Lead exposure in scaffolders during refurbishment construction activity—an observational study

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The toxic effects of lead have been known for centuries. Occupational exposure to this chemical hazard has also been well documented in relation to various industry groups, including construction, where workers are recognized as being significantly exposed during refurbishment work, in particular through inhalation and ingestion of lead fumes and dust. It is easy to see how so-called ‘burners’, ‘cutters’ and ‘blasters’—workers directly involved in removing old lead paint—may become exposed; the influence of personal hygiene, smoking, eating/drinking and nail biting has also been documented in the literature. We now report on one group, the scaffolders, not previously considered to be at risk. Although not directly involved in the paint removal, anecdotal and personal experience of the authors indicate that these workers, who erect and later dismantle access structures during the renovation of previously lead-painted surfaces, may take up significant amounts of lead, mainly by ingestion, to raise their personal blood lead levels (and body burden) in line with recognized ‘lead workers’. Exposures of this magnitude would also bring the scaffolders involved in such refurbishment work under the Control of Lead at Work Regulations 1998. The authors make various recommendations on measures to minimize and control exposure of scaffolders to lead.

Key words: Construction; lead exposure; refurbishment; regulations; scaffolders.

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Introduction

Although the toxic effects of lead have been known for centuries, from the 1960s onwards it was recognized increasingly as a public health hazard [1]—from leaded fuel and from domestic leaded paint—in addition to its long-established effect on occupational health. Lead poisoning by inhalation (including smoking items with lead contamination), ingestion (lead contamination of drinking water, canned foods and hands handling food) or even through the skin (with lead alkyls) remains a serious problem for some groups of children [2] and adults. Adults are primarily exposed in the workplace [3]. ‘Take home’ lead exposure, resulting from lead particles brought home on a worker’s clothes, shoes or body, can also poison other household members [4], with children being particularly vulnerable.

Background

Construction has long been recognized as a high-hazard/high-risk industry, which is also hard to ‘police’ from a health and safety point of view as site conditions often change from day to day, and workers move from site to site. Lead is a recognized chemical hazard in two areas of this sector’s activities: demolition and refurbishment [5,6]. The paints on many structures, including railway
bridges and stations, road furniture and road bridges, contain a lot of lead—50% by weight is not uncommon in old and weathered primer. During renovation, tasks such as abrasive blasting (dry or wet shot blast), chipping by hand or with powered needle guns, welding and torch cutting of surfaces coated with lead-based paints have a high risk of lead exposure from the generation of lead dusts and fumes. Without appropriate control measures in place, these construction workers face the potential for significant lead exposure and even ill-health [7–10]. When the Occupational Safety and Health Administration (OSHA) standard to control lead exposure was introduced in the USA in 1978, construction workers were specifically exempted from some of the requirements on various grounds, including brief and variable exposure and difficulties of provision. Exposure monitoring, provision of hygiene facilities and medical surveillance were not required for construction workers in the USA until 1993 [11], the same time that the lead in air limit was changed from 200 to 50 µg/m³. This followed a National Institute for Occupational Safety and Health (NIOSH) Alert [12] calling for assistance in preventing lead poisoning of workers engaged in maintenance, repainting or demolition of bridges and other steel structures coated with leaded paint. In 1997, Levin et al. [13] reported the improvement in workers’ blood lead levels on a major bridge renovation project in 1993–1994 during the transition to the implementation of the more stringent OSHA standard.

There is a tendency to assume that the most exposed workers will present with the highest blood lead levels, and that the main route of absorption is inhalation. This seems to be supported by Feldman et al.’s study [7], which divided workers into oxygas ‘burners’ and ‘non-burners’, and found that the blood lead levels in the non-burners were significant but lower than those in the burners. However, neither assumption is true if the most exposed workers are given protection but the hygiene system in place does not protect everybody equally. Piacitelli et al. [14], reporting on a bridge renovation site in Connecticut, identified other significant routes of absorption, and commented on the risks of taking contamination home on the body and clothing through not washing and changing before leaving the worksite. The authors identified the highest levels of contamination in workers’ automobiles for a low-exposure group (industrial hygienist/safety officers) and the lowest contamination for a high-exposure group (blasters and painters). They related this to the observation that only 25% of the low-exposure group wore company-supplied clothing and changed, or showered and changed, before going home. Half of this group took their work shoes home. By contrast, 90% of the high-exposure group wore company clothing and changed, or showered and changed, before going home. None took their work footwear home. Results to the same effect were obtained at a bridge site in Ohio [15]. A substantial NIOSH publication [16] made extensive recommendations about these matters.

Two other studies [17,18] identified lead poisoning in workers carrying out concrete breaking and renovation on a bridge that had supposedly had the leaded paint removed some years previously. There were few protective arrangements in place (no respiratory protective equipment or engineering controls, no requirement to change clothes or wash or shower). After provision of information, equipment and training to the workers, and improved hygiene arrangements, blood lead levels fell significantly. The authors concluded that lead debris and residues could persist in inaccessible locations. The fact that workers doing work that is not particularly dust-raising may nevertheless have high lead absorption has been reported a number of times [19].

In Great Britain, control of lead at work is ‘managed’, to an extent, by statutory legislation. The Control of Lead at Work Regulations (CLAW) 1998 [20] revised version of the original 1980 legislation places a duty on the employer to identify lead in the workplace and to assess whether exposure is likely to be significant by inhalation, ingestion or through the skin. Where workers are significantly exposed, the law then requires statutory medical surveillance to include biological monitoring; such statutory surveillance must be carried out by a Health & Safety Executive (HSE) medical inspector or appointed doctor. Although lead exposure in construction has been recognized for some time (references already cited), one group—scaffolders—have not previously been considered to be at risk. We now report on those workers who erect and later dismantle the access structures during the renovation of previously lead-painted surfaces, and highlight the possible mechanism whereby they may become significantly exposed to lead.

Case report

The project

The present report refers to a major refurbishment of a steel railway bridge in 2000–2001. The main contractor dealt with civil engineering and construction. Separate subcontractors were appointed for erection and maintenance of access scaffolding, for paint removal and application, and for metal cutting and welding. Access to the railway viaduct was via a lift and extensive scaffolding. The actual renovation work took place on the so-called ‘crash deck’, created by screwing down plywood sheeting onto scaffold boards with a layer of Visqueen plastic sandwiched in between.

The decision had been made to remove the old paint
before repainting. However, because the bridge remained in traffic use for electric trains, except for restricted periods at weekends, it was not possible either to weather-proof the work area or to use wet-blasting methods to remove the paint; dry blasting without extraction and with only partial enclosure was the method used. The job of cleaning the scaffold surfaces (tubes, clamps, joints and boards) lay with the subcontractor involved in paint removal and application; ‘wash and brush’ was the method most commonly used, although compressed air to blow surfaces clean and simple brushing were also used from time to time.

The changing and hygiene arrangements at base were spacious and well provided; the scaffolders shared both the mess room and the decontamination/hygiene unit (with clearly demarcated ‘clean’ and ‘dirty’ areas) with the main civil engineering contractor on site. There was a general prohibition, covering the whole site, on eating, drinking or smoking, except in designated places and after washing of hands and face. Overalls were provided, but the scaffolders took home and washed their own work clothing, including overalls. Other personal protective equipment worn by the scaffolders included hard hat, rigger gloves, safety boots and disposable filtering masks, with an assigned protection factor of 20. We believe that this should be sufficient respiratory protection during dismantling and erecting of scaffolds contaminated with lead dust.

**The workforce**

Twenty-seven scaffolders in total were employed on site from July 2000 onwards; a peripatetic workforce, they were not all present for the duration. Involved solely with the erection, dismantling and further re-erection of scaffolding structures, this group was not directly involved in paint removal or cleaning of scaffolding material and surfaces. Only five of the 27 were smokers.

Based on information about the presence of lead on site, as well as experience and information from similar refurbishment activities going on elsewhere in the country, the scaffolding company placed all its men under a statutory medical surveillance programme, as required under CLAW. A doctor was appointed and blood samples were taken, initially within a few days of each worker starting work on site, followed by repeat tests at intervals recommended by the doctor. The laboratory was part of a quality assurance surveillance scheme jointly organized by HSE and the United Kingdom National External Quality Assessment Scheme. The determination of lead in blood involves dilution of the sample before analysis by atomic absorption spectrophotometry with electrothermal atomization. The results are shown in Table 1.

**Surface lead measurements: technique and results**

Measurement of lead on surfaces was undertaken using radioisotope-excited energy dispersive X-ray fluorescence (XRF) spectrometry. This technique irradiates a surface with X-rays generated from a radioactive source. This radiation excites lead atoms on the surface, causing them to emit their own characteristic X-rays. The energy of these characteristic X-rays emitted following excitation and decay identifies the element present on the surface, and the intensity of these X-rays is proportional to the amount of lead on the surface. The technique has been shown to provide an effective, rapid, non-destructive elemental analysis of workplace surfaces [21,22].

An SP9000 portable X-ray fluorescence spectrometer (TN Technologies, Round Rock, TX) with a $^{109}$Cd (180 MBq) radioisotope and high-resolution mercury (II) iodide X-ray detector was used to take *in situ* readings on various workplace surfaces at the site. The instrument probe was placed on the surface of interest and a 4.91 cm$^2$ area was irradiated with X-rays for a period of 90 s. The results obtained were stored electronically and subsequently downloaded to a PC.

An energy calibration check, a resolution check and a
target element response check were carried out prior to the site visit, in accordance with internal quality procedures. The lower limit of detection (LLD) was calculated by determining the standard deviation (σ) of 10 consecutive blank measurements. The detection limit (3σ) for the samples taken for this project was determined as 2.1 µg/cm², and all measurements taken were equal to or greater than the LLD. The overall uncertainty of the measurements is ±10% (this excludes the effects of sample placement, non-uniformity of deposit and matrix effects).

Surface measurements of lead results found on site are shown in Table 2.

### Discussion

Twenty-five out of 27 (93%) of the scaffolders on first testing on site had a blood lead value of <10 µg/dl. This would seem to support the industry-held belief that, as a subgroup of the construction sector, they are normally not exposed to lead through their work activity. Twelve out of 27 were retested 5–8 months later; the others were no longer on site and, therefore, were not retested. In 10 cases (83%), there was an increase in blood lead level (range of the increase = 1.8–33.3 µg/dl); the mean increase in blood lead level of all 12 subjects was 11.3 µg/dl, equivalent to a mean percentage increase of 182%, indicating a substantial increase in overall blood lead level (range of the increase = 1.8–33.3 µg/dl).

With 25 of the initial blood lead levels below 10 µg/dl and the remaining two well below the 35 µg/dl threshold level recommended in the CLAW Approved Code of Practice (ACoP) & Guidance [20] as a level for initiating statutory medical surveillance, it is likely that, without the benefit of previous experience of possible lead exposure in this group of workers, routine biological monitoring would not have been instituted. We were already aware of several major renovation contracts on large Victorian railway structures where scaffolders had been found to have blood lead measurements indicating serious uptake, even as high as the ‘suspension’ concentration of 60 µg/dl of lead in blood, as recommended in the ACoP & Guidance. At least six scaffolders were suspended during the dismantling phase of a North West station refurbishment where, initially, few precautions were put in place by their employer or principal contractor.

How is it possible that scaffolders who were not directly involved in the removal of lead-based paint and were outside, and often far removed from the encapsulated areas where blasting or chipping was taking place, became exposed and took up lead to give, on average, an almost 2-fold increase in their baseline blood lead level over a relatively short period of time? Although instructions on the use of the decontamination unit were provided and widely posted, there was some discrepancy between theory and practice, in that the ‘clean’ side contained no lockers for clean clothing and there were very few items of clean clothing found hanging there. As expected, the results of the XRF surface monitoring show that the highest surface contamination occurred in the ‘dirty’ side of the decontamination unit (a mean surface concentration of 269 µg/m² on the floor and 53 µg/m² on the benches). However, contamination was noted in the form of dusty surfaces and a visibly contaminated piece of clothing in the ‘clean’ side of the decontamination unit (one high reading of 136 µg/m² was found on a bench; range 73–136 µg/m²). This suggests that people went home in the same clothing (shirts, tee-shirts, vests, socks) they had been wearing for work, and that these items were being taken through from the ‘dirty’ side to the ‘clean’ side for reuse. The scaffolders, though provided with overalls, were required to wash them for themselves—and we wonder how frequently this happened.

Lead contamination of surfaces in the mess cabin used exclusively by scaffolders was low (range 2.1–6.5 µg/m²). However, if there were failures in the implementation of the ‘clean’ versus ‘dirty’ area policy, this is one place where lead uptake is again likely to have taken place—through the ingestion of lead dust shed onto surfaces, including food and drink, as well as from lead contamination of skin of the hands and face, particularly around the lips and mouth [23–25]. We believe that it is this type of contamination, which had taken place either at the ‘clean’ side of the decontamination unit or from contaminated items taken into the mess room, which had resulted in the significant increase in blood lead values in those scaffolders who had remained on site.

From this brief case report, the authors conclude that
scaffolders, previously not considered an at-risk group in terms of lead exposure and uptake, are at risk if involved in scaffolding activity during the refurbishment of structures previously painted with lead-based paint. We would, therefore, make the following recommendations:

1. Reusable items (scaffolding poles, joints and clips, planks/boards, tools and plant items used on the working level or liable to be contaminated by run-off) should be cleaned, preferably by knocking off superficial dirt before dismantling and then washing before removal from site, to prevent further exposure to lead dust.

2. Scaffolding poles should be capped to prevent entry and collection of lead-containing dust that could later be released during the dismantling process.

3. Scaffolders should be included in the population requiring properly fitted and effective respiratory protective equipment when involved in work where old lead paint is being removed. This should be risk assessment based.

4. The general prohibition should remain on eating, drinking and smoking except in designated areas and after washing hands and face. Suitable instructions and notices should be provided.

5. A ‘clean’ and ‘dirty’ area policy should exist at the decontamination point, with the mess room being on the ‘clean’ side.

6. Several contractors, we know, provide a ‘uniform’ of shirt and trousers, which are laundered, and this system is recommended for scaffolders and other trades liable to get clothing, under protective outer clothing, contaminated. (Socks, neck scarves and even underwear are liable to be heavily contaminated with dust.) Such clothing, likely to be dirty with lead dust through work, should not then be worn to go off site.

7. Provision of towels and overalls to be laundered by a laundry service and arranged by the employer is recommended. (The laundry service must be advised of the possibility of lead contamination.) No work clothing should be taken home.

8. Training and supervision should be regularly audited, to ensure that the system of separation of ‘clean’ and ‘dirty’ clothing is operated properly, with clean clothing stored and accessible on the ‘clean’ side of the decontamination unit. Dirty clothing should remain on the ‘dirty’ side, unless bagged for removal for washing.

9. Finally, the variable nature of the work and the possible routes of contamination of workers, such as scaffolders, with lead should be emphasized to the medical adviser carrying out biological monitoring, who should then draw the management’s attention to any rapid rise in an individual’s blood lead level. Appointed doctors should visit the site to acquaint themselves with work practices and the welfare facilities available, and advise on improvements, including issues such as smoking, nail biting and personal hygiene. The education of medical practitioners as well as those working in the construction sector involved in this kind of refurbishment work has to be the key.

Further research is needed to evaluate the relative impact of these recommendations as well as other work-related conditions that may impact worker exposures.

References

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