Lead Exposure in Radiator Repair Workers: A Survey of Washington State Radiator Repair Shops and Review of Occupational Lead Exposure Registry Data

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Radiator repair workers in Washington State have the greatest number of very elevated (≥60 μg/dL) blood lead levels of any other worker population. The goals of this study were to determine the number of radiator repair workers potentially exposed to lead; estimate the extent of blood lead data underreporting to the Occupational Lead Exposure Registry; describe current safety and health practices in radiator repair shops; and determine appropriate intervention strategies to reduce exposure and increase employer and worker awareness. Lead exposure in Washington State's radiator repair workers was assessed by reviewing Registry data and conducting a statewide survey of radiator repair businesses. This study revealed that a total of 226 workers in Washington State (including owner-operators and all employees) conduct repair activities that could potentially result in excessive exposures to lead. Approximately 26% of radiator repair workers with elevated blood lead levels (≥25 μg/dL) were determined to report to Washington State's Registry. This study also revealed a lack of awareness of lead's health effects, appropriate industrial hygiene controls, and the requirements of the Lead Standard. Survey respondents requested information on a variety of workplace health and safety issues and waste management; 80% requested a confidential, free-of-charge consultation. Combining data derived from an occupational health surveillance system and a statewide mail survey proved effective at characterizing lead exposures and directing public health intervention in Washington State.
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Lead poisoning in radiator repair workers and their families is well-documented.[1–10] Studies of radiator repair workers in California[2] and Colorado[11] revealed that 60% and 62%, of workers, respectively, had blood lead levels (BLLs) >25 μg/dL. Radiator mechanics are exposed to airborne lead fumes when they disassemble radiators by melting solder joints using torches heated to at least 260°C (500°F).[9] Mechanics may also be exposed to lead fumes while reassembling the radiators by heating lead-containing solder (typically 60% lead). Although inhalation of lead fume from solder is an important exposure route, exposure to lead dust can occur when mechanics clean radiator tanks using abrasive blasting units and perform other activities that generate dusts. Lead dust may then be deposited throughout the shop (including lunch rooms, offices), where it may be ingested or inhaled. The family members of radiator mechanics may also be exposed by transportation of lead dust to the home environment.[7,8,10] These "take-home" exposures are particularly problematic for pregnant women and young children, reflecting lead's effects on the developing nervous system.

Despite the demonstrated effectiveness of inexpensive ventilation systems,[1,12] lead exposure and poisoning continues to be problematic in this industry. Other simple workplace changes can also be effective at

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reducing lead exposure in mechanics and their families, including improved personal hygiene habits, modified shop cleaning protocols, and the provision of laundry facilities for lead-contaminated clothing.

Since September 2001, BLLs for adults have been reported in 35 states. An Occupational Lead Exposure Registry (Registry) has operated in Washington State since May 1993, when the Washington Administrative Code for blood lead reporting was established. This rule requires any Washington State laboratory that performs blood lead analysis to report the results to the Washington State Department of Health (DOH), regardless of the BLL result. The DOH's Office of Non-Infectious Conditions Epidemiology forwards test results for adults to the Safety & Health Assessment & Research for Prevention Program of the Washington State Department of Labor and Industries (L&I). Information derived from laboratory reports is key-entered into the Registry, which is maintained in a secure database. All workers employed in Washington State that undergo blood lead testing are included in the Registry, except self-employed individuals and those who fall under Federal Occupation Safety and Health Administration's jurisdiction (for example, longshoremen, federal workers, and contractors at federal facilities). The term elevated BLL is used to describe a venous (or comparable) BLL $\geq$25 μg/dL. The term lead poisoning is used to describe BLLs $\geq$50 μg/dL. Education and prevention efforts directed toward workers with elevated BLLs, workplaces, industries, and occupations stem directly from the information obtained through the Registry.[13]

State programs submit their counts of blood lead test results to the Adult Blood Lead Epidemiology and Surveillance Program of the Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health to assist in the national surveillance effort investigating elevated BLLs in adults.[14]

A review of Washington State's Registry data collected between May 15, 1993 and June 30, 2001 revealed that the greatest number of extremely elevated BLL ($\geq$60 μg/dL) reports for any industry sector were associated with radiator repair (Standard Industrial Classification [SIC] code 7539).[13] A 1995 survey of selected Washington State employers suggested that 74% of the 283 targeted radiator repair businesses conduct activities that could potentially involve lead exposure.[15,16] Studies conducted in other states suggest that only a very small fraction of lead-using employers perform environmental or blood lead monitoring.[3] For example, a Colorado study[2] suggested that the sensitivity of their surveillance system for detecting radiator repair workers with elevated BLLs was only 11%. A California study[6] revealed that only 8% of radiator repair workers received routine BLL testing.

Registry data were reviewed, and a statewide survey of radiator repair shops was conducted to quantify the number of employers and workers potentially exposed to lead; estimate the extent of BLL underreporting in this industry sector; evaluate current safety and health practices in radiator repair shops; and determine the needs of radiator repair shops with regard to health and safety information to devise intervention strategies aimed at reducing exposures and increasing employer and worker awareness.

Methods

Washington State Registry Data Review

The Registry is maintained in a secure Microsoft Access™ relational database. The reporting period for this analysis spanned the inception of the Registry (May 15, 1993) through June 30, 2001. BLL report dates reflect the quarter in which the BLL report was entered into the Registry database (ie, the "ascertainment" date). Radiator repair data were extracted from the Registry by querying the database for BLL reports associated with SIC codes 7539 and 3714 (SIC codes were derived from L&I's Workers' Compensation database). Data were exported to Microsoft Excel™ for further analysis and preparation of charts.

Radiator Repair Shop Survey

Selection of Eligible Employers. Four sources of information were used to generate a master list of radiator repair shops in Washington State. Unless otherwise noted, these data sources were accessed in September of 2000. The first data source was QwestDex™ on-line Yellow Pages™ (www.qwestdex.com). Business addresses and telephone numbers were retrieved for all companies listed under "Radiators-Auto" in Washington State. The second source of data was the State Business Directory™ on CD-ROM. This commercial database is produced by American Business Information, Inc. (ABI; Omaha, NE). This product uses the DOL's SIC coding system to categorize businesses. However, ABI adds a two-digit extension to the standard four-digit SIC code to more specifically characterize business activity. For example, radiator repair is included in the U.S. Department of Labor (DOL's) SIC code 7539 - Automotive Repair Shops, Not Elsewhere Classified ("Establishments primarily engaged in specialized automotive repair, not elsewhere classified, such as fuel service [carburetor repair], brake relining, front-end and wheel alignment, and radiator repair"). However, ABI's SIC code 7539-01 is specific for "Automobile Radiator Repairing." When appropriate, ABI assigns multiple six-digit SIC codes to reflect the range of activities performed at a single business location. ABI's "primary" six-digit SIC code reflects the principal business activity. To generate a list of eligible businesses for the radiator shop survey, the State Business Di-

TABLE 1
Elevated BLL Reports for Radiator Repair: May 15, 1993 to June 30, 2001

BLL	Number and Percentage of Reports in SIC Code 3714	Number and Percentage of Reports in SIC Code 7539	Total Number of Reports in Registry (All Industries)
25–39 μg/dL	54 (2.6%)	186 (8.9%)	2,082
40–49 μg/dL	12 (2.3%)	41 (7.9%)	516
50–59 μg/dL	1 (1.9%)	24 (16%)	154
≥ 60 μg/dL	0 (0.0%)	9 (13%)	45
Total ≥ 25 μg/dL	**67 (2.4%)**	**260 (9.3%)**	**2,797**

BLL, blood lead level.

rectory™ was queried for businesses designated as SIC code 7539-01 at any level—primary, secondary, tertiary, and so on. Consequently, this search included any business that could potentially perform radiator repair according to ABI's coding scheme—not only those whose principal business activity was automobile radiator repair. The third data source was the membership list for the National Automotive Radiator Service Association (NARSA). Business names and addresses for Washington State members were retrieved from NARSA's World Wide web site (www.narsa.org/shops/). The fourth source of information was the Registry. Any company that had provided a BLL report to the Registry through August 2001 was included in the list of eligible employers. Data from these four sources were combined and duplicate records were eliminated to generate the master list of eligible employers.

Survey Strategy. The survey instrument was mailed to the eligible employers in September 2001. Included in the package was a cover letter describing the purpose of the survey, a brief description of the Registry, an educational pamphlet specifically designed for owners and operators of radiator repair shops, and a document that provided more general information about preventing lead exposure and the Lead Standard. As an incentive to complete and return the survey, NARSA provided a letter in support of the study and offered discounted memberships to participating employers. Employers were provided a deadline of 2 weeks to complete and return the survey. A reminder postcard was mailed 3 weeks after the initial mailing (ie, 1 week after the specified deadline expired). In January 2002, employers who failed to respond to the reminder postcard were telephoned to attempt completion over the telephone or to gain commitment to return the survey by mail.

Survey Instrument. The survey instrument was adapted from a questionnaire developed by the California Department of Health Services' Lead STAR Program. A major goal of this study was to focus on radiator shops that repair copper-brass radiators, rather than those that merely sell, remove and replace, distribute, and/or subcontract radiator repairs. Consequently, the first "sentinel" question attempted to determine whether any worker (including the business owner) conducted radiator repair activities that could potentially result in high lead exposures: "Do you or any of your employees repair (ie, recore, clean, or rod-out) copper-brass radiators?" If the answer to this question was "no," the respondent was instructed to return the survey without answering the remaining questions. However, if the answer to this first question was "yes," the respondent was instructed to answer the remaining questions. Other questions covered the following subject areas: lead repair status; employment—total and potentially lead-exposed; perceptions about lead's health effects; business information (number of radiators repaired per week etc.); workplace exposure controls and facilities; air lead and blood lead testing; and health and safety information needs. Open-ended questions were included, which asked why air-lead or blood-lead testing had not been performed in the previous 12 months and if there was anything else the respondent would like to add. The survey instrument is included as an Appendix.

Data Entry and Analysis. Survey data were key-entered into a custom Microsoft Access™ database. Descriptive analyses were performed by querying this database and exporting data to SPSS statistical software (SPSS for Windows, Release 10.1.0) and Microsoft Excel™. Initial analyses involved segregating the shops for which valid survey responses were received from those that refused to participate or could not be contacted (by mail or telephone). The shops that responded "yes" to the first sentinel question about radiator repair (hereafter referred to as "high exposure" shops) were enumerated relative to those that responded "no." More extensive descriptive analyses were then performed only on the shops that self-reported as conducting "high exposure" radiator repair.

Results

Lead Registry Data Review

Elevated Blood Lead Reports. A review of Registry data[13] revealed that the greatest number of extremely elevated BLL reports for any industry sector was associated with SIC code 7539 (Automotive repair shops, not elsewhere classified). This four-digit SIC code was also associated with the second-greatest number of BLL reports between 50 and 59 μg/dL (24 reports). Subsequent Registry analysis for this current study revealed that an additional nine employers and 67 BLL reports for radiator workers were assigned SIC code 3714 (Motor vehicle parts and acces-

TABLE 2
Number of Radiator Shops Providing Elevated BLL Reports*

BLL	SIC Code 3714	SIC Code 7539	Total
25–39 μg/dL	9	28	37
40–49 μg/dL	7	14	21
50–59 μg/dL	1	8	9
≥60 μg/dL	0	2	2

*Note that number of shops reporting by BLL category exceeds the total number of shops reporting to the Registry because a single shop may submit reports at several blood lead levels.

BLL, blood lead level.

sories), as shown in Table 1. Consequently, a total of 327 elevated BLL reports were associated with radiator repair.

Reporting Employers. Elevated BLL reports for radiator repair workers were reported for 29 employers. Of the nine BLLs ≥60 μg/dL (as shown in Table 1), a single radiator shop was responsible for eight of these extremely elevated BLLs (89% of the total; see Table 2). This shop was also associated with 14 BLLs of 50–59 μg/dL (56% of the total) and 10 BLLs of 40–49 μg/dL (19% of the total). However, from the first quarter of 1999 through the second quarter of 2001, only 11 radiator repair shops contributed 45 elevated BLL reports (for 19 individuals) to the Registry. One shop accounted for 15 of these reports, and another contributed 10 elevated BLL reports.

Time Trends. Figure 1 illustrates the temporal trend in elevated BLL reports submitted to the Registry for radiator repair workers. The nine BLLs ≥60 μg/dL were submitted between the second quarter of 1993 and the first quarter of 1997. The 25 BLLs of 50–59 μg/dL were submitted between the second quarter of 1993 and the fourth quarter of 2000; however only three BLLs at this level have been reported since 1998.

Reports Versus Individuals. The Registry data analyses described above focused on the number of elevated BLL reports submitted to the Registry, rather than the number of individuals associated with those reports (a single individual may have several blood lead tests/reports). However, to determine the burden of lead poisoning on the radiator repair worker population, it is instructive to determine the number of individuals associated with the submitted BLL reports.

The 327 elevated BLL radiator repair reports submitted to the Registry were associated with 94 individuals. A single individual had 13 elevated BLL reports, including six of the nine BLLs ≥60 μg/dL (67%). This individual was responsible for six of the seven BLLs ≥60 μg/dL (86%) recorded by the Registry between the second quarter of 1995 and first quarter of 1997 (see Fig. 1). This individual also had six of the 25 BLLs of 50–59 μg/dL (24%). Another individual had 14 elevated BLL reports, including one BLL ≥60 μg/dL. This individual also had eight of the 25 BLLs of 50–59 μg/dL (32%) submitted to the Registry (see Fig. 1).

Survey Findings

Employer Data Source Comparison. A master list of 250 radiator repair shops was generated using the four data sources. A combination of the QwestDex™ on-line Yellow Pages™ and the State Business Directory™ identified all 250 radiator shops. All businesses identified in NARSA's Washington State membership listing and the Lead Registry (with the exception of 11 closed businesses) were also identified by QwestDex™ and the State Business Directory™.

Survey Response Rate. Of the 250 businesses to which the survey was mailed, survey responses were received from 197 shops (either by mail or telephone), yielding an overall response rate of 79%. Two anonymous surveys were received that could not be matched to the master list. The radiator repair status of 43 shops was determined by contacting two corporate headquarters. Telephone follow-up was necessary to determine the status of 113 nonresponding shops; completed surveys were retrieved from 79 of these shops.

Survey Responses. Of the 197 businesses for which we could retrieve survey responses, 79 (40%) stated that they recore, clean, or rod-out copper-brass radiators. The remaining discussion will focus on the survey responses from these 79 "high-exposure" shops, in which lead exposures were assumed to be high relative to those in which these repairs were not conducted. Note that survey data were collected from 77 of these shops; two shops reported that they repaired radiators, but provided no additional information. The denominator used to calculate percentage responses varied from question-to-question, because respondents occasionally skipped questions.

Survey responses concerning background business information for the high exposure shops are summarized in Table 3. A total of 226 workers (including owner-operators and all employees) were estimated to work in "high-exposure" shops. Of these, 167 workers (including owner-operators and all employees) were estimated to repair copper-brass radiators; 135 employees are potentially required to undergo annual blood lead testing under the Lead Standard (167 total workers minus 32 owner-operators). Consequently, on the average, 74% of workers in "high exposure" radiator repair shops actually perform radiator repair (167/226 total). Survey re-

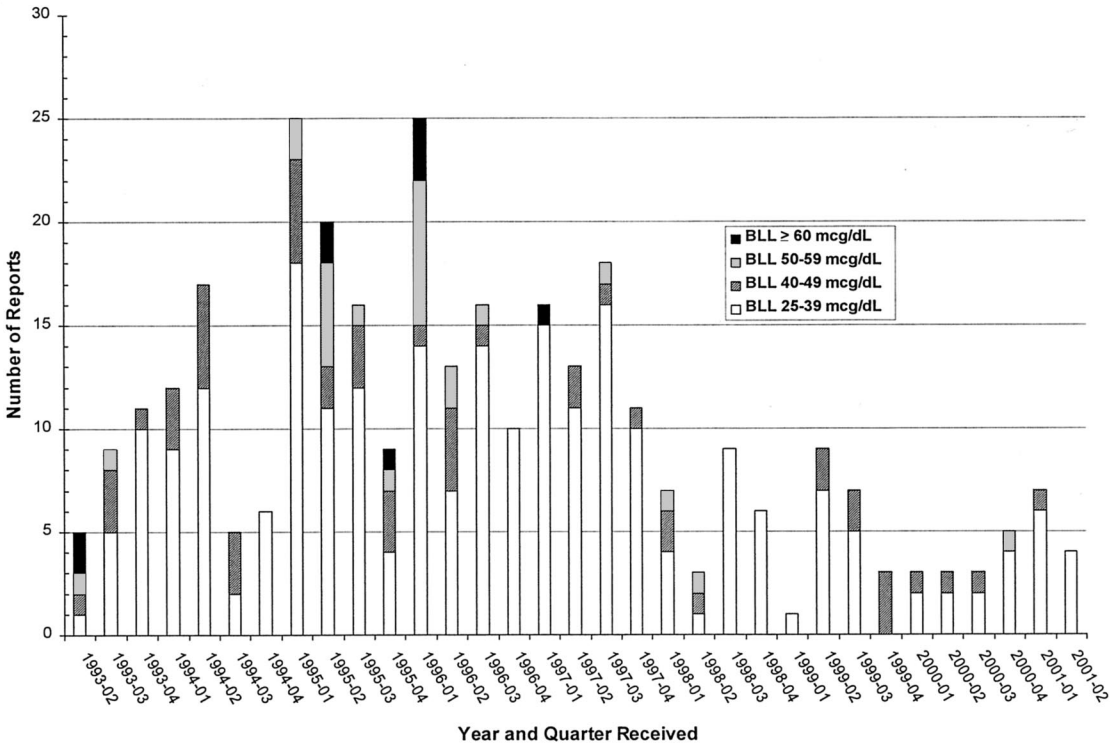

Fig. 1. Elevated blood lead level (BLL) reports for radiator repair workers.

TABLE 3
Business Information for "High-Exposure" Shops

Issue	Response
Number of employees during the respondent's busiest period	Median: 1 employee 0 employees: 32 shops (40%) 1–4 employees: 36 shops (47%) 5–9 employees: 9 shops (12%) 10 employees: 1 shop (1%)
Number of employees *that repair* (ie, recore, clean, or rod-out) copper-brass radiators during the respondent's busiest period?	Median: 1 employee 0 employees: 32 shops 1 employee: 20 shops (44%) 2 employees: 16 shops (36%) 3–6 employees: 9 shops (20%)
Length of time in the radiator repair business?	Median: 20 years Range: 2 years (1 shop) to 56 years (1 shop)
Membership in the National Automotive Radiator Service Association	33 shops (45%)
Number of copper-brass radiators repaired during the respondent's busiest period.	Median: 10 repaired per week Range: 1 per week (1 shop) to 70 per week (1 shop)
Shops that work on agricultural, industrial, or heavy equipment radiators?	55 shops (72%)
Percentage of copper-brass radiators replaced with complete units out of the box	Median: 60% Range: 0 (2 shops) to 100% (1 shop)

sponses concerning workplace facilities and practices and health and safety needs are summarized in Tables 4 and 5, respectively.

Discussion

This study was the first attempt to characterize lead exposures among radiator repair workers across Washington State. Although combining survey data with Registry data provided considerable insight into radi-

TABLE 4
Workplace Facilities and Practices in "High-Exposure" Shops

Issue	Response
Use of lead-free solder	22 shops (28%)
Ventilation system(s) currently used	No ventilation system: 6 shops (8%) Local exhaust systems: 33 shops (43%) Wall- or roof-mounted propeller fans: 54 shops (70%) Electrostatic precipitators: 0 shops Other: 6 shops (8%)
Willing to spend up to $3,000 on a ventilation system to control lead fumes?	14 shops (20%)
Employees eat, drink, or smoke on the shop floor	11 shops (14%)
Use of a laundry service for work clothes	62 shops (82%)
Frequency of cleaning shop surfaces (including floors) with a HEPA vacuum and wet washing	Never: 12 shops (16%) Once per month: 13 shops (17%) Once per week: 24 shops (32%) Once per day: 26 shops (35%)
Provided blood lead testing for employees in the past 12 months?	26 shops (35%)
Monitored air-lead levels in the past 12 months?	12 shops (16%)

TABLE 5
Health & Safety Issues in "High Exposure" Shops

Issue	Response
Perception of lead as a health problem	Not at all-12 shops (16%) Slight-20 shops (27%) Moderate-29 shops (39%) Quite a bit-10 shops (14%) Extreme-3 shops (4%)
Information requested	Designing ventilation systems: 36 shops (56%) How to choose and use respirators: 25 shops (39%) Starting a blood lead testing program: 27 shops (42%) Starting an air lead monitoring program: 26 shops (41%) WISHA lead regulations: 33 shops (52%) Shop illness and injury prevention: 30 shops (47%) Hazardous waste regulations: 35 shops (55%)
Requested a health and safety consultation—free-of-charge and without risk of penalty	49 shops (80%)
Languages is which educational materials for employees should be prepared	English: 69 shops (100%) Spanish: 5 shops (7%)

ator repair practices, certain limitations in the study design may serve to either over- or underestimate the extent of lead exposure and poisoning in this population. The first limitation of the study is that survey responses were self-reported by employers. Consequently, the responses may not reflect actual conditions and practices at the surveyed workplaces, as has been noted by others.[4,17] For example, although 26 shops stated that they had conducted BLL testing in the previous 12 months, BLL reports from only 11 radiator repair shops were recorded by the Registry from the first quarter of 1999 through the second quarter of 2001. Although there are several reasons why BLL data for some employers may not appear in the Registry (see the discussion below), it is unlikely that 26 shops provided BLL testing to their employees. As was noted by Nelson and Kaufman[15,16] in their survey of lead-using workplaces in Washington State, many employers

provided surprisingly candid answers, insofar as they admitted to not having performed recent air lead testing. In this current radiator survey, only 12 "high-exposure" shops (16%) stated that they had performed air lead testing in the previous 12 months; the remaining businesses are potentially in violation of the Lead Standard (depending on prior air sampling results). Nelson and Kaufman[15,16] suggest that one would not expect survey respondents to admit lack of air lead testing unless it were true, and they were unaware of the Lead Standard's requirements.

A second study limitation is that high lead exposures in the radiator repair industry were assumed to be associated solely with repairs that involved recoring, cleaning, or rodding-out radiators. Although it is likely that the greatest exposures are associated with these activities, it is possible that other activities, including minor soldering repairs, could potentially overexpose workers to lead.

Strengths of the study include the use of several data sources to identify employers eligible for inclusion in the study. Combining employer listings derived from Yellow Page™ headings (QwestDex™), the State Business Directory™, the Lead Registry, and NARSA's membership roster likely includes most radiator repair shops in Washington State. Although SIC code 7539 is typically used to characterize radiator repair, subsequent analysis revealed that the "high exposure" radiator repair businesses identified in the statewide survey were included in ten additional SIC codes, as specified in L&I's Workers' Compensation database (unpublished data). Businesses in SIC code 3714 were included in the analysis because it was determined that they were radiator repair shops. To ensure that radiator repair businesses were not inadvertently excluded from this study's Registry data extraction (by focusing on SIC codes 7539 and 3714), the Registry was reviewed to determine whether radiator repair shops were classified in any of the nine additional L&I-designated SIC codes. This review revealed that no radiator repair businesses were associated with these additional SIC codes.

A further comparison of L&I-designated SIC codes with those assigned in databases from the State Business Directory™, the Washington State Department of Revenue, and the Washington State Employment Security Department (linked by Universal Business Identifier number) revealed numerous examples of SIC coding discrepancies. This inconsistency in SIC coding suggests that it is imperative to combine disparate data sources when targeting industry sectors for surveillance and intervention. In this study, 100% of the radiator repair shops were identified from the State Business Directory™ and QwestDex™. Combining these data sources obviated problems associated with relying on a single four-digit SIC code, for the following reasons: 1) QwestDex™ relies on the business owner's choice of Yellow Page™ heading to characterize a business, rather than SIC code; and 2) the multiple six-digit SIC codes assigned by the State Business Directory™ encompass the spectrum of activities conducted at a single business location, rather than the primary business activity.

A second strength of this study is the high (79%) response rate to the survey, thereby providing a comprehensive profile of the radiator repair industry in the state. Finally, because the study included all targeted radiator repair shops in Washington State, rather than a sample, the study was not subject to the errors typically associated with sampling strategies.

One purpose of the study was to determine the number of radiator repair workers potentially exposed to lead while repairing copper-brass radiators. At least 79 companies currently repair radiators in Washington State, and 167 workers (including business owners) were reported to recore, clean, or rod-out copper-brass radiators. (On the average, 74% of workers in "high exposure" shops actually performed radiator repair). Anecdotal reports from radiator repair mechanics suggest that the practice of repairing copper-brass radiators is in decline, reflecting their perception that occupational and environmental regulations are excessively burdensome and the fact that many new passenger vehicles are no longer equipped with copper-brass radiators. In Washington State, several businesses have ceased to operate since the inception of the Registry (May 1993).

The number of elevated BLL reports for radiator repair workers reported to the Registry peaked in 1995 through 1997 and has declined significantly since 1998. There are several possible explanations for this pattern. First, special emphasis on this industry sector conducted in this time period by Washington State's Occupational Safety and Health Administration Program served to temporarily increase compliance with the Lead Standard. Second, fewer radiator shops are currently performing "high-exposure" repairs; this hypothesis is supported by the finding that (1) 11 businesses that historically reported to the Registry have closed; (2) only a single shop in a chain of 36 locations currently performs radiator repair; and (3) radiator repair mechanics suggest that the industry is in decline. The third explanation is that the very elevated BLL reports for this group were associated with a few individuals, whose BLLs are no longer captured by the Registry. This "autocorrelation" results in a disproportionate number of elevated BLL reports associated with a few highly exposed individuals. Consequently, using only counts of elevated BLL reports to evaluate the burden of lead exposure in an industry and to target intervention activities is problematic. It is critical to evaluate the number of individuals associated with elevated

BLL reports in addition to temporal trends.

Another goal of the study was to determine the degree of BLL underreporting in this industry sector. Eleven radiator repair shops provided 45 elevated BLL reports to the Registry for 19 individuals from January 1999 through June 2001. This study suggests that 135 radiator repair employees would be required to undergo annual blood lead testing if air lead levels triggered the requirement for a medical monitoring program. If we further assume that (1) all 135 workers received annual blood lead testing, (2) all elevated BLL reports are received by the Registry, and (3) all 135 employees had a 62% prevalence of elevated BLLs,[2] then approximately 84 workers should have been recorded in the Registry if the system was 100% sensitive. Because the Registry identified only 19 workers, the sensitivity of the surveillance system for radiator repair workers with BLLs $\geq$25 μg/dL is 23%. This estimate is twice that determined by Dalton et al.[2] in Colorado. However, there are several uncertainties associated with the assumptions that may serve to over- or under-estimate the Registry's sensitivity. First, the sensitivity may be overestimated because this study relied on self-reporting from study respondents for estimates of the number of "high-exposure shops" and potentially exposed employees, rather than site visits and industrial hygiene measurements. A relatively large fraction of shops that chose not to participate in the survey may actually perform "high-exposure" radiator repair. In addition, those who did respond may not have been candid about their radiator repair status for fear of regulatory action. Respondents also have a vested interest in reporting that only the owner-operator performs radiator repair, because the Lead Standard would not apply under these circumstances. Second, aspects of the Registry reporting system may also serve to overestimate the Registry's sensitivity. Although BLL reporting by testing laboratories is mandatory under the state's Reportable Conditions Rule, on occasion laboratories have failed to report for 6 months or more. In addition, resource constraints limit the Registry to collecting employer information for BLL reports $\geq$25 μg/dL; these elevated BLLs represent only six percent of the total number of reports recorded in the Registry.[13] Since Washington State has not empirically determined the prevalence of elevated BLLs in radiator repair shop workers, the influence of this factor on the sensitivity estimate cannot be determined.

The third goal of the study was to evaluate current safety & health perceptions and practices in radiator repair shops. Despite previous intervention activities in this industry, survey respondents generally considered lead to be between a slight and moderate health problem; 12 respondents considered that lead does not present a health problem. These perceptions are especially disconcerting considering that these individuals work in relatively "high-exposure" radiator shops and the median length of time they had been in the business was reportedly 20 years.

Twenty-eight percent of shops responded that they used lead-free solder exclusively. Only 43% had a local exhaust system (the most cost-effective ventilation control[12]) and 70% used propeller fans, which are ineffective at maintaining air lead levels below Permissible Exposure Limits.[5] Only 20% suggested that they would be willing to spend $3000 on a ventilation system. In the previous 12 months, 35% had provided blood lead testing for their employees and only 16% had conducted air lead testing. These findings suggest that many owners are not aware of the potential for lead exposure in their shops and many may be in violation of the Lead Standard. The most common reason given for failure to conduct air lead or blood lead testing was that "the owner-operator conducts all repairs."

Positive findings with regard to health and safety included reports that only 14% of businesses allowed employees to eat, drink or smoke on the shop floor; shop surfaces were frequently cleaned with HEPA vacuums and wet washing; and 82% reported using a laundry service for work clothes.

The final goal was to determine the needs of radiator repair shops with regard to health & safety information, and to use the responses to help direct education and outreach activities. Despite the considerable length of time many of the respondents had been in the radiator repair business and the general lack of concern about the lead's health effects, between 39% and 56% of shops requested information on designing ventilation systems, respirator usage, blood lead testing, air lead testing, lead regulations, illness and injury prevention, and hazardous waste regulations. Surprisingly, 80% of shops suggested that they would welcome a health & safety consultation. All shops requested that educational materials aimed at workers should be presented in English, whereas only seven percent requested Spanish.

From this study, we determined that 32 business owners perform radiator repair and do not participate in blood lead testing, largely because owner-operators of businesses are exempt from the blood lead testing requirements of the Lead Standard (and other worker protection standards). These individuals represent a segment of the working population that deserves particular attention. Clearly, education and outreach to owner-operators is an essential component of any intervention activity in radiator repair or any other industry.

The results of this study will be used to develop an intervention strategy for the radiator repair industry in Washington State. This study has shown that the present burden of lead poisoning in this worker population may not be as severe as was originally indicated from simple counts of elevated BLL reports submitted to

Safety & Health Assessment & Research for Prevention (SHARP) Program

All information you provide on this survey will be treated in the strictest confidence. We will not share this information with WISHA, OSHA, or anyone else. We will only publish data that summarizes information for all shops combined (with no identifying information). Thank you for helping SHARP reduce lead poisoning in radiator repair workers and their families.

To be completed by shop owner or manager

Please print name below

Last First

( ) ( )

Telephone no. Fax no.

Shop name and address

Shop name

Street address City State

1. Do you or any of your employees repair (i.e., recore, clean, or rod-out) copper-brass radiators? ❑ Yes ❑ No
   If you answered **No**, please stop here and return the survey. If **Yes**, please complete the remainder of the survey.
2. How long have you been in the radiator repair business? ☐ years
3. Do you think lead is a health problem? ❑ Not at all ❑ Slight ❑ Moderate ❑ Quite a bit ❑ Extreme
4. How many employees do you have during your busiest period? ☐
   ❑ Check here if you are the owner/operator without employees
5. How many employees repair (i.e., recore, clean, or rod-out) copper-brass radiators during your busiest period? ☐
   ❑ Check here if owner/manager does all the repairing.
6. On average, how many copper-brass radiators do you repair during your busiest period **each week**? ☐
7. Does your shop work on agricultural, industrial, or heavy equipment radiators? ❑ Yes ❑ No
8. Out of every 10 copper-brass radiators that need repair, how many do you replace with completes out of the box?
   ❑ 0 ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8 ❑ 9 ❑ 10
9. Do you only use lead-free solder in your shop? ❑ Yes ❑ No
10. Check the type(s) of ventilation system(s) that your shop currently uses.
    ❑ No ventilation system ❑ Local exhaust systems (booths, elephant trunks, hoods, or other enclosures)
    ❑ Wall- or roof-mounted propeller fans ❑ Electrostatic precipitators ❑ Other (List)_____
11. Would you be willing to spend up to $3,000 on a ventilation system to control lead fumes? ❑ Yes ❑ No ❑ Already have system
12. Do you or your employees eat, drink, or smoke on the shop floor? ❑ Yes ❑ No
13. Do you use a laundry service for work clothes? ❑ Yes ❑ No
14. How often do you clean shop surfaces (including floors) with a HEPA vacuum and wet washing?
    ❑ Once a day ❑ Once a week ❑ Once a month ❑ Never
15. Have you provided blood lead testing for your employees in the past twelve months? ❑ Yes ❑ No ❑ No employees
16. Have you had the air in your shop monitored for lead in the past twelve months? ❑ Yes ❑ No
17. If you have not had the air in your shop monitored for lead or provided blood lead testing, please tell us why not.
    (Please continue on the back of this sheet if you need more space)
18. Please help us provide the resources that radiator repair shops need by telling us what information would be useful to you.

Designing ventilation systems	❑ Yes	❑ No
How to choose and use respirators	❑ Yes	❑ No
Starting a blood lead testing program	❑ Yes	❑ No
Starting an air lead monitoring program	❑ Yes	❑ No
WISHA lead regulations	❑ Yes	❑ No
Shop illness and injury prevention	❑ Yes	❑ No
Hazardous waste regulations	❑ Yes	❑ No
Other (List)_____	❑ Yes	❑ No

19. Would you take advantage of a health & safety consultation – free-of-charge and without risk of penalty? ❑ Yes ❑ No
20. Are you currently a member of the National Automotive Radiator Service Association (NARSA)? ❑ Yes ❑ No
21. If we developed educational materials for your employees, what languages should they be prepared in? (Check all boxes that apply)
    ❑ English ❑ Spanish ❑ Other (List)_____
22. We value your opinion! Is there anything you'd like to add? (Please continue on the back of this sheet if you need more space)

Thank you for completing the survey. **Please mail** in the envelope provided **or fax** (360) 902-5672 **by September 30, 2001.**

the Registry. However, factors such as the reported decline in the industry, the association of very high BLLs with a few individuals, the decline in number of elevated BLL reports over time, and the relatively few individuals currently determined to be at risk must be balanced against the potential for underreporting, pervasive ignorance of lead's health effects, lack of workplace and employee monitoring, the potential for high lead exposures, the potential for "take-home" exposures of family members, and the need for technical assistance within this industry.

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