systems[4]. Acute or short-term exposure to high concentrations of mercury causes tightness and pain in the chest, difficulty in breathing, coughing, inflammation of the mouth and gums, headaches, and fever[4,5].

Chronic or long-term exposure to lower concentrations of mercury is more common. Chronic mercury poisoning is known to cause kidney damage (nephrosis), tremors and shaking (usually of the hands), inflammation of the mouth and gums, metallic taste, increase in saliva, weakness, fatigue, insomnia, allergic skin rash, loss of appetite and weight, and impaired memory. These symptoms generally occur gradually and may be associated with personality changes such as irritability, temper outbursts, excitability, shyness, and indecision[4,5]. Finally, there is theoretical potential for adverse reproductive effects, but these have not been documented[6,7]. The relationship between dose of mercury absorbed and physiologic response may be affected by age, sex, nutritional status and previous mercury exposure.[8]

Recent occupational exposure to mercury can be assessed by monitoring blood and urine mercury levels. The reported correspondence of air levels (in ug/m^3) to urine levels (in ug/l) varies from a ratio of 1:1 to 1:2.6. There is no generally accepted value, although a World Health Organization study group currently uses 1:2 (i.e., exposure to an air level of 50 ug/m^3 would tend to result in a urine level of 100 ug/l, on the average)[9].

Renal and neurobehavioral symptoms may appear with air levels in the 50-100 ug/m^3 range. There are reports (of uncertain validity) of effects at even lower levels[9]. Recent reports suggest that minimal neurobehavioral and subclinical renal effects may be detected with urinary levels as low as 50-100 ug/g creatinine[10] (levels standardized to ug Hg/g creatinine are roughly comparable, on a group basis, to those measured in ug Hg/l urine).

It is important to note that air measurements of inorganic mercury may not always correlate well with urinary excretion or the development of symptoms. Several factors, including mercury body burden, mode of exposure, and physiologic variations in metabolism may influence the urine mercury level.[11,12]

VI. RESULTS

A. Environmental

All of the samples from the May 13, 1987 walk through survey were obtained with the direct reading instrument. These values are reported in Tables 1-3. The notation of rooms and other locations in these tables refers to the floor diagram presented in Figure 1. The mercury levels given in these tables are for surface contamination (Table 1), contamination of the vacuum cleaners used by personnel to clean the floors of the dental office (Table 2), and for instantaneous measurements of airborne concentrations (Table 3). The measured mercury levels from the May survey are consistently higher than the measurements made in the June

survey with the direct reading instrument. The surface contaminations ranged from 0.027 to 1.216 mg/m^3. The high values were found in examination room #3 which contained an amalgamator. The amalgamator, which did not have a cover over it, was located next to a carpeted wall. Small particles of silver-colored dental material were observed sticking to the carpeted wall during the May survey. Examination of the three vacuum cleaners used in the dental office for cleaning revealed that all three were contaminated with mercury. The levels ranged from 0.157 to 1.219 mg/m^3. The instantaneous air mercury levels, however, were all less than the 0.100 mg/m^3 ceiling value stipulated by the OSHA regulation.

The mercury exposure levels measured during the June, 1987 survey were lower than the initial observations. Breathing zone samples from the four employees present ranged from 0.016 to 0.020 mg/m^3. The full-shift area samples obtained at this time had results similar to those of the personal breathing zone levels (Table 4). Additionally, levels measured with the direct reading instrument during the latter survey were considerably lower than those from the first set of measurements. We observed during the June survey that several work practices had changed since the earlier survey. Scrap material from the amalgamators was being placed in water filled jars with screw caps. The amalgamator in Examination Room #1 was now covered with a clear plastic shell. Also, the obvious mercury contamination evidenced by small beads of mercury on the tables where the amalgamators were located, and on the wall carpeting, was not seen in the June survey.

B. Medical

All three persons interviewed had histories of regularly working directly with the dental amalgam. None reported symptoms suggestive of mercury toxicity, nor did the one neurological examination yield any suggestive findings. Although work histories revealed that work practices for handling mercury were being revised at the time of the first visit, frequent episodes of lax handling of the amalgam material were reported. Urine mercury concentrations were 6.9, 12.2, and 20.0 ug/l.

VII. DISCUSSION AND CONCLUSIONS

The industrial hygiene survey results indicate that the office personnel were not being exposed to high levels of airborne mercury contamination. The levels measured during the June survey were well below current occupational exposure limits and regulations. The higher surface concentrations were associated with poor work practices, i.e., spillage of mercury, uncovered amalgamators, and vacuuming carpets with conventional vacuum cleaners.

This health hazard evaluation presented the opportunity to measure the effects of changes in work practices (covering amalgamators, storage of mercury scraps under water) on the resulting surface contamination by the mercury. The general cleaning and more conscientious handling of the mercury led to reductions in surface concentrations by factors of ten and greater. It is also encouraging that these reductions occurred immediately as is evidenced by the short time period between survey periods.

The use of conventional vacuum cleaners to clean the dental office carpet is a practice to be avoided. The potential for high levels of mercury exposure does exist when an employee comes into contact with the vacuum cleaner. The practice of changing dust bags or drive belts on the vacuum cleaners could expose the employee to mercury. Employees should be made aware of the higher levels of surface contamination associated with these cleaners.

The urine mercury concentrations measured in this study ranged from 7 to 20 ug/l, with an average of 13.0 ug/l. This average is higher than the range of values found in NIOSH's most recent evaluation of a large group without occupational exposure to mercury.[14] There is no clear consensus on the urine mercury concentration expected in a non-occupationally exposed population. A widely-quoted 1970 study of a chlorine manufacturing facility examined urine mercury levels in 142 workers without mercury exposure. Thirty-five percent had urine mercury levels less than 10 ug/l, and 98 percent had levels below 100 ug/l.[13] A technical bulletin published in 1967 by the state of California presented a commonly-applied guideline of 30 ug/l for the upper limit of urine mercury in a group without occupational exposure.[14] A 1983 NIOSH evaluation in a Vermont thermometer plant showed urine levels in unexposed workers to be less than 10 ug/g creatinine[15], which is roughly equivalent to 10 ug/l.

Several factors make interpretation of the urine mercury values difficult. Diet, which was not examined in this study, may have a large influence on urine mercury values in the range found in this study. Normal variations in urinary mercury excretion make conclusions based on one sample difficult. Urine mercury is a reflection of current or recent mercury exposure, but one sample can not be used to determine with certainty whether absorption from dental amalgam has occurred. Urine mercury is not an indicator of past exposure or total body burden. Because the data we collected did not suggest mercury toxicity, detailed neurobehavioral testing, which can detect subtle abnormalities, was not conducted.

VIII. RECOMMENDATIONS

The following recommendations are made to the dental office personnel as a result of the observations made and the analytical results obtained during the two survey periods.

1. The improved work practices involved in the handling of the amalgam materials seen during the second visit to the dental office should be continued. This includes the storage of mercury scrap under water, the use of covered amalgamators, and the heightened cleaning activity of any accidental mercury spills. The lowering of mercury exposures which were documented during the two survey periods shows that these practices do improve the levels of mercury contamination in the office.

2. A vacuum cleaner designed to pick up mercury spills should be purchased for the office. This would eliminate the contamination of the conventional vacuum cleaners currently in use and would reduce employee exposure. It would also provide a safe method to clean up any kind of accidental spillage of mercury in the office.

3. The contaminated wall carpeting in Examination Room #3 should be thoroughly cleaned in a proper fashion, using a vacuum cleaner designed to clean mercury. Following the cleaning, a hard plastic shield should be placed over the carpet in the area where an accidental spillage of mercury would accumulate. Thus, any further contamination of the carpeted wall would be eliminated.

4. Placement of the amalgamators on a tray with a lipped edge, and cushioning material placed under the amalgamator, will help keep accidental mercury spills contained in a small area, eliminating contamination of the entire examination room or even the entire dental office.

5. Any accidental spills of mercury or amalgam material should not be handled with bare hands or skin because of the risk of dermal absorption of mercury.

6. Because of the initial high mercury surface contamination measured, and because intermittent exposures may be missed by environmental sampling, a medical monitoring program for mercury should be instituted. Urine mercury concentrations should be measured in a uniform fashion every six months. The most accurate method is collection of 24 hour urine samples. If this is not practical, initial morning urine samples can be used.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluation and Technical Assistance Branch, 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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Joseph T. Luttmer, D.D.S.
2. NIOSH, Cincinnati Region
3. OSHA, Region V

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 calendar days.

Table 1
Surface Mercury Vapor Levels
Using Direct Reading Instrument
Joseph T. Luttmer, DDS
Cincinnati, Ohio HETA 87-265

		Mercury Concentration (mg/m^3)	
	Location	5/13/87	6/15/87
Room 1			
	at amalgamator	0.200	0.030
	at amalgamator (repeat)	0.214	
	in doorway	0.160	
	at sink cabinet	0.082	
	foot of chair	0.064	0.022
	below window	0.060	
Room 2			
	doorway between Rm 1 & 2	0.086	
	foot of chair	0.070	
	sink #1 (see diagram)	0.056	
	sink #2	0.059	
	small table at back of chair	0.061	
Room 3			
	hall doorway	0.073	
	sink #1 (see diagram)	0.056	
	sink #2	0.080	0.031
	at amalgamator (front)	0.278	
	between amalgamator & sink #2	0.486	0.030
	between amalgamator & back wall	0.620	
	carpeted wall across from amalgamator	0.880	0.030
	carpeted wall across from amalgamator (repeat)	1.216	
	carpeted wall 2 ft. above amalgamator	0.076	0.020
	in front of register	0.306	
	below window	0.121	

Table 1 (continued)
Surface Mercury Vapor Levels
Using Direct Reading Instrument
Joseph T. Luttmer, DDS
Cincinnati, Ohio
HETA 87-265

Location	Mercury Concentration (mg/m^3) 5/13/87	6/15/87
Room 4		
hall doorway	0.109	
sink #1 (see diagram)	0.074	
sink #2	0.067	
behind chair back	0.158	
between Rm 3 & 4	0.061	
carpeted wall near Rm 3	0.060	
Room 5		
hall doorway	0.055	
sink #1 (see diagram)	0.048	
sink #2	0.035	
foot of chair	0.036	
between Rm 4 & 5	0.040	
Room 6		
hall doorway	0.041	
at amalgamator	0.046	
dental chair side of bowl	0.029	
behind chair	0.027	
at table	0.028	
Panogram X-ray room		
in front of chair	0.043	
Hallway		
in front of reception desk	0.072	0.026
between Rm 5 & 6	0.057	
between Rm 2 & 3 & 4	0.053	
between Rm 1 & 2 & lab	0.055	0.032
records area	0.049	
billing area	0.041	
doctor's private office	0.041	0.018
Kitchen		
in front of sink	0.090	0.016
underneath table next to window	0.059	
underneath table next to window (repeat)	0.045	

Table 2

Mercury Levels Measured in Vacuum Cleaners

Joseph T. Luttmer, DDS
Cincinnati, Ohio
HETA 87-265

Vacuum Cleaner	mg/m^3
located under sink near X-ray unit:	
crevice tool connected to hose	1.129
upright located in kitchen (green bag):	
beater brush roller	0.157
beater brush roller (repeat)	0.222
canister cleaner located in kitchen:	
hose entrance	1.219

Table 3

Mercury Vapor Levels in Air
Using Direct Reading Instrument

Joseph T. Luttmer, DDS
Cincinnati, Ohio
HETA 87-265

Location		mg/m^3
Room 1:	center of room	0.051
Room 2:	center of room	0.052
Room 3:	center of room	0.053
Room 4:	center of room	0.060
Room 5:	center of room	0.061
Room 6:	center of room	0.066
Laboratory		0.048
Panogram X-ray Room		0.051
Reception Area		
	near hallway door	0.049
	far end of area (opposite entrance)	0.057
Outside		
	front of building	0.024
	back of building	0.007

Table 4
Results of Personal Breathing Zone
and Area Mercury Samples
Joseph T. Luttmer, DDS
Cincinnati, Ohio
HETA 87-265

Location	Date	Sampling Duration	Sample Volume	Mercury Concentration (mg/m^3)
Personal:				
Dentist	6/15/87	0803-1704	48 L	0.019
	6/16/87	0741-1653	48 L	0.020
Dental Assistant	6/15/87	0802-1650	44 L	0.020
	6/16/87	0751-1651	49 L	0.020
Dental Hygienist	6/15/87	0755-1649	41 L	0.020
	6/16/87	0753-1651	44 L	0.020
Receptionist	6/15/87	0835-1704	45 L	0.016
	6/16/87	0834-1651	41 L	0.017
Area:				
Room 1	6/15/87	0932-1133	12 L	0.021
Room 1	6/15/87	1430-1630	12 L	0.018
Room 1	6/16/87	0848-1659	45 L	0.022
Receptionist	6/16/87	0855-1659	48 L	0.016
NIOSH Recommended Exposure Limit				0.050