

Disposable nitrile gloves protect hairdressers from systemic exposure to paratoluenediamine

Claire L Higgins, Rosemary L Nixon

The interventional workplace-based study of Geens *et al*¹ showed that appropriate glove use by hairdressers significantly reduced systemic exposure to the permanent hair dye intermediate paratoluenediamine (toluene-2,5-diamine; PTD). These results are of interest because this is one of only three such real-work studies among hairdressers, and the first to demonstrate protection against systemic PTD exposure. Interestingly, adequate glove use did not protect against systemic exposure to paraphenylenediamine (PPD), raising the question of potential differences between PTD and PPD absorption and toxicokinetics.

The pivotal question of the study was whether appropriate glove use in 11 Belgian hairdressers would reduce systemic exposure to the aromatic diamines PTD and PPD in a real-work situation. PTD and PPD are widely used in permanent hair dyes and consistently rank in the leading occupational skin allergens in hairdressers.¹ Sensitisation rates among hairdressers range from 8% to 25% for PTD and 14–45% for PPD.^{2–3} Both in vitro and in vivo studies have demonstrated the efficacy of gloves in reducing both dermal and systemic exposure to hair dye compounds.^{4–5} Use of disposable nitrile gloves is recommended.⁶ However, the protective capacity of gloves has not previously been demonstrated in a real-work hairdressing setting. In a workplace study by Lind *et al*,⁷ glove use was insufficient to prevent dermal exposure to aromatic amines, including PPD and PTD. The authors concluded that this was due to improper glove use, with gloves often rinsed, turned inside-out and reused, and in some cases used repeatedly for months. A further real-work study by Gube *et al*⁸ assessed systemic exposure to PPD and

PTD using urinary diamine biomarkers. They found no significant difference in systemic exposure to either compound between hairdressers who reported wearing gloves and those who did not. Again, inadequate glove use was postulated.

Numerous studies from various countries have reported that hairdressers have poor knowledge of occupational skin hazards and low compliance with appropriate glove-use practices.^{7–9–10} This is in contrast with other occupations such as dental workers in Finland, who demonstrated good awareness of the sensitising properties of the acrylate chemicals they worked with, and an understanding of correct use of gloves, including the need to immediately change gloves if they contacted methacrylates.¹¹ The work of Geens *et al* seeks to overcome this knowledge gap with a practical intervention. Participants were supplied with properly fitting long-cuff 0.11 mm nitrile gloves and educated on appropriate usage; glove technique was then continuously observed and corrected, and reuse prohibited. Preintervention, the researchers found that systemic PTD levels accumulated in the participants, increasing progressively over consecutive measurement moments. After correcting for external exposure to PTD, the participants' urinary PTD concentration increased linearly with increasing exposure duration. The same effect was not observed in week 2, confirming that the intervention had significantly reduced systemic exposure to PTD through improved glove technique. The participants' exposure to hair dye compounds was observed to be comparable between the 2 weeks and therefore was not a confounder.

With regard to PPD, no accumulation effect was observed preintervention, or a reduction in systemic exposure postintervention. The latter finding is unlikely to be related to the glove material or duration of exposure, given that 0.04 mm nitrile gloves have been shown to afford good protection against 0.9% PPD for 60 min⁶ and against 5% PPD for >4 h.^{4–5} Nor is it likely related to glove technique,

which was optimised in all participants. The exact PPD concentration in the study was unknown, but was estimated around 1.5% for dark shades, which is considerably less than the concentrations (4% and 5%) tested in vitro.^{4–5} One explanation may be that the majority of dermal exposure to PPD in fact occurs during the hair-cutting/drying phases, when gloves are usually not worn. However, the lack of PPD accumulation preintervention suggests that there may be a difference in percutaneous absorption compared with PTD. Although the two compounds are closely chemically related (figure 1), in toxicokinetic studies the in vitro dermal absorption of PPD was 20–30 times lower than PTD after application to human skin under oxidative circumstances (0.1–0.2% of the applied dose vs 3.4%).^{12–13} Urinary excretion of PPD was also considerably lower than PTD (0.19–0.5% of the applied dermal dose vs 1.3%).^{12–13} The reasons for this are unclear, but may relate to the more lipophilic nature of PTD, allowing it to better penetrate the stratum corneum. Excretion kinetics may also vary, with the urinary half-life for PPD (8–12 h) being slightly longer than for PTD (8 h).⁸ Thus, the timing of urine collection in this study may have been sub-optimal. There may also be differences between these chemicals in dermal N-acetylation, hepatic metabolism or excretion rates, but there are few human studies investigating these aspects.

A key strength of the study of Geens *et al* is its repeated measure design, whereby the same participants were followed preintervention and postintervention. Additionally, glove misuse was identified and corrected continuously, rather than at the start point only. Duration of exposure to hair dye was observed by a single researcher instead of being self-reported, thereby avoiding reporter and recall bias, factors which may have influenced results in other studies. Limitations of the study, as noted by the authors, include the lack of a control group, which would have allowed

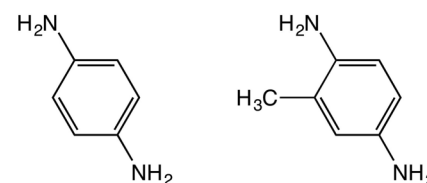


Figure 1 Molecular structure of paraphenylenediamine (left) and paratoluenediamine (right).

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adjustments for confounders and bias such as normal biological variation, learning effects and researcher bias. Precise PPD/PTD concentrations, rather than estimates, would have better facilitated comparison with similar studies. Although this was a small study with only 11 hairdressers, statistical significance was still achieved. Of note, however, a third of the urinary PPD results were below the level which could be reported with a high degree of confidence (LOQ), although the significance of this is unclear.

In summary, this study confirms the protective effect of appropriate glove usage against PTD in a real-work setting, and raises thought-provoking questions regarding the percutaneous absorption and toxicokinetics of PPD. The findings of this study are also consistent with the recent interventional study by Oreskov *et al.*,¹⁴ in which education about correct glove technique halved hand contamination during the hair-washing process. Given that PTD is the predominant primary intermediate used in permanent hair dyes in Europe,⁸ and is highly sensitising (albeit less so than PPD), correct glove use has the potential to considerably reduce allergic contact dermatitis among the hairdressing sector. However, prevention must be targeted early, before sensitisation occurs.

Competing interests None declared.

Provenance and peer review Commissioned; internally peer reviewed.



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To cite Higgins CL, Nixon RL. *Occup Environ Med* 2016;**73**:219–220.

Received 12 October 2015

Accepted 28 October 2015

Published Online First 16 November 2015



► <http://dx.doi.org/10.1136/oemed-2014-102708>

Occup Environ Med 2016;**73**:219–220.
doi:10.1136/oemed-2015-103222

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Occup Environ Med 2016 73: 219-220 originally published online November 16, 2015
doi: 10.1136/oemed-2015-103222

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