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OEESC
2005

Occupational and Environmental Exposures of Skin to Chemicals - 2005

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Assessing the contribution of dermal exposure to total beryllium exposure

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Background

This work represents part of a comprehensive initiative to evaluate the contribution of skin exposure to total exposure in the workplace. Our conceptual model takes into account the multiple and dynamic pathways by which metal-containing particles may be inhaled, ingested, or enter the body through the skin following transfer from a source to workplace air; from the air to work surfaces, skin, and clothing; from surfaces back into air; and from air, surfaces, and clothing to areas of exposed skin and breathing zones.

Observed health effects associated with exposure to beryllium compounds include both sensitization and chronic beryllium disease (CBD). Efforts to prevent beryllium sensitization and CBD have historically focused on controlling inhalation exposures; however, skin exposure may also be a biologically plausible contributor to sensitization. Sensitization to other metals, such as nickel, is known to occur by the dermal route. Sensitization (measured by positive patch testing) has been demonstrated experimentally to occur in humans who were exposed via the skin to soluble beryllium salts. Sensitization has also been demonstrated experimentally to occur in laboratory animals exposed via the skin to soluble beryllium salts or to insoluble beryllium oxide particles. It is not known what route(s) of exposure induce sensitization in industrial work environments.

A prior cross-sectional epidemiological study performed at a copper-beryllium alloy strip and wire finishing facility demonstrated levels of sensitization (7%) and CBD (4%) that were comparable to levels found at other primary beryllium production facilities associated with higher airborne exposure. A comprehensive personal exposure assessment also confirmed the low airborne beryllium concentrations at the facility (n=562 lapel samples; geometric mean [GM]=0.026 $\mu\text{g}/\text{m}^3$; geometric standard deviation [GSD]=1.7).

Improvements were made to engineering and administrative controls, including a dermal protection program that required the use of long sleeves and nitrile gloves in production areas. The current post-intervention study was designed to measure the levels of beryllium in general workplace air, on work surfaces, on cotton gloves worn by workers, and on the necks and faces of those same workers, and to evaluate their interrelationships.

Methods

We divided work at the facility into 21 separate areas covering the categories of production, production support, and administration. Production work included annealing, inspection, pickling, rolling, slitting, shipping and receiving, die grinding, point and chamfer, straightening, and wire drawing. Production support work included maintenance mechanics, quality assurance, and waste treatment. Administrative work was limited to office staff, with limited access to production work areas.

We collected five types of samples: from 1) air, 2) work surfaces, 3) cotton gloves worn by workers, 4) workers' necks, and 5) workers' faces. All samples were collected over a 6-day period. High-volume general area air samples ($n=10$) were collected continuously. In each of the 21 separate areas, 12 surfaces routinely encountered by workers were identified and a total of 252 wipe samples were collected. Thin cotton gloves ($n=113$ pair) were worn by 27 employees (21 production or production support, 6 administration) over their nitrile gloves for the first 2 hours of each of 6 shifts. The same workers provided skin wipe samples from necks and faces ($n=218$) at the end of each work shift. All samples were analyzed for beryllium by inductively-coupled plasma atomic emission spectrometry (limit of detection [LOD]= $0.005 \mu\text{g}$; limit of quantification [LOQ]= $0.02 \mu\text{g}$).

Relationships between beryllium levels on work surfaces and on cotton gloves as well as levels of beryllium on cotton gloves relative to levels on necks and faces were analyzed. We calculated measures of central tendency (medians, arithmetic means [AM], and GMs) and variability (standard deviations [SD] and GSDs). Pearson correlations were calculated on the log-transformed data within work areas to evaluate the relationships between various sample types. A weighted least-squares approach was used to account for heterogeneity.

Results

General area airborne beryllium concentrations throughout the facility ranged from 0.0007 to $0.02 \mu\text{g}/\text{m}^3$ ($\text{GM}=0.003 \mu\text{g}/\text{m}^3$; $\text{GSD}=2.8$). Average concentrations of beryllium on work surfaces were highest in production areas, lower in production support areas, and lowest in administrative office areas. In contrast, average amounts of beryllium on cotton gloves and on both neck and face wipes were highest in production support. All results of neck and face wipe samples collected from administrative staff were below the LOQ.

A moderately strong correlation was observed between concentrations of beryllium on work surfaces and levels of beryllium on cotton gloves ($r=0.75$, $p<0.0001$). We observed moderate correlations between levels on surfaces and necks ($r=0.53$, $p=0.002$) and faces ($r=0.52$, $p=0.003$). Because low beryllium concentrations were observed in administrative areas, we reanalyzed the data by excluding those measurements. The recalculated correlations were only slightly lower when surfaces were related to cotton gloves ($r=0.66$, $p=0.0003$). A more pronounced reduction in the magnitude of the correlation was observed between surfaces and necks ($r=0.32$, $p=0.12$) and surfaces and faces ($r=0.33$, $p=0.11$).

Conclusions

Statistically significant relationships were observed between beryllium contamination on surfaces and on gloves and between beryllium contamination on surfaces and on skin. The data collected will be useful in supporting longitudinal follow-up of the workers and the possible establishment of a dose-response relationship between total exposure (inhalation, ingestion, and skin) and the onset of sensitization and CBD. The correlation between beryllium levels on surfaces and on cotton gloves and between beryllium on surfaces and on necks and faces suggests that workers may transfer beryllium to skin despite wearing gloves. These results support the importance of a comprehensive approach to control beryllium exposure by lowering levels of contamination on surfaces, modifying work practices to prevent skin contact with contaminated surfaces, using clothing, gloves and over garments to protect skin, and implementing hygienic practices to prevent transfer of beryllium from all sources via all exposure pathways.

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The National Institute for Occupational Safety and Health (NIOSH) and the Karolinska Institutet in cooperation with the Stockholm County Council are taking the lead in organizing this conference. NIOSH is maintaining this website.

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Menu items on the left provide more information about OEESC-2005.

This conference follows the success of the first [International Conference on Occupational and Environmental Exposures of Skin to Chemicals: Science and Policy](#), which was held near Washinton, DC, in September, 2002.

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The organizers of OEESC-2005 appreciate those organizations that supported the goals of this conference through financial or in-kind contributions. Contributions were used to pay the full or partial travel and conference registration costs of invited speakers and guests and to reduce the registration fees of attendees by paying part of the costs associated with such expenses as meeting room rental, poster display board rental, abstract book, breaks, reception and conference dinner.

The conference account is managed by Karolinska Institutet.

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