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Lead and Methylene Chloride Exposures Among Automotive Repair Technicians

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Potential exposures among repair technicians engaged in vehicle resurfacing operations prior to spray painting have not been thoroughly characterized. Environmental and personal air monitoring conducted in the State of Rhode Island have shown that automotive repair technicians may be exposed to metal particulates in sanding dust and methylene chloride vapors during vehicle paint removal operations. Hand wipe samples demonstrated that metals in sanding dust adhered to the hands of workers throughout the duration of the work day and were available for incidental ingestion from the handling of food/nonfood items and hand-to-mouth contact. A blood lead (PbB) screening effort among 21 workers at 2 facilities showed that 4 non-/less-exposed workers had mean PbB levels at the U.S. geometric mean of 2.8 μg/dL, while 2 out of 9 (22%) dedicated vehicle repair technicians had PbB levels at or above 30 μg Pb/dL whole blood—the level for potential adverse reproductive effects. Methylene chloride exposures were also found to exceed the Occupational Safety and Health Administrations (OSHA) 8-hr time-weighted average (TWA) action level and permissible exposure limit (PEL) in a limited number of samples (120 and 26 ppm, integrated work shift samples). Our findings suggest that thousands of professional technicians and vocational high school students may be at increased risk of adverse reproductive and/or other systemic effects.

Keywords automobile refinishing, blood lead, chemical paint stripping, lead, lead paint, methylene chloride

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INTRODUCTION

Prior to spray painting, body repair technicians (known in the trade as "body men") perform a myriad of vehicle repair and surface preparation operations including frame straightening, welding, grinding, chemical paint stripping, silica sand blasting, the application of adhesives and styrene-based "body filler" compounds, surface sanding, solvent cleaning, and spot spray painting (i.e., priming). Best available engineering control technologies (for example, ventilated sanding equipment) are not always employed during these operations, and workers often fail to adequately protect themselves from potential workplace exposures.[1−3]

In this study, we evaluated worker exposure to lead in dust and methylene chloride vapors generated during two operations: air-assisted orbital sanding and chemical paint stripping. This investigation was conducted as part of a larger study that aimed to characterize facility operations, work practices, and risk reduction strategies in the Rhode Island automotive refinishing industry sector.[4,5] While reports concerning lead and methylene chloride exposures among Rhode Island body repair technicians could not be located, work published by researchers in other states hinted at the potential for lead exposure during vehicle sanding operations.

In 1979, for example, Powell[6,p.340] observed that "a worker who held [a] sanding disc between his teeth when not grinding on automotive bodies presented evidence of lead intoxication although the environmental levels for lead were essentially negative."

More than 10 years later, while studying the effectiveness of ventilated sanding equipment, National Institute for Occupational Safety and Health (NIOSH) researchers also noted that the short-term airborne Pb level on a worker who sanded on plastic body filler compound was 90 $\mu g/m^3$.[7] These findings are noteworthy since, historically, much of the focus in this industry has been on preventing exposures while spray painting, with relatively less attention given to lead dust generated during sanding on painted surfaces or cured body filler compound. While lead in many of the newer coating systems has been reduced or eliminated, some of the older automotive paints that are currently mechanically sanded may still pose a lead hazard.

Given the prevalence of repair operations—roughly 60,000 commercial facilities, 20,000–40,000 "backyard operations," 1400 vocational technical high schools, and more than 400,000 workers employed nationally[4,5]—and the paucity of data concerning occupational exposures associated with employment as a body man, our goal was to undertake a pilot study of the hazards encountered by "dedicated" repair technicians (exclusive of professional painters) during surface sanding and methylene chloride paint stripping. Personal air samples for dust (total, respirable, and inhalable), metals, and methylene chloride vapors were collected at two complete vehicle repainting facilities (shops that specialize in repainting the entire surface of cars and small trucks) and one vocational technical school located in Rhode Island. The results of hand wipe samples and a blood lead (PbB) screening effort among 21 employees are also presented. Major exposure pathways and practical risk reduction measures for industry workers are discussed.

MATERIALS AND METHODS

This study focused on developing a general understanding of potential workplace exposures encountered by body men during vehicle sanding and methylene chloride paint stripping. Our field efforts were directed toward determining whether methylene chloride exposures could exceed OSHA PELs and whether dust particles presented an inhalation or ingestion hazard, though no formal attempt was made to define particle size distributions. Though we did not initially intend to obtain blood lead samples, field observations of workplace conditions (such as workers eating and drinking in production areas, coupled with poor personal hygiene) eventually led us to collaborate with Rhode Island Department of Health (DOH) officials in the screening of 21 workers at two large, complete vehicle repainting facilities.

Air Monitoring

Dust and Metals

Air monitoring for total, respirable, inhalable dust, and metals was performed at a large vehicle repainting facility where approximately 80% of the total annual work flow, estimated to be 1100 vehicles per year, was comprised of complete vehicle repainting. This facility employed 14 people, including 5 dedicated body repair technicians (i.e., workers who mechanically sanded vehicles 6 to 8 hours a day, 5 days per week) and 1 dedicated spray painter. At a second facility of comparable size (i.e., 1400 vehicle annual throughput, 5 body men, and 1 dedicated painter), DOH industrial hygienists performed personal air monitoring for total/respirable dust and metals. Total and inhalable dust samples were also taken at a vocational technical high school where students sanded on paint under the close supervision of their instructor. Altogether, 17 total/inhalable and 4 respirable dust samples were taken at the 3 facilities.

Dust samples were collected while technicians and students sanded with either ventilated or nonventilated equipment. Total and respirable dust samples were collected using 37 mm MWAA (matched weight Millipore 0.8 μm mixed cellulose ester filters) three-piece plastic cassettes, and 10 mm nylon lapel cyclone MSA samplers, respectively. Inhalable samples were collected using SKC Institute of Occupational Medicine (IOM) inhalable dust samplers (catalog no. 225-70; SKC, Eighty Four, Pa.). Laboratory-calibrated SKC 224-PCXR series universal sample pumps were used in all cases, including air monitoring for methylene chloride as described below. Pumps were calibrated with a primary standard; pre- and postcalibrations were within 5%. Pump flow rates for total dust samples varied between 2.4 and 2.8 L/min. Flow rates for IOM and cyclone samplers were 2.0 L/min and 1.7 L/min, respectively. Dedicated body repair technicians were sampled over entire work shifts excluding lunch breaks, while vocational school students were monitored for just over 3 hours.

Hand wipe samples were taken just before lunch and at the end of the work shift. Standard 5″ × 7″ PaceWipes (manufactured by Pace Environs, Inc., Cary, N.C., to ASTM standard E1792-96a for sampling lead in dust) were used to sample hand surfaces and then packaged in plastic twist-lock bags for transport to the laboratory.

Methylene Chloride

Personal air monitoring for methylene chloride was conducted for one day in the spring and fall. The sampling train consisted of Anasorb CSC Coconut Charcoal (SKC #226-01) tubes and SKC 224-PCXR series universal sample pumps. Pump flow rates for each of two 4-hr personal air sampling events were 40–53 cc/min. Three task-based samples, 9 to 18 min in duration, were also taken.

Blood Lead Testing

Blood samples of 21 workers employed at the two repainting facilities were taken by a trained technician and certified industrial hygienist from the Rhode Island Department of Health, Occupational and Radiological Health Division, Providence. Microtainer safety flow lancets (Becton Dickinson Vacutainer Systems, Franklin Lakes, N.J.) were used for the finger stick procedure. To minimize the potential for false positive readings, all blood samples were drawn after the weekend, on a Monday morning just prior to the start of the work shift. Subjects' hands were washed with a commercial soap, dried, and then cleaned with an alcohol pad. On two separate occasions, blood samples from one of the body men coagulated before they could be analyzed. As a result, a venous sample from this worker was drawn at a local clinic.

A multipart Rhode Island DOH specimen form and employee questionnaire were completed just prior to blood sampling. The questionnaire sought information on job title, work history, and length of time employed in the industry; hours engaged in sanding/grinding, spray painting, chemical paint stripping, and other operations; smoking status; hobbies outside of work—hunting/shooting firearms, stained glass work, furniture refinishing, making pottery; auto repair work for family/friends; scraping/painting homes; personal hygiene (i.e., frequency of hand washing at work, use of gloves and respirators, and habitual nail biting); and the consumption of ethnic foods/folk remedies such as greta or azarcon for an upset stomach—that might influence blood lead results.

Laboratory Analyses

All personal air monitoring samples were analyzed by an industrial hygiene–environmental health laboratory accredited by the American Industrial Hygiene Association for metals, silica, organic solvents, asbestos, and other fibers. Samples for total metals were analyzed by inductively coupled plasma-atomic emission spectrometry (ICP-AES) according to Occupational Safety and Health Administration ID-125G protocol,(8) while NIOSH method 0500 was used for all gravimetric determinations.(9) Volatile organic compounds were determined by gas chromatography using NIOSH method P&CAM 127. Blood lead samples were analyzed by the Rhode Island DOH laboratory using atomic absorption spectrometry with graphite furnace.

TABLE I. Personal Air Monitoring Data by Operation

Airborne Dust, Lead, and Methylene Chloride Concentrations[A]	
Orbital Sanding (mg/m^3)	
Nonventilated Equipment	*Ventilated Equipment*
Total dust (Pb)[B]	Total dust (Pb)
11.3 (ND < 0.013)[C]	12 (0.02)[H]
8.2 (ND < 0.013)	3.5 (ND < 0.0074)[I]
4.8 (ND < 0.011)	1.1 (ND < 0.028)[J]
4.3 (0.047)[D]	0.62 (ND < 0.028)[K]
2.4 (ND < 0.013)	Inhalable dust (Pb)
NA (0.0072)[E]	38 (0.014)[I]
NA (0.0039)[F]	32 (0.12)[H]
NA (ND <= 0.0027)[G]	6.5 (ND < 0.036)[K]
Respirable dust (Pb)	3.8 (ND < 0.019)[J]
1.19 (ND < 0.0005)[F]	**Chemical Paint Stripping (ppm)**
1.14 (ND < 0.0011)[G]	
0.834 (ND <= 0.0012)[E]	*Methylene Chloride*
0.57 (ND < 0.0033)[D]	26, 120
Inhalable dust (Pb)	Task-based, <20 min
NA (0.036)[C]	72, 93, 120

Note: ND = not detected; NA = not analyzed for, gravimetric determination not made; Pb = lead; Respirable dust = 10 mm MSA nylon lapel cyclone sampler; Inhalable dust = Institute of Occupational medicine inhalable dust sampler.

[A] Integrated work shift samples, unless otherwise noted.

[B] Values shown in parentheses are for lead.

[C−K] Simultaneous personal air samples.

RESULTS

Personal and Area Samples

Gravimetric and Metals Analyses

Gravimetric data from personal air monitoring are shown in Table I. The total dust concentration on one technician who sanded paint with nonventilated equipment in the summer was 4.3 mg/m^3, and metals analysis revealed detectable levels of Al, Cr, Co, Fe, Pb, and Zn. The airborne concentrations of these metals with the exception of Pb, which measured at 0.047 mg/m^3, however, were well below applicable threshold limit values (TLVs®); lead was present at 1.4% in the total airborne dust. Lead was not detected in a simultaneous respirable dust sample. Total dust on a second technician who engaged in a number of panel repair activities including sanding, grinding, and welding on the same day was 2.4 mg/m^3, and no detectable level of lead was found.

By comparison, though the concentration of total dust on the first technician listed above was 11.3 mg/m^3 on one day in November, lead was not detected. This technician, however, also wore an inhalable dust sampler that resulted in the detection of higher metal concentrations, as well as Pb at 0.036 mg/m^3.

Gravimetric results for three respirable dust samples taken by DOH while body men sanded on painted surfaces with nonventilated equipment were 1.19 mg/m^3, 1.14 mg/m^3, and 0.834 mg/m^3. Metals analysis of the respirable dust samples revealed detectable levels of Ba, Fe, Mg, Mn, and Zn; Pb was not detected in any of the samples. Simultaneous total dust samples (though gravimetric analyses were not performed, Table I) showed lead concentrations in the breathing zone of two workers to be 0.0039 and 0.0072 mg/m^3.

Simultaneous total and inhalable dust samples were taken of four individuals (two professional body men and two vocational school students) who used ventilated equipment while sanding on painted surfaces (column 2, Table I). Airborne dust levels ranged from 0.62 to 12 mg/m^3 total dust, and 3.8 to 38 mg/m^3 inhalable dust. Lead was found in the breathing zone of the two professional body men (0.028 mg/m^3 total dust; 0.12 and 0.014 mg/m^3 inhalable dust, Table I), but not the students, who exhibited lower overall total and inhalable dust levels.

Metals present in the sanding dust(4) were found at similar frequencies on the hands of workers; one notable exception was arsenic, which was below the limit of detection (LOD). Metals found at the highest levels included Pb (2.64–211 μg per hand wipe), Ba (60.9–459.6), Zn (60.1–8,580), Fe (324–6,750), and Al (ND<12.5–766).

Methylene Chloride

Solvent vapor concentrations measured during chemical paint stripping operations are shown in Table I. Personal methylene chloride air monitoring samples, taken on the same technician during the spring and fall, exceeded OSHA's 8-hr TWA action level (12.5 ppm) and PEL (25 ppm), respectively; other solvents were also detected but at concentrations orders of magnitude below any applicable PEL or TLV. Methylene chloride vapor concentrations were below the OSHA 15-min short-term exposure limit (STEL) of 125 ppm during three personal task-based sampling trials conducted one day in the spring.

Blood Lead Testing

Blood samples representing a cross-section of employees (i.e., front office salesmen, owners, body men, spray painters, detailers, and shop managers) were obtained from two facilities—Refinishing Facilities A and B, Table II. The data for each facility, organized by job function, show a general trend of increasing PbB concentrations from employees who work in the front office (non-/less-exposed workers) to those who sand vehicles for 6 to 8 hours per day. Facility B presented the widest range in PbB concentrations, 2 μg Pb/dL blood to 38 μg/dL. Professional spray painters at both facilities had lower blood lead levels than body men.

The data collected from an employee questionnaire did not reveal any potentially significant nonworkplace exposures that could alone or in combination account for elevated PbB levels among the body men. In response to questions concerning hobbies and foods/folk remedies, only two shop employees (Refinishing Facility B) indicated that they either worked with stained glass or hunted. (This individual, however, had not been hunting for one year prior to the blood lead test.) Several others indicated that they occasionally engaged in autobody work for family and friends outside of work as noted in Table II; however, blood samples at both facilities were drawn in the winter, and it is unlikely that this potential source could have significantly contributed to blood lead levels.

DISCUSSION

The data presented in this article, as supported by prior research findings,[4,5] suggest that occupational and environmental health risks attributable to metal particulate and methylene chloride vapors exist in the U.S. automotive refinishing industry. In general, these risks tend to be greater at facilities that engage in chemical paint stripping and sanding painted surfaces for extended periods of time without appropriate engineering controls or personal protection. Technicians who sand on cured body filler compounds that contain lead and other toxicants may also face inhalation and/or ingestion hazards. Moreover, potential exposures among vocational school adolescents and women of childbearing age have not been adequately characterized. Though females presently comprise only about 1% of the work force (most are employed in administrative capacities), there has been a call for increased hiring of women in production roles.[10]

Metal Particulate Exposures

Hand wipe samples taken over 4- and 8-hr periods confirmed that the metals in sanding dust were also present on the skin of workers. With the exception of arsenic, reported to be

TABLE II. Employee Blood Lead (PbB) Laboratory Data for Two Complete Vehicle Repainting Facilities

	Refinishing Facility A				Refinishing Facility B		
Job Function	Hrs/Day Sanding[A]	Smoker (packs/day)	PbB (μg/dL)	Comments	Hrs/Day Sanding[A]	Smoker (packs/day)	PbB (μg/dL)
Bodyman	6–8	S (1/4 − 1/2)	28[B,C]	venous sample[D]	6–8	NS	38[E]
Bodyman	6–8	NS	11		6–8	S (1)	24[E]
Bodyman	6–8	NS	10		4	NS	22[E]
Bodyman	6–8	S (<1/4)	4	good hygiene practices	6–8	S (<1/2)	13[C] hobby: hunting
Bodyman					3	S (2)	9[C]
Shop manager	1–2	S (1/2)	16[B]		0	NS	8[C,F] hobby: stained glass
Detailer					2	S (1)	8 mostly detail work
Detailer	0	NS	8		0	S (1/2)	5[C]
Owner	0	NS	8	manages office[F]	0	NS	2 manages office
Painter	0	NS	6		0	NS	4
Masker	0	NS	5				
Office salesman	0	NS	3		0	S(1)	4
New employee	0	S (1/2)	2	1st day on job			

Note: S = smoker; NS = nonsmoker.
[A] Hours approximated based on observation and self-reported data for a 9-hr workday; less frequent and variable duties may also include surface grinding, chemical paint stripping, welding, spot sand blasting and priming, and application of body filler compound.
[B] Observed smoking/drinking (coffee) in immediate work area.
[C] Performed auto body work for family/friends outside of work.
[D] Laboratory was unable to run lead analysis on blood samples obtained on two separate occasions using finger stick method due to clotting. A third (venous) sample had to be taken.
[E] Ate/drank in immediate work area (self-reported).
[F] Occasionally assisted in shop clean-up (e.g., swept floors) or other body shop activities.

below the LOD, all of the metals typically found in sanding dust[4] were also detected, with nearly identical frequency, on the hands of each worker. This demonstrated that sanding dust not only adhered to the hands of workers (where lead was detected at median and maximum values of 104 and 211 μg Pb/hand wipe, respectively) but that metals were present over extended periods of time, that is, throughout the duration of the workday, where they were available for incidental ingestion from the handling of food/nonfood items and other hand-to-mouth contact. This finding had direct relevance to the behavior observed in shops where technicians were observed to eat, drink, and smoke in the immediate work area without washing their hands. It has been estimated, for example, that hand-to-mouth behavior in a pack-a-day smoker is repeated approximately 200 times each day.[11]

Air monitoring conducted during this study confirmed that lead and other metals detected in sanding dust and on the skin may also be found in the workplace air and breathing zone of workers. While dust concentrations were generally higher in the fall, lead was not detected in the total dust samples for any of three technicians monitored during that time (Total dust entries 4.8, 8.2, and 11.3 mg/m^3, Table I). A simultaneous personal air sample taken on one of the three workers with an IOM sampler, however, showed that lead was present at a concentration of 0.036 mg/m^3. Had lead been present in the total dust of the fall samples at the same concentration found in the summer (1.1%), OSHA's PEL for lead (50 μg/m^3) would have been exceeded. This, in fact, is what the Minneapolis Area Office of OSHA found while sampling a worker in Wisconsin who was sanding a 1975 Ford truck on January 27, 1999. The 8-hr TWA for lead in the worker's breathing zone was measured at 110 μg/m^3.[12,13]

Biological Monitoring

While personal air monitoring is used to assess compliance with occupational exposure limits, biological monitoring can provide valuable data on lead absorption and, therefore, potential adverse health risks. For inorganic lead and blood-soluble lead compounds, it is well established that the absorbed dose reflects recent multipathway exposures integrated over a period of about 28 or 36 days (the biologic half-life of lead in blood).[14] In our PbB screening study, four non-/less-exposed workers (Facility A: office salesmen and new employee; Facility B: office salesman and shop owner, Table II) had a mean PbB concentration at essentially background levels (2.8 μg/dL, U.S. geometric mean),[15] while the mean PbB concentration for eight bodymen who did not wear or were inconsistent in their use of personal protective equipment was 19 μg/dL (range 9 to 38 μg/dL). The mean age and number of years that these workers had been employed in this industry were 39 (range 18 to 57) and 23 (range 2 to 38), respectively.

Increasing PbB levels observed at both facilities, from the non-/less-exposed workers to body repair technicians who engage in sanding for 6 to 8 hours per day, strongly suggest that vehicle paint dust present in the occupational environment is the principal source of lead exposure among these individuals. The lack of potential nonworkplace exposures, assessed through an employee questionnaire, further supports the conclusion that the lead in the paint-dust matrix is bioavailable.

Although PbB concentrations for the nine bodymen were under OSHA's PEL of 40 μg/dL whole blood (said to be protective of "most workers"), the agency acknowledges that the inhibition of heme biosynthesis and adverse reproductive effects may occur at levels below this concentration.[16,17] Whether low PbB levels are also causally related to hypertension is currently being debated.[14] Due to the potential for adverse effects on reproductive function and genetic damage to the ovum and sperm, OSHA recommends a 30 μg/dL maximum blood lead level in males and females who are planning to have children.[18] OSHA further cautions that workers whose PbB levels are less than 30 μg/dL "may still be at risk [of adverse reproductive effects] especially if they have extended tenure in a lead industry."[17,p.39]

Although our sample size was small and involved only two facilities, the fact that two technicians out of nine (22%) had PbB levels of 28 and 38 μg/dL raises concern over the potential for adverse health impacts on workers, who may be uninformed about the hazards associated with vehicle sanding. Evidence supporting this concern is provided by a 1994 Illinois Department of Public Health case report[19] of a body man who also had an elevated PbB level (32 μg/dL), and by results of a 1998 industry-wide survey showing that most U.S. males ($>$80%) who work in the industry are within the age group of $<$21 to 45 years old, most likely to be planning a family.[20] Clearly, educational and intervention strategies are indicated for body men whose PbB levels may put them at increased risk for adverse reproductive effects.

The implications of these findings are important because concurrent exposure to low-level concentrations of other metals (including arsenic and cadmium) and toxic organics (for example, di-2-ethylhexyl phthalate and butyl benzyl phthalate, EPA probable and possible human carcinogens, respectively)[4,21,22] found in sanding dust may also occur via ingestion and/or inhalation pathways. Finally, because lead is primarily stored in bones where the biologic half-life is more than 20 years,[15,23] it is possible that older body men who may have worked extensively with higher lead content paint systems in the past currently maintain elevated total body burdens of lead.

Methylene Chloride Monitoring

Analysis of 1998 statewide survey data[5] showed that approximately 17% to 22% of all Rhode Island licensed auto body shops (n = 353) used methylene chloride in addition to mechanical sanding. At Facility A (Table II), for example, approximately one to two gallons (ca. 2.5 pints per body man) of methylene chloride was used each week. Personal air monitoring conducted at this shop showed that in addition to lead dust, technicians who also engage in chemical paint stripping can be exposed to methylene chloride vapors at or above OSHA's revised 8-hr TWA PEL. Solvent concentrations in the breathing zone of one worker exceeded OSHA's action level and PEL for methylene chloride in the spring and fall, respectively (Table I). This technician engaged in chemical paint stripping an average of 1–2 times per week, 3–4 hours per day (self-reported). As with personal air monitoring for total dust, breathing zone concentrations for methylene chloride were higher in the fall than during the warmer months when overhead facility doors were open and floor fans running. Three task-based samples were below OSHA's STEL, which was established to reduce the potential for adverse cardiovascular and central nervous system effects resulting from acute exposures.[24]

RISK REDUCTION

One method for reducing occupational and environmental health risks associated with metal particulates is to use ventilated sanding equipment. This engineering control technology was demonstrated by NIOSH to be effective at reducing airborne dust concentrations by a factor of 10 when sanding on body filler compound.[1] Limited personal air monitoring conducted by the authors at a vocational technical high school appears to confirm that portable ventilated sanders can be effective at reducing airborne dust levels. Total dust levels on two students, who sanded on painted surfaces under the close supervision of instructors, were 0.62 and 1.1 mg/m^3 (Ventilated Equipment, Table I). When technicians are inadequately trained or when ventilated equipment is not properly used however, we also found that total dust levels while sanding on painted surfaces can be as high as when nonventilated units are employed. One technician (Table I), for example, had a total dust concentration of 12 mg/m^3 when sanding (in the spring) with a ventilated unit. The concentration of Pb in the total dust sample of this worker was 0.02 mg/m^3. By comparison, a simultaneous breathing zone sample taken with an IOM sampler resulted in a Pb concentration of 0.12 mg/m^3.

Although ventilated sanders may reduce workplace exposures to body filler dust and metal particulates, they cannot eliminate risk entirely. When used, ventilated equipment captures much but not all of the dust that is generated during sanding. Some of the dust falls to the floor, becomes airborne, or remains on the vehicle's surface. Over the course of a workday, technicians lean against the vehicle (resulting in the contamination of their clothes), run their hands along the surface being sanded, and, in many shops, use high-pressure air to blow residual dust off clothes and working surfaces. Wipe samples taken from both vocational high school students and professional technicians who used ventilated sanders showed that lead was still present (range 12.2 to 319 μg) on the hands of workers in every sample tested.

Based on the data presented in this article, the best approach for reducing occupational and environmental health risks associated with dust from shop operations appears to be a combination of engineering controls (e.g., ventilated equipment) and personal protection (e.g., disposable gloves). Changing clothes and shoes at work, frequent washing with a suitable hand cleaner, and not using high-pressure air to blow dust from surfaces are also indicated. On a national scale, the continued elimination of lead from automotive paint systems and toxics reduction in body filler compounds are the most reliable approaches for reducing future workplace exposures.

Health risks associated with the use of methylene chloride can be reduced through product substitution, engineering controls, and/or personal protection measures. The most effective method for controlling exposures among technicians is product elimination or chemical substitution. Considering that fewer than 1 in 5 body shops reported using methylene chloride, the question arises as to whether chemical paint stripping in automotive refinishing is necessary at all.

A comparison between two major vehicle refinishing facilities (Facility A and B, Table II) provides insight into paint removal operations conducted within similar production environments. Facilities A and B, located within 10 miles of each other, perform the same type of work (complete vehicle repainting), employ the same number of bodymen, and process similar vehicle makes/models. While each facility can be characterized as a "high-volume shop," only the smaller of the two shops, Facility A (which has a 20% lower annual throughput), engages in chemical paint stripping—using on average more than 4 gallons of methylene chloride-based product each month. When asked about the need for chemical paint strippers in refinishing operations, several professionals (including an experienced vocational school instructor) have indicated that usage is driven for the most part by technician preference. That is, some technicians like using methylene chloride-based products because they are fast acting (penetrating quickly through multiple layers of paint), effectively saving time that would otherwise be spent sanding. This comparison suggests that chemical paint stripping is not a necessary operation in automotive refinishing.

CONCLUSIONS

Vehicle refinishing operations may result in exposure to a range of chemical substances. Sanding on lead-based paints was found to result in slightly to moderately elevated PbB levels among several technicians who failed to adequately protect themselves. The cumulative health risks resulting from concurrent multipathway exposures to low-level concentrations of lead, other metals (such as arsenic), and toxic organics found in sanding dust are unknown. The results of personal air monitoring conducted during this study indicate that where appropriate engineering controls or personal protective equipment are not employed, technicians who engage in chemical paint stripping are also at risk of exposure to methylene chloride vapors at or above OSHA regulatory limits. Together, these findings suggest that thousands of professional body repair technicians and vocational students (who train in schools and work part-time in the trade) may be at increased risk of adverse reproductive and/or other systemic effects.

While there has been concern over the potential for lead exposure in the spray painting profession, our data suggests that among today's U.S. automotive refinishing workers, those who remove paint (body men) at large repainting facilities are more likely to be overexposed to lead than those who apply it (spray painters). Employers in this industry sector therefore may need to reevaluate their health and safety programs, especially with regard to the OSHA requirement calling for initial exposure monitoring in workplaces where lead is present "in any quantity."[25] In developing countries where older vehicles are maintained for longer periods of time and engineering controls/personal protective measures used less often, the potential for exposure may be even higher. Due to the diverse nature of their work, additional research is needed to better characterize occupational exposures and potential adverse health impacts among body repair technicians.

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