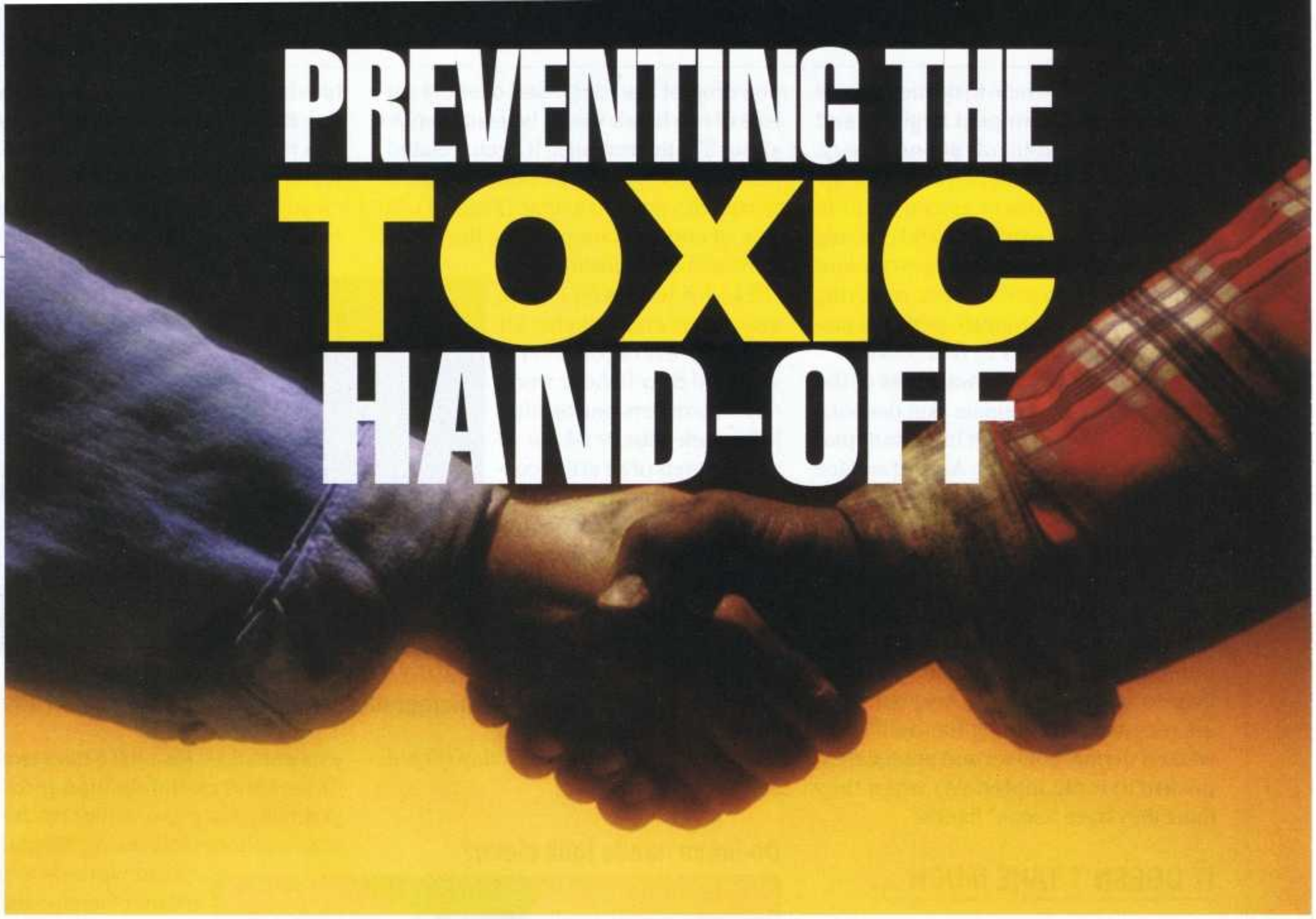
PREVENTING THE TOXIC HAND-OFF



Why it's import to identify and remove lead (and other toxic elements) from workers' skin and contact surfaces.

by Eric Esswein and Mark F. Boeniger

In Vienna, Austria, in the mid-19th century, a young assistant physician named Ignac Semmelweis (1818-1865) became an extremely controversial personality for a reason that seemed absurd at the time: He demanded that people wash their hands. A simple proposition? Not really. At that time, mortality rates in European maternity hospitals ranged from 25 to 30 percent of all births. Many believed these deaths were a normal consequence of birthing; some even considered them non-preventable. The principal cause of death was postpartum infection, also known as puerperal or childhood fever.

Semmelweis, being a good scientist, was an especially keen observer; his observations made him a zealot about the need for hand decontamination. After studying many hospital-related deaths (including that of a close friend who died from a wound infection), Semmelweis correctly predicted that hand washing was the key to preventing the contagion responsible for puerperal fever.

Semmelweis published articles that raised considerable consternation and even outrage among his peers and colleagues because his proposals were a cutting indictment to their ignorant practices. Semmelweis' conclusions served as a basis for future investigators (Kock, Pasteur, Lister) who went on to develop the germ theory of disease for which they became known as distinguished thinkers and contributors to the art and science of public health.

WHAT'S SO IMPORTANT ABOUT HAND WASHING?

For most workers it's not really a big issue, while for others it's a job requirement. Health care workers spend hours of in-service training studying infection control practices, particularly the importance of hand washing. Health care workers understand that: 1) hands spread contamination; 2) hand washing is a proven means to reduce contamination; and 3) people don't wash their hands often enough, nor well enough.

UNSEEN OR UNKNOWN DERMAL EXPOSURES POSE EXPOSURE RISKS TO WORKERS

Do workers really know what types of contamination might be on their hands or how to effectively remove these contaminants? With the exception of sewage treatment plant workers and plumbers, most workers generally don't lose sleep worrying about skin contamination (and decontamination) with toxic materials. Hand washing becomes a perfunctory obligation before eating, smoking and after using the toilet. But at the end of the day, how clean is clean and why does it matter?

In workplaces where toxic metals pose exposure risks, stringent hygiene and housekeeping protocols are necessary. In addition to engineering controls, appropriate work practices can include showering after a work shift, and clothing change-outs before leaving work and during breaks. In some cases, requiring workers to use appropriate personal protective equipment (PPE) is necessary.

Developing worker awareness of the importance of appropriate skin decontamination also can be an important part of preventing exposures. Air and surface wipe sampling can identify exposure risks, but most workers are unlikely to appreciate the risks that unseen surface contaminants – toxic metals, for example – may pose. More importantly, they are unlikely to know how effective they are in removing these contaminants when they do wash their hands. Are your workers receiving the "toxic hand-off" (unwanted dermal contact and potential exposure to toxic materials) when they think they have "clean" hands?

IT DOESN'T TAKE MUCH ...

What workers don't know they have on their hands could result in serious harm, because even minute or invisible amounts of toxic metals such as lead or cadmium can be transferred to food, beverages and cigarettes. Workers may ingest these substances or take them home, presenting exposure risks to the family. With sufficient doses over time, toxic metals accumulate in the body and cause a variety of health problems. Despite a rigorous program of industrial hygiene controls, well-thought-out work practices and PPE use, toxic hand-offs still occur and can result in unanticipated exposures and toxic body burden.

Most managers know that smoking and eating in the workplace should not be allowed because workers with "dirty" hands might transfer contamination to food or cigarettes. The level of concern depends on the toxicity of the contaminant/substance, not only on how much is on the skin. For example, a small quantity of a highly toxic substance could be much worse than a larger quantity of a mildly toxic substance. Paracelsus stated, "the dose makes the poison" so for the purposes of illustration, let's use lead (an ancient poison) as an example.

Lead is a particularly dense compound. A drop of lead weighs about 570,000 micrograms.[1] Only one-one thousandth of one drop of lead dispersed over the surface of two hands would be equivalent to about 570 micrograms. If accumulated, this amount would be about the size of Roosevelt's nose on a dime (Figure 1). By way of another comparison, the OSHA Permissible Exposure Limit (PEL) for lead is 50 micrograms per cubic meter air (µg/m3) averaged over a standard 8- to 10-hour workday. If workers performing light work activity inhale 10 cubic meters of air at this concentration during the work shift, they would inhale about 500 µg of lead.[2] Clearly this is a minute amount of lead; if present on a worker's hands, it would be invisible. However, this same amount would represent a significant exposure dose if repeatedly absorbed by the body each day (Figure 2).

FIGURE 1: As this photo demonstrates, 500 micrograms of lead oxide is a very small amount.

Do these hands look clean?

FIGURE 2: Although these hands may look clean, they have 500 micrograms of lead oxide rubbed into the palms.

SKIN CONTAMINATION AS A CONTRIBUTOR TO ORAL INGESTION EXPOSURES

National Institute for Occupational Safety and Health (NIOSH) researchers measured workers' hand contamination during health hazard evaluations (HHEs) at two lead battery manufacturing facilities. Hand wipe samples were collected from numerous workers using pre-moistened towelettes. In both facilities, results of hand wipe samples taken as workers engaged in activity showed lead contamination between 6,000 to 20,000 µg per pair of hands. After workers washed their hands with soap and water, contamination decreased to an average 530 µg, but was far from eliminated.[3,4] Even though workers washed and appeared to have clean hands, the quantity of lead on their hands was equivalent to the permissible exposure dose for a full 8-hour work day. Thus, hand contamination provided a potential (but preventable) risk for exposure for these workers. Additionally, because workers were unaware of getting the toxic hand-off, they potentially took toxics home on their hands.

In the first facility, significant surface contamination with lead was detected on the cafeteria's doorknobs and numerous other skin contact surfaces such as the stainless steel railing in front of the steam table, the steam table itself, buttons on soft drink machines and on the tabletops. In all cases, surface contamination was invisible. Paired wipe samples from opposite sides of a table were consistently similar, suggesting that individual tables were contaminated uniformly, but differences existed between pairs of samples collected and compared table to table. In the same facility, an investigation of six randomly selected workers who said they had washed their hands prior to entering the cafeteria demonstrated that surface contamination of lead contributed to hand contamination. Paired hand wipe samples collected before workers entered the cafeteria and again after eating showed a statistically significant increase of lead on the skin of both hands after eating (Figure 3). In both facilities, em-

CFR 1926.62(i)(4)(iii) 1910.1025(i)(4)(iii)	The employer shall assure that employees whose airborne exposure to lead is above the PEL, without regard to the use of a respirator, wash their hands and face prior to eating, drinking, smoking or applying cosmetics.
CFR 1926.62(i)(4)(iv) 1910.1025(i)(4)(iii)	The employer shall assure that employees do not enter lunchroom facilities or eating areas with protective work clothing or equipment unless surface lead dust has been removed by vacuuming, downdraft booth or other cleaning method that limits dispersion of lead dust.
CFR 1926.62(i)(5)(i) 1910.1025(i)(5)	The employer shall provide adequate hand washing facilities for use by employees exposed to lead in accordance with 29 CFR 1926.51(f); Lavatories.
CFR 1926.62(i)(5)(ii) 1910.1025(i)(3)(i)	Where showers are not provided, the employer shall assure that employees wash their hands and face at the end of the work shift. The employer shall assure that employees who work in areas where their airborne exposure to lead is above the PEL, without regard to the use of respirators, shower at the end of the work shift.

TABLE 1

ployees removed the protective aprons worn in their work areas but did not change the remainder of their work clothing before entering the cafeteria. Similar increases in lead on hands were seen in the second facility, despite rigorous workplace controls and appropriate standard work practices such as vacuuming clothing and covering table tops with butcher paper that was replaced daily.

Two other NIOSH studies took place at a waste-to-energy plant and at a coal-fired power plant. In these studies, NIOSH investigators found similar employee hand contamination with lead, chromium, arsenic and nickel before and after washing as the employees prepared to eat.[5,6]

A recently published article described three cases of severe lead poisoning in the plastics industry. In the plants described, management relied heavily on material safety data sheets as a basis for comprehending the inherent health risks and necessary work practices when working with lead-containing materials. Neither workers nor management understood or recognized the hazards of the lead-containing products they used, or the PPE and stringent hygiene practices necessary to prevent exposures from the airborne or dermal routes.[7]

Numerous other workplace investigations have documented the contribution of dermal exposures to total body burden and have suggested the importance of hazard identification and dermal decontamination in reducing the workplace exposures.[8,9]

WHAT ABOUT OSHA REGULATIONS?

OSHA CFR 1910.141 (General Environmental Controls) includes requirements to maintain a clean and hygienic workplace, including providing uncontaminated eating facilities, change rooms and toilet facilities.

The OSHA lead standards, 29 CFR 1926.62 (construction) and 1910.1025 (general industry), provide numerous and specific requirements intended to provide hygienic conditions to reduce exposures to lead. Table 1 summarizes some of the requirements that discuss facility and personal hygiene.

While the OSHA lead standards contain performance language related to skin and surface hygiene, how do you really know if these requirements are adequate for your workplace and are effective for each worker? What level of action and compliance do you need to truly protect workers?

As the NIOSH and other studies have shown, exposure recognition and hand decontamination have a place in the overall picture of workplace health and safety, if for no other reason than awareness of risks can lead to better hazard control. Within the last 10 years, numerous techniques and methods have become available for sampling lead (and other elements) on work surfaces and on skin (specifically hands). Some of these sampling methods use colorimetric indicators to show the presence of lead visually, whereas other methods require sending the samples to an analytical laboratory for results. Each of these methods has advantages and disadvantages, and all were designed to meet a range of individual requirements, levels of sophistication and, of course, budgets.

Colorimetric methods provide immediate results and are inexpensive, but are limited to semi-quantitative assessments. In contrast, laboratory analyses provide quantitative results, but require much more time, sophisticated skills and training and specialized equipment. Costs for laboratory results are higher, but when collected by trained personnel using a standardized protocol, quantitative results are considered more definitive, but not always superior considering the urgency and questions that need to be answered at the time.

A number of commercially available colorimetric sampling products use the reagent sodium rhodizonate for lead detection. Rhodizonate in solution and at proper concentrations can be an exquisitely sensitive indicator of the presence of lead. Lead ions are substituted for sodium, producing a red color change. Rhodizonate also produces a color change in the presence of other ions, including barium, silver, cadmium, mercury, strontium and titanium, but it typically requires the presence of larger amounts of these elements to see a color change. The rhodizonate-based methods are not recommended for individuals who are color-blind to red-pink hues.

EM lead detection strips are an example of a commercially available colorimetric product based on the rhodizonate reaction. These look and function very much like the pH detection strips used to test liquids or surfaces for acids or bases. Other products include Lead Check (HybriVet, Natick, Mass.), which consists of a small paper tube containing two thin-walled glass ampoules, a product with rhodizonate solution and another containing a weak acid. Squeezing the tube crushes the ampoules, allowing the solutions to mix. Additional squeezing forces the solution into a quarter-inch applicator swab, which is rubbed against the surface to be sampled. If lead is present and can be solubilized by the acid, a reddish colorimetric reaction occurs. A product involving similar chemistry, but different application techniques, is offered by Sensidyne Pace Environs (Clearwater, Fla.) as a product called Lead Alert.

Another colorimetric option is using sodium sulfite for lead detection. This reagent, less sensitive than rhodizonate, turns dark grey in the presence of lead. Thus, it may be harder to distinguish if the wiped surface is dirty. Sodium sulfite also may react with silver, copper, iron, nickel and mercury. A product based on this reagent is called Lead Inspector (Abotex Enterprises, Detroit). The products mentioned so far are purely qualitative colorimetric detectors that cannot be analyzed at a laboratory and quantified.

A fourth product, Full Disclosure for Lead (SKC Inc., Sixty Four, Pa.) is a newly developed method designed specifically to address some of the problems inherent with other colorimetric methods (getting chemicals on skin, staining surfaces, no ability for quantitative analysis, etc.). Full Disclosure for Lead involves using an ASTM-certified wipe to collect the sample and then spraying the wipe with a leaching solution to solubilize the lead. Lead is then "disclosed" using a rhodizonate spray. The color change is immediate, and no chemical reagents contact the skin or the surface being tested. A color change occurs with 15 to 20 µg of lead. Full Disclosure wipes also can be sent to an analytical laboratory for quantitative confirmation with quantification to 1 µg.

PREVENTION OF HAND-TO-MOUTH LEAD TRANSFER

In concept, preventing hand-to-mouth transfer and ingestion of lead and other toxic metals is simple. If workers do not eat or smoke with contaminated hands, if lunchrooms and change rooms are kept free of contamination, and if workers leave the plant without taking contaminants with them (i.e., avoiding a toxic hand-off), then theoretically there should be little risk of exposure. In practice, however, keeping minute amounts of contamination off skin and skin contact surfaces can be quite challenging, and NIOSH studies clearly document these difficulties. Aside from controlling exposures through engineering controls, good housekeeping and work practices, appropriate PPE use and effective identification and decontamination of toxic metals can be considered linchpins in helping workers avoid the toxic hand-off.

WHAT CONSTITUTES EFFECTIVE DECONTAMINATION?

Figure 3 illustrates that hand washing using soap and water does not effectively clean skin or skin contact work surfaces. Contrary to what workers have been told for years, washing with soap and water is not an efficient and effective method to remove toxic metals from skin because more than surfaction is required to remove metals from skin. To address this issue, numerous commercial products specifically claim to be effective in removing toxic elements. These include various soaps and heavy-duty cleansers containing a variety of grits, surfactants and chelating agents such as EDTA. Controlled studies evaluating the efficacy of these products, including multi-element, blind subject testing, are not available. Some of these products are harsh and, if used daily, may contribute to or cause skin problems such as dermatitis.

NIOSH recently conducted controlled human comparison testing of various products advertised to remove lead and other toxic metals from the skin as part of development of a novel skin decontamination technique and product. As expected, and as illustrated in Figure 4, some products proved more effective than others, and most were better than standard soap and water. Included in this evaluation was the new technique NIOSH developed for use in industrial settings that specifically removes lead and other toxic metals from the skin. "Hands Off!" (a preliminary brand name that could change depending on the licensee) was developed based on a systems approach to skin decontamination. The design intent was to develop a skin cleansing product that incorporated three necessary aspects of metals decontamination: mechanical removal, surfaction and pH adjustment. The design philosophy included using materials that did not harm the skin and could be used repeatedly. Chelating agents, grits and irritating surfactants were specifically ruled out. The result was a novel method (patent pending) that removes metals extremely effectively, yet is kind to the skin. Results indicate that Hands Off! was statistically superior in removing lead and other metals (including Ni, Cd, As) from the skin compared with all the other commercial cleansers tested, including some containing scrubbers or even abrasive sand (H, N, I) and a hand wipe (G).

Workplace exposure to toxic metals, especially lead, is a problem of global significance. Controlling incidental routes of exposure is a challenging, but not impossible, task. Engineering controls, managerial practices, PPE and good work practices all are important aspects of an effective exposure control program. Now, new sampling and decontamination techniques can help identify lead exposure risks on work surfaces and skin. Effective decontami-

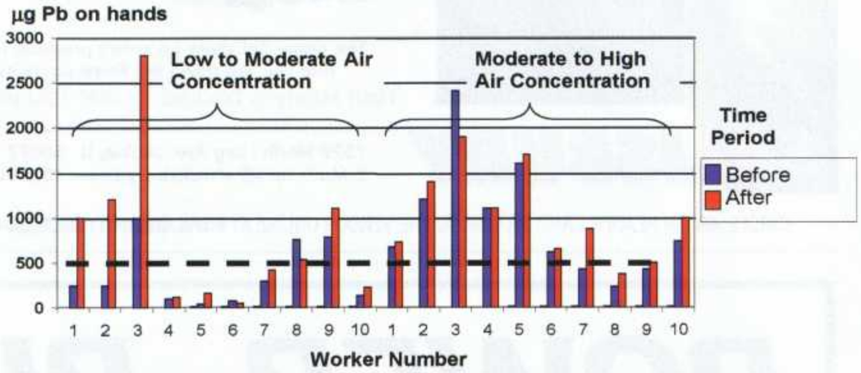


FIGURE 3: This shows the amount of lead found on workers hands after they washed their hands just before entering the cafeteria (blue bars), and later when leaving the cafeteria but before entering the plant (red bars). The workers were from areas where air concentrations ranged from low to high. The dashed line at 500 mg represents approximately the OSHA permissible dose per day based on the permissible exposure limit for air and an average of 10 cubic meters of air inhaled per work shift.

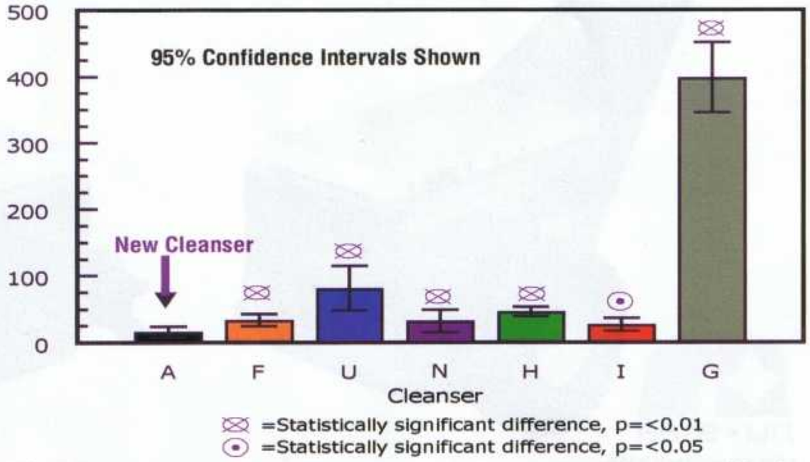


FIGURE 4: Comparison of the cleansing ability of a new cleanser with six commercial hand cleansers. The new cleanser was statistically superior in removing lead from hands. See text for details.

nation techniques and appropriate skin cleansers also are available to prevent workers from getting the toxic hand-off.

Mention of company names or products does not constitute endorsement by NIOSH. The findings and conclusions of this report are those of the authors and do not necessarily represent the views of NIOSH. OH

[1] 1 drop Pb = 1/20th mL x 11.34 grams per mL x 1 million µg/gram)

[2] For simplicity, this theoretical example did not take into account retention and bioavailability in the respiratory and oral routes. An analysis would suggest that this omission may not be very important. The penetration and retention of inhaled particles into the respiratory tract is generally less than 20 percent, whereas the absorption of inhaled lead into the blood for the average adult was estimated to be only 40 percent, or about 8 percent total absorption (Drill, et al., 1979). On the other hand, absorption of lead in the gut is between 8 percent and 10 percent (Tola, et al., 1973; WHO, 1977). Thus, the net absorbed lead by either route is approximately the same.

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[5] NIOSH [1992] Esswein, E.J, Tepper, A, "Health Hazard Evaluation Report, Delaware County Resource Recovery Facility," Chester, Pa. U.S. Department of Health and Human Services, CDC, NIOSH, HETA # 91-0366-2453.

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[7] Coyle P, Kosnett M.J. and Hipkins K [2005], "Severe Lead Poisoning in the Plastics Industry: A Report of Three Cases." *American Journal of Industrial Medicine*, 47:172-175.

[8] Deubner, Lowney, et.al., [2001], "Contribution of Incidental Exposure Pathways to Total Beryllium Exposures." *Applied Occupational and Environmental Hygiene*, Vol. 16(5); 568-578.

[9] Far, HS, Pin, NT and Kong, CY [1993], "An Evaluation of the Significance of Mouth and Hand Contamination for Lead Absorption in Lead Acid Battery Plant Workers." *International Archives of Occupational and Environmental Health*, 64:439-443.

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