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Characterisation of exposure to volatile organic compounds associated with nail treatments in nail salons

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Abstract

Workers in the nail salon industry are exposed to various volatile organic compounds (VOCs) in their line of duty. Exposures are due to the chemicals such as formaldehyde, toluene, xylene, and acrylates contained in the nail treatment products. Such chemicals have been linked to acute irritation of the skin and mucous membranes to more severe and irreversible cancer-related effects. Despite the proven correlation between VOC exposure and negative health effects in the nail salon industry, there have been very few exposures profiled studies done in the South African context. Additionally, limited studies on exposure to nail salon chemicals have led to the industry being regarded as "safe" irrespective of contradictory findings in numerous studies. Therefore, the study characterised and determined exposure to eight VOCs and subsequently determined the associated health risk amongst nail technicians. The study was conducted in a controlled laboratory environment which was tailored to mimic real-world scenarios in the South African informal nail salon setting. A miniature practice hand was procured and used for laboratory simulation resembling a human hand. Exposure monitoring was done using a MiniRAE 3000 Photoionization Detector (PID) to measure VOC emitted during nail treatments. The PID instrument probe was placed within the 30 cm breathing circumference of the receptor (nail technician) to detect the VOC concentration in the microenvironment. Two exposure scenarios namely, nail treatment without ventilation (scenario A) and nail treatment with ventilation (scenario B) were used to monitor two types of nail treatments (acrylic as well as buff and paint). Furthermore, the VOC concentrations were used to obtain dose estimates. Data from the PID instrument was exported to a Microsoft Excel spreadsheet. All outliers were removed from the data and correction factors applied. Thereafter, averages and statistical tests (student F- test and T-test) were calculated.

The average concentrations were further used to obtain the dose estimates expressed as hazard quotients for the health risk assessment. Single nail treatment averaged TVOC emissions of the acrylic as well as the buff and paint nail treatments in exposure scenario A were 604,26 mg/m^3 and 301,84 mg/m^3, respectively. Whereas, in exposure scenario B, the averaged TVOC emissions were 304,67 mg/m^3 and 82,15 mg/m^3 for acrylic as well as buff and paint nail treatments, respectively. Despite the low VOC emissions in the buff and paint nail treatments under both exposure scenarios, the treatment was classified as a high-risk situation. This was mainly because of the increased exposure duration and health outcomes (ranging from irritation

and carcinogenic effects) associated with the chemicals contained in the products. Moreover, a more than 70% reduction in the VOCs emission under exposure scenario B was observed. Given that on average, nail technicians provide seven (7) treatments per shift and the results showed TVOC emissions of 3237,71 mg/m^3 and 2518,88 mg/m^3 for acrylic as well as buff and paint nail treatments, respectively. In addition, associated with the high acrylic TVOC emissions, methyl methacrylate and ethyl methacrylate were shown to have high emissions. For risk characterisation, all selected VOCs were categorised as non-carcinogenic based on toxicological data. Furthermore, acetone, toluene, methyl methacrylate, and ethyl acetate showed the risk of developing health effects (HQ>1) amongst nail technicians. Toluene was of concern due to carcinogenic effects. On the other hand, xylene showed that despite the risk of exposure amongst nail technicians, females were at an increased risk of developing health effects (HQ=1,1) as opposed to males (HQ=0,9). Overall, there is a need to implement ventilation measures to reduce exposure as highlighted in this study. Furthermore, this study showed the importance of obtaining exposure data to estimate risk instead of relying solely on environmental concentration.

Keywords: TVOC, nail treatment, acrylic, buff, and paint