sense, each pesticide poisoning report could potentially serve as a true sentinel health event for the state. □

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Lead Exposure in Outdoor Firearm Instructors

Ram K. Tripathi, PhD, Peter C. Sherertz, PhD, Gerald C. Llewellyn, PhD, and Carl W. Armstrong, MD

ABSTRACT

This study was conducted to determine lead exposure of firearm instructors at an outdoor firing range, while cadets were firing nonjacketed and jacketed lead ammunitions. The breathing zone air for lead exceeded the Occupational Safety and Health Administration standard of 50 $\mu g/m^3$ for two instructors during firing exercises using nonjacketed bullets. The use of totally copper-jacketed bullets reduced the breathing zone lead levels by 92 percent for instructor #1 and by 96 percent for instructor #2; subsequent blood lead levels showed a significant decline in both instructors. (*Am J Public Health.* 1991;81:753–755)

Introduction

Lead poisoning from exposure to airborne lead in indoor firing ranges is an occupational disease of public health concern. Several studies of occupational lead toxicity have been documented at indoor firing ranges.[1–7] The major route of absorption for lead in firing ranges is through inhalation of lead dust and fumes. Inadequate ventilation and lack of personal protective equipment use by instructors may result in lead toxicity.

Instructors assigned to firing ranges are likely to have higher exposures because they may spend significant time in that environment. Several occupational studies have suggested that exposure to lead may be a health risk for users of indoor firing ranges.[8–10] However, the extent of this risk among firearm instructors at outdoor firing ranges has not been documented. This study had two objectives: to evaluate the health risks to instructors from airborne lead exposure from nonjacketed, lead bullets; and to document the reduction or elimination of this risk by using totally copper-jacketed lead ammunition.

Methods

Two instructors, not involved in firing, were studied from June 17 to Septem-

From the Division of Health Hazards Control, Bureau of Toxic Substances, Virginia State Department of Health. Address reprint requests to Ram K. Tripathi, PhD, Virginia Department of Health, Bureau of Toxic Substances, P.O. Box 2448, Richmond, VA 23218. This paper, submitted to the Journal June 11, 1990, was revised and accepted for publication December 5, 1990.

TABLE 1—Personal Breathing Zone Air Lead Levels of Instructors using Nonjacketed and Jacketed Lead Ammunition, 8-Hour, Time-weighted Averages, Richmond, 1987

Dates	Personal Air Lead Level ($\mu g/m^3$) Instructor #1	Instructor #2
Nonjacketed bullets		
June 18, 1987	36.7	49.1
June 19, 1987	95.6	431.5
July 7, 1987	69.0	152.6
Mean	67.1	211.1
Copper-jacketed bullets		
September 4, 1987	5.4	8.7
Reduction	92.0%	96.0%

TABLE 2—Blood Lead Levels of Instructors using Nonjacketed and Jacketed Lead Ammunition, Richmond, 1987[a]

Dates	Blood Lead Level ($\mu mol/L$) Instructor #1	Instructor #2
Nonjacketed bullets		
June 18, 1987	1.01	0.48
June 19, 1987	1.30	0.77
July 7, 1987	1.21	0.77
Mean	1.16	0.68
Copper-jacketed bullets		
September 4, 1987	1.06	0.63

[a]Pre-exposure baseline blood lead levels collected on June 17, 1987, in $\mu mol/L$, for instructors 1 and 2 were 1.01 and 0.48, respectively.

ber 4, 1987. Cadets fired a total of 950, 1,539, 3,000 nonjacketed, and 2,160 jacketed bullets on June 18, 19, July 7, and September 4, 1987, respectively. The total number of cadets involved in firing were seven, seven, six, and six on June 18, 19, July 7, and September 4, 1987, respectively. A description of the covered outdoor range was reported previously.[11] Thirty-eight caliber police revolvers and conventional, nonjacketed lead bullets (.38 special caliber, manufactured by 3D Inv, Inc., Doniphan, NE) were used, as well as totally copper-jacketed lead bullets (.38 caliber special ammunition, Omark Industries, Lewiston, IA).

All background, general area, and breathing zone air samples were collected on cellulose ester filters following standard procedures.[11] Background and general area samples were collected within the perimeter of the range one hour before and during firing, respectively. The breathing zone samples were collected near the chest and face of the instructors. All samples were analyzed by atomic absorption spectrophotometry.[12]

Prior to firing activities, individual interviews were conducted and questionnaires administered to obtain information on demographic and other potential sources of lead exposure. Venous blood was drawn to obtain baseline values for blood lead on June 17, 1987. A second questionnaire was administered on July 7, 1987 to assess any symptoms of lead toxicity and to ascertain any other recent potential sources of lead exposure. A third questionnaire was administered on September 4, 1987 after the study was completed. Blood was drawn on June 18, 19, July 7, and September 4, 1987 after each firing activity. All samples were analyzed according to the method of Brodie and Routh (1984)[13] by the National Health Laboratory, Vienna, VA.

Results

The mean concentration of lead in $\mu g/m^3$ for June 18, 19 and July 7, 1987 was 0.8 (range 0.3–1.2) in the background area air samples and 87 (range 3.8–299) in general area air samples during the firing. The mean concentrations of lead for background and general area air samples during use of copper-jacketed bullets for September 4, 1987 were 0.5 $\mu g/m^3$ and 9.5 $\mu g/m^3$, respectively, as previously reported.[14] Use of copper-jacketed ammunition resulted in an 89 percent reduction in lead levels in general area air samples.

The instructors were exposed to different personal breathing zone air lead concentrations on two sampling dates (Table 1). The mean breathing zone lead level with nonjacketed bullets was 67.1 $\mu g/m^3$ for instructor #1, and 211.1 $\mu g/m^3$ for instructor #2. The mean breathing zone lead levels during use of the jacketed bullets for instructors 1 and 2 were 5.4 $\mu g/m^3$ and 8.7 $\mu g/m^3$, respectively. This resulted in a reduction of 92 percent for instructor #1 and 96 percent for instructor #2.

After use of nonjacketed lead bullets, the mean blood lead level was 1.16 $\mu mol/L$ for instructor #1, and 0.68 $\mu mol/L$ for instructor #2 (Table 2). None of these values exceeded the current Occupational Safety and Health Administration (OSHA) return standard of 1.93 $\mu mol/L$ (40 $\mu g/dl$) or removal standard of 2.4 $\mu mol/L$ (50 $\mu g/dl$).[15] After the use of copper-jacketed lead bullets, blood lead levels for instructors 1 and 2 were 1.06 $\mu mol/L$ and 0.63 $\mu mol/L$, respectively.

Discussion

All personal breathing zone lead level samples collected on June 19 and July 7 were above the current OSHA standard of 50 $\mu g/m^3$.[15] The majority of air lead levels for general area air samples and all breathing zone samples taken while using nonjacketed lead bullets were above the action level of 30 $\mu g/m^3$, for an eight-hour, time-weighted average (TWA).

The instructor blood lead levels measured during the nonjacketed lead bullet study indicated increases in blood lead concentrations. Blood lead levels reflect very recent lead exposures and are influenced by inhalation and ingestion. They may not reflect the total body burden of lead. Several studies have suggested that inhalation of air containing 1 $\mu g/m^3$ will increase the blood lead concentrations of an adult by about 0.048 $\mu mol/L$ when air lead concentrations range from 1 to 5 $\mu g/m^3$.[16–18] Public health officials, as well as range owners, should be aware of design problems and work habits in outdoor ranges, especially covered ranges where exposures of instructors and other users may occur.

While no definite case of lead toxicity was encountered herein, the instructors ex-

perienced increased levels of lead in their blood while cadets were firing nonjacketed lead bullets. Interviews conducted with instructors revealed that the firearm instructors commonly supervise new cadets two to three times per month. This intermittent supervision probably has prevented serious lead toxicity in these instructors. If other covered outdoor firing ranges have air lead levels similar to those found in this study, frequent users would have an increased health risk from the lead exposure based on the present data.

The present study emphasizes a potential health risk of exposure to lead for firearm instructors in this type of outdoor firing range. Such levels were attributed to the firing of conventional, nonjacketed, lead bullets by the cadets. Inadequate ventilation may have contributed to the elevated lead levels found in the general area air samples and personal samples of the instructors. This potential health risk was substantially reduced by using totally copper-jacketed ammunition. The use of jacketed ammunition, as shown in this study and other studies, was very effective in reducing the air lead levels in general area and personal breathing zone air samples.[19–22] Even with such short-time exposures, instructors showed elevated blood lead levels. Remedies to such exposures not only include the use of jacketed ammunition but the adequate ventilation of the facility. □

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