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Respiratory symptoms and lung function in foundry workers exposed to low molecular weight isocyanates

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ABSTRACT

Background: Some foundries use the Hot Box method, which involves use of a nitrogen-containing binder system to produce cores for hollow castings. During the process, low molecular weight isocyanates such as isocyanic acid (ICA) and methyl isocyanate (MIC) are formed, which are potentially toxic. However, data regarding exposure to these agents, and their health effects, were sparse.

Aims: The objectives of the studies were to characterise levels of exposure to low molecular weight isocyanates in Swedish foundries using Hot Box core binders, and their potential health effects, especially on the upper and lower airways. The specific questions addressed were as follows. What are the exposure levels to ICA and MIC in foundries using Hot Box core binders, and what symptoms are reported by the workers? Are there any signs of acute or residual effects on lung function? Have symptoms and lung function changed over time, and are there any associations between exposure and health parameters?

Material and methods: The four Swedish foundries using Hot Box core binders were invited to participate in four studies. In Study I, individual exposure to ICA, MIC and formaldehyde in 64 foundry workers was assessed. In a parallel study (II), the respiratory symptoms and lung function of the same workers and 134 local referents were evaluated. Four years later, 43 exposed workers and 69 referents participated in a nasal examination. Their exposure to previously described agents complemented with total dust was measured (Study III). Study IV was a four-year follow-up of 70 subjects (25 exposed workers and 55 referents) assessed in Study II, aiming to relate changes in exposure to the prevalence of respiratory symptoms and lung function following improvements to the work environment.

Results: Exposure levels of ICA (GM (geometric mean) 27 µg/m³), MIC (GM 5.3 µg/m³) and formaldehyde (GM 120 µg/m³) at baseline were 50% lower at follow-up. There was a high prevalence of ocular and respiratory symptoms at baseline and nasal symptoms had increased among the exposed workers at follow-up. However, lower airway symptoms were less frequently reported at follow-up. Dry nasal mucosa was observed among exposed workers. FEV_1 (the forced expiratory volume in 1 second) levels pre-shift were slightly reduced in the exposed group both at baseline and follow-up, but the small decrease in lung function over shift in the exposed group at baseline, was not observed at follow-up. However, the effects seemed to be small and not relevant on an individual level. Dose-response relationships were observed between the measured levels of ICA, MIC and formaldehyde and the nasal symptoms, but the nasal signs were only weakly associated with exposure estimates. Lung function findings were not significantly related to current exposure to ICA, MIC or formaldehyde.

Conclusions: The nasal mucosa is a highly sensitive indicator of potentially harmful exposure to air pollution and the high prevalence of nasal symptoms and dry mucosa suggested a link with ICA, MIC and other airway irritants, such as formaldehyde and dust. This may indicate a persistent influence of the working environment, although exposure levels have fallen. The absence of lung function effects over shift and the decline in lower airway symptoms in the exposed group at follow-up indicate positive effects of the remedial measures undertaken since baseline. However, the slightly reduced FEV_1 levels pre-shift in the exposed group at follow-up suggests there may be a residual effect of previous exposure, which would be interesting to address in further studies. The nasal findings indicate that further improvement of the working environment in these foundries is required.

Key words: formaldehyde, foundry, isocyanic acid, methyl isocyanate, lung function, nasal symptoms

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