Medical Surveillance of Clandestine Drug Laboratory Investigators

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Law enforcement officers investigating clandestine drug laboratories may be exposed to a wide range of hazardous chemicals. This study was conducted to determine the extent of persistent health effects seen in California drug laboratory investigators after occupational exposure. Study participants with a minimum of 1 year of laboratory investigations completed a questionnaire evaluating occupational and personal health history and consented to review of their medical surveillance examinations and administrative records. The 40 participating investigators averaged 6.1 ± 2.5 annual medical evaluations for the period 1991 to 1998. Average annual decline in forced expiratory volume in 1 second (FEV_1) was 64.0 ± 138.0 mL/year (median, 40.0 mL/year). For 34 subjects with valid exposure data, longer duration use of respiratory protection was associated with a less rapid decline in FEV_1, whereas lack of respiratory protection during the processing phase of laboratory investigation was associated with a more rapid annual decline. There were no significant longitudinal changes in serum alanine aminotransferase, serum aspartate aminotransferase, hemoglobin, and white blood cell count, although platelets declined slightly. Law enforcement personnel investigating clandestine drug laboratories may have long-term respiratory effects from chemical exposure, for which more assiduous use of respiratory protection is recommended. (J Occup Environ Med. *2002;44:184–189*)

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Clandestine drug laboratories manufacture methamphetamine and other illicit drugs. Such laboratories may be found in a variety of structures, including houses, hotel rooms, storage units, automobiles, and other locations. A wide variety of precursor chemicals and synthetic pathways may be used during drug manufacture.[1,2] Common chemicals include ephedrine or pseudoephedrine, red phosphorus, strong acids and alkalis, a multitude of solvents, and (to a lesser degree) other organic chemicals, ammonia, and water-reactive solids. These chemicals are commonly heated in reaction vessels and may be released during the synthetic process.

Clandestine drug laboratories are increasing in number throughout the United States, particularly in the West and Midwest. Although complete numbers are not available, the Drug Enforcement Agency reported 1627 methamphetamine laboratory seizures in 1998, increased from 263 in 1994.[3] Adverse effects from exposure to these laboratories have been reported in the individuals manufacturing the illicit drugs (also known as “cooks”), their families, law enforcement personnel, and even subsequent inhabitants of the structure after all glassware containing toxicants has been removed.[4–6]

Law enforcement personnel are responsible for arresting individuals manufacturing illicit drugs, collecting evidence documenting criminal activity, and performing initial cleanup of laboratories to ensure public safety. This process of laboratory investigation is divided into

three major phases: entry, assessment, and processing. Entry is usually a short (5- to 30-minute) period in which law enforcement officers secure the laboratory through the arrest and removal of suspects. Because of their need for speed and surprise, and the possibility of hostile actions from laboratory occupants, respiratory protection may be limited to a cartridge respirator or nothing at all. After entry, assessment is the phase in which chemical and physical hazards are evaluated and the contents of the laboratory determined. Processing is the longest phase, commonly several hours or more in duration, in which the laboratory contents are removed and representative chemicals sampled. During assessment and processing, either self-contained breathing apparatuses or cartridge respirators may be used.

Very little information has been published concerning adverse effects in law enforcement personnel stemming from clandestine laboratory investigation. Active laboratories (ie, those in the process of manufacturing illicit drugs) have been associated with an increase in acute symptoms in laboratory investigators.[5] However, other than case reports, there is no published information on the possible chronic effects of clandestine laboratory investigation. The aim of this study was to evaluate, through review of medical surveillance data, potential long-term effects of clandestine laboratory work in a group of officers with a relatively large number of annual laboratory investigations.

Methods

This study was approved by the University of Arizona Human Subjects Committee. California State Department of Justice, Bureau of Narcotics Enforcement agents assigned to clandestine drug laboratory teams were asked to voluntarily participate in this study. Agents were eligible to participate if they had completed one initial 40-hour training period, at least one 8-hour follow-up training, and two medical surveillance examinations. To meet study criteria, participating agents had to have completed at least 1 year of clandestine drug laboratory work.

Participating agents agreed to (1) complete a questionnaire evaluating occupational and personal health history, (2) consent to a review of their medical surveillance examinations for each year of clandestine drug laboratory work, and (3) consent to a review of their Hazard Assessment and Recognition Plan (HARP) forms. One HARP form is completed for each drug laboratory that is seized. Signed informed consent was obtained before study initiation.

Questionnaires and consent forms were distributed to Bureau of Narcotics Enforcement agent participants during training sessions. A follow-up letter was sent to agents not participating in these training sessions. Medical information was collected from previous occupational surveillance examinations for each agent for each available year during their clandestine drug laboratory work. Data collected included forced expiratory volume in 1 second (FEV_1); alanine aminotransferase; aspartate aminotransferase; and hemoglobin, platelets, and white blood cell count. Medical information was entered directly into a database with manual verification of each data field. For participating agents, information on HARP forms generated from 1991 to 1998 was entered directly into a database. Variables included laboratory type, laboratory status (active, in the process of active chemical reactions; set-up, ready for manufacture but without ongoing chemical reactions; boxed, stored for transit), time in each phase of laboratory investigation (entry, assessment, processing), and type of personal protective equipment worn. Level B protection includes use of a positive-pressure self-contained breathing apparatus and chemical protective clothing, level C protection includes an air purifying cartridge respirator and chemical protective clothing, and level D protection includes no respiratory protection and regular work clothing only.

Longitudinal measurements of FEV_1 were analyzed using multiple linear regression with a random-effects model.[7,8] Separate models were built for entry, assessment, and processing, because the nonuniform effects of minutes of exposure with various levels of respiratory protection did not permit combined analysis. Age, height, gender, smoking (current, former, never), and race (white, non-Hispanic/other) were forced into all initial models as fixed, main effects, and removed from the final models in a stepwise manner ($P > 0.05$) to generate the most parsimonious model. Because only one subject evaluated in the models had asthma, this condition was not included as a variable in the model. To detect significant relationships between the dependent variables and drug laboratory investigation, the following variables were included in the model: self-reported years as laboratory investigator at baseline, total laboratories entered over the study period, and minutes within each phase for the three levels of personal protective equipment (B, C, D). Time spent in a particular phase and protection-level condition was summed separately for each of these conditions and for each period of observation, defined as the period between each annual occupational health examination, including spirometry. Because minutes within each phase were allowed to vary for each time period, these variables are referred to as time-dependent. Interaction terms with years of follow-up, age, and smoking were tested for significance with each of the exposure covariates.

FEV_1 data were analyzed using algorithms described by Jones and Boadi-Boateng[8] in Stata™ 6.0 (Stata Statistical Software, College Station, TX), testing the first-order autore-

TABLE 1
Clandestine Drug Laboratory Investigator Participants*

Age (years)	43.2 ± 6.0
Age (range)	31–56
Female gender	4 (10%)
Race/ethnicity	
White	27 (68%)
Hispanic	7 (18%)
Black	3 (7%)
Asian	3 (7%)
Current smoker	4 (10%)
Ever smoker	11 (28%)
Ever asthma	2 (5%)
Baseline FEV_1 (L)	4.01 ± 0.57
Baseline FEV_1 (% predicted)	102.8 ± 11.4
Baseline FVC (L)	4.92 ± 0.66
Baseline FVC (% predicted)	97.4 ± 8.9

* n = 40 subjects. FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second.

gressive within subject error structure. Selection of the best fitting model was done using maximum likelihood ratio tests for nested models. Annual changes in FEV_1 and annual medical laboratory data were calculated from the beta coefficients produced in linear regression models on each individual.

Results

Study Subjects

Of the 48 agents enrolled in the study, eight did not meet the study criteria (two were not Bureau of Narcotics Enforcement agents and six had completed only one training session or had missing spirometry data) and were excluded. This left 40 (45%) of an estimated 88 eligible Bureau of Narcotics Enforcement agents. The characteristics of the study participants are listed in Table 1. The participating investigators averaged 6.1 ± 2.5 annual medical evaluations (range, 2 to 11 annual medical evaluations) for the period 1991 to 1998 and experienced an average annual decline in FEV_1 of 64.0 ± 138.0 mL/year (median, 40.0 mL/year decline; range, 549.5 mL/year decline to 219.1 mL/year increase). Average annual decline in forced vital capacity was 72.0 ± 166.6 mL/year (median, 50.3 mL/year decline; range, 652.8 mL/year decline to 159.4 mL/year increase). Only two investigators had ever had asthma, and only one had asthma during the study period.

Clandestine Laboratory Exposures

HARP form exposure data were available for 34 of the 40 agents. Of 2030 total laboratories investigated, laboratory status was available on 676 (33%). Of these, 123 (18%) were active laboratories, 257 (38%) were set up but not actively manufacturing illicit drugs, and 295 (44%) were boxed. Of the 2030 laboratories, 1797 (88%) were manufacturing methamphetamine or a combination of methamphetamine and other illicit drug(s), 49 (2%) were manufacturing precursor chemicals, 19 (1%) were manufacturing phencyclidine (PCP), 2 (<1%) were manufacturing amphetamine, and 170 (8%) were manufacturing other chemicals. For methamphetamine laboratories, information was available from the questionnaires on synthetic pathways expressed as a total of all career investigations. These included ephedrine (or pseudoephedrine)–red phosphorus laboratories (86%), P-2-P-methylamine laboratories (9%), ephedrine–thionyl chloride laboratories (2%), unknown laboratories (2%), and other laboratories (1%).

The 34 agents with valid exposure data averaged 2.2 ± 1.9 years of laboratory investigation during the study period. On average for a typical laboratory during the study, they spent 11 ± 17 minutes (median, 5 minutes, range, 1 to 180 minutes) during entry, 34 ± 40 minutes (median, 28 minutes; range, 1 to 360 minutes) minutes during assessment, and 194 ± 148 minutes (median, 180 minutes; range, 2 to 1020 minutes) minutes during processing. Summary information on annual use of respiratory protection is provided in Table 2. Respiratory protection was less likely to be worn during entry than assessment and processing.

TABLE 2
Annual Use of Respiratory Protection*

	Level of Respiratory Protection		
Phase (minutes)	B	C	D
Entry			
0–15	123	120	94
16–150	12	15	41
Assessment			
0–15	97	60	72
16–150	32	55	42
>150	6	20	21
Processing			
0–15	91	53	59
16–150	12	9	13
151–600	23	38	30
>600	9	35	33

* n = 34 subjects with 135 total annual observations.

TABLE 3
Self-Reported Respiratory Illnesses Associated With Laboratory Investigation*

	New		Preexisting†			
			Worse		Same	
Illness	*n*	%	*n*	%	*n*	%
Wheezing	6	15	1	3	4	10
Breathlessness	6	15	1	3	4	10
Persistent cough	5	13	1	3	2	5
Bronchitis	3	8	0		2	5
Chest colds	4	10	3	8	14	35
Pneumonia	3	8	1	3	5	13
Chronic bronchitis	0		0		1	3
Emphysema	1	3	0		0	
Asthma	0		0		0	

* n = 40.
† Worse or same since starting clandestine laboratory investigation work.

Reported Illnesses

Self-reported illnesses limited to the respiratory system for all 40 agents are listed in Table 3. Agents with missing data for a particular illness were assumed to not have experienced that illness. Twelve (29%) agents reported at least one new illness since starting clandestine drug laboratory work. Seven (17%)

TABLE 4
Multiple Regression Model for FEV_1 (L): Entry Phase*

Variable	Coefficient	SE	*P* Value
Baseline age (years)	−0.010	0.014	0.451
Height (inches)	0.073	0.026	0.005
Male gender	0.538	0.297	0.070
Time (years during exposure period)	−0.038	0.013	0.003
16–150 annual minutes in level C protection†	−0.300	0.171	0.080
Time × 16–150 minutes level C protection	0.093	0.047	0.047
Intercept	−1.110	1.863	0.551

* $n = 34$. FEV_1, forced expiratory volume in 1 second.
† Compared with subjects with 0–15 minutes of annual level C protection.

TABLE 5
Multiple Regression Model for FEV_1 (L): Assessment Phase*

Variable	Coefficient	SE	*P* Value
Baseline age (years)	−0.011	0.014	0.427
Height (inches)	0.079	0.025	0.002
Male gender	0.506	0.301	0.093
Time (years during exposure period)	−0.044	0.013	0.001
16–150 annual minutes in level B protection†	−0.029	0.085	0.738
>150 annual minutes in level B protection†	−0.750	0.299	0.012
Time × 16–150 minutes level B protection	0.006	0.033	0.845
Time × >150 minutes level B protection	0.265	0.071	<0.001
Intercept	−1.444	1.841	0.433

* $n = 34$. FEV_1, forced expiratory volume in 1 second.
† Compared with subjects with 0–15 minutes of annual level B protection.

TABLE 6
Multiple Regression Model for FEV_1 (L): Processing Phase*

Variable	Coefficient	SE	*P* Value
Baseline age (years)	−0.011	0.014	0.438
Height (inches)	0.080	0.026	0.002
Male gender	0.532	0.297	0.074
Time (years during exposure period)	−0.032	0.028	0.254
16–150 annual minutes in level B protection†	−0.018	0.169	0.913
151–600 annual minutes in level B protection†	−0.015	0.103	0.886
>600 annual minutes in level B protection†	−0.125	0.146	0.391
Time × 16–150 minutes level B protection	0.030	0.047	0.526
Time × 151–600 minutes level B protection	−0.023	0.038	0.550
Time × >600 minutes level B protection	0.105	0.051	0.039
16–150 annual minutes in level C protection‡	−0.011	0.219	0.961
151–600 annual minutes in level C protection‡	−0.207	0.090	0.022
>600 annual minutes in level C protection‡	−0.114	0.117	0.332
Time × 16–150 minutes level C protection	−0.068	0.073	0.353
Time × 151–600 minutes level C protection	0.080	0.031	0.010
Time × >600 minutes level C protection	0.049	0.039	0.205
16–150 annual minutes in level D protection§	0.062	0.165	0.709
151–600 annual minutes in level D protection§	0.202	0.105	0.054
>600 annual minutes in level D protection§	0.221	0.118	0.061
Time × 16–150 minutes level D protection	−0.019	0.061	0.758
Time × 151–600 minutes level D protection	−0.086	0.034	0.010
Time × >600 minutes level D protection	−0.061	0.036	0.087
Intercept	−1.552	1.856	0.403

* $n = 34$. FEV_1, forced expiratory volume in 1 second.
† Compared with subjects with 0–15 minutes of annual level B protection.
‡ Compared with subjects with 0–15 minutes of annual level C protection.
§ Compared with subjects with 0–15 minutes of annual level D protection.

agents reported worsening of a preexisting condition. No agents reported improvement in a preexisting illness. Five (12%) agents reported days missed from work because of chemical exposure. These included two with 1 day of time loss and one each with 7, 14, and 40 days of time loss.

Medical Surveillance

The 34 agents with valid exposure data averaged 4.0 medical evaluations from 1991 to 1998, for a total of 135 annual medical evaluations. Mean decline in FEV_1 was 70.5 ± 147.9 mL/year, ranging from a 549.5-mL/year decline to an increase of 219.1 mL/year. Median decline in FEV_1 was 46.2 mL/year. First-order random effects models (Tables 4 through 6) revealed associations between use of respiratory protection in each investigation phase and longitudinal changes in FEV_1. During entry, longer duration (16 to 150 minutes compared with 0 to 15 minutes) of annual use of level C protection was significantly associated with a less rapid rate of decline. During assessment, longer duration (>150 minutes compared with 0 to 15 minutes) of annual use of level B protection was significantly associated with a less rapid rate of decline. During processing, longer duration (>600 minutes compared with 0 to 15 minutes) of annual use of level B protection and longer duration (151 to 600 minutes compared with 0 to 15 minutes) of annual use of level C protection were significantly associated with a less rapid rate of decline in FEV_1. During processing, longer duration (151 to 600 minutes compared with 0 to 15 minutes) of exposure without respiratory protection (level D) was significantly associated with a more rapid rate of decline in FEV_1. All models were correctly specified as determined by Hausman specification test, and the coefficients were jointly significant (Wald chi-squared test; $P < 0.001$). The overall R^2s for the entry, assessment, and processing random effects models were 0.32,

0.33, and 0.33, respectively. History of smoking was not associated with rate of decline in FEV_1 and, therefore, was not included in the final models.

There were no significant longitudinal changes in serum alanine aminotransferase (−0.72 IU/year; 95% confidence interval [CI], −1.67 to 0.23), serum aspartate aminotransferase (−1.03 IU/year; 95% CI, −2.98 to 0.91), hemoglobin (−0.067 g/dL; 95% CI, −0.154 to 0.021), and white blood cell count (−0.092 cells/mm^3; 95% CI, −0.215 to 0.032). Minimal longitudinal decline occurred in platelets (−3.13 cells/mm^3; 95% CI, −6.22 to −0.04).

Discussion

Overall, the clandestine drug laboratory investigators evaluated in this study demonstrated an average rate of annual decline in FEV_1 (64 mL/year) similar to that of continuing smokers, which in one study was 52.9 mL/year for men.[9] However, only 28% of the laboratory investigators were ever smokers. In addition, our study identified statistically significant associations between annual decline in FEV_1 and use of respiratory protection in each phase of laboratory investigation. This was true for minutes of exposure with level C protection during entry, level B protection during assessment, and all levels of respiratory protection during processing.

Level D protection does not include respirator use. Therefore, the observed association between increased duration of laboratory response in level D protection during processing and increased rate of decline in FEV_1 could be explained by higher levels of exposure to toxic chemicals produced during drug synthesis. The association between increased time spent in level C protection during entry and level B protection during assessment and reduced rate of decline in FEV_1 is more difficult to explain. Ideally, level B protection provides protection factors of over 10,000, assuming proper respirator fit,[10–12] and level C protection (half-face cartridge respirator) should provide a protection factor of at least 10, given use of cartridges appropriate for the chemicals found in clandestine drug laboratories.[13] It is possible that longer duration of use of respiratory protection could serve as a proxy for more careful handling of chemicals, which may itself reduce injurious exposure.

There are no comparable studies of chronic effects of clandestine drug laboratory investigation. In a study of acute health effects in law enforcement personnel involved in laboratory investigation, increased symptoms were reported in association with active drug laboratories compared with laboratories not producing illicit drugs at the time of investigation.[5] In this study, irritant symptoms were the most prevalent. The majority of symptoms were reported during processing, which also accounted for 87% of all time spent in illicit laboratories. Chemical exposures from methamphetamine laboratories have anecdotally been reported to cause permanent lung damage, although no cases have been published. A case of phosphine gas exposure in a laboratory investigator resulted in persistent respiratory symptoms.[6]

Although the potential exposures associated with investigation of clandestine drug laboratories are unique, there are comparable occupational groups. In particular, the uncontrolled nature of the chemical hazards with a preponderance of respiratory irritants may be similar to those faced by hazardous materials team members. However, to our knowledge, no one has evaluated the effects of respirator use on longitudinal changes in lung function in this group. The lack of changes in transaminase, hemoglobin, and white blood cell count in our study was also reported by Kales et al in a prospective study of Boston area firefighters.[14]

Active laboratories are associated with acute symptoms, even with use of cartridge respirators[5]; therefore, a self-contained breathing apparatus is more appropriately used in this setting. In other settings, choosing appropriate respiratory protection, including use of chemical-specific cartridges is made difficult by the extensive variability in potential exposures from laboratory to laboratory. This variability stems from the differences in chemicals used for methamphetamine and other illicit drug synthesis and differences in chemical volumes and ventilation used at each site. Direct-reading air monitors are both expensive and limited to a predefined set of chemicals. More specific testing for chemicals can be done, but usually not on a real-time basis. Cartridge respirators provide some degree of protection, as evidenced by the association between use of level C respiratory protection in entry and processing and the reduced rate of decline in FEV_1. However, for any specific clandestine drug laboratory, it will not be possible to guarantee that their use will prevent injurious pulmonary exposure.

There are several limitations to the study. Less than half of the eligible agents chose to participate in the study, and we were unable to characterize the nonresponders. Answers on questionnaire were subject to recall bias, and for this reason, exposure assessment used information from HARP forms. The number of HARP forms should be representative of the overall number of laboratories seized; however, some duplicates were noted, and the percentage of total laboratories represented was difficult to determine. The accuracy of the information entered on the HARP forms could not be verified. Methods of manufacturing methamphetamine may vary geographically, and risks of occupational exposure may vary with these methods. Therefore, the results of this study may not be generalizable to all law enforcement officers investigating clandestine drug laboratories. However, this group was chosen on the basis of their relatively high number of annual laboratory seizures, and their risks would be expected to be higher than many other clandestine laboratory investigation teams.

Law enforcement officers are faced with a quandary in dealing with clandestine drug manufacturing laboratories. Especially during the entry phase, officers must weigh the potential risks of wearing respiratory protective equipment that may interfere with their ability to perceive and react to threats from laboratory operators. During assessment and processing phases, however, circumstances allow more careful use of protective equipment. The major finding of this study is that use of respiratory protection is associated with reduced rate of decline in FEV_1. Accordingly, we recommend that law enforcement officers should remain vigilant and use appropriate means of decreasing chemical exposure protection during laboratory seizures.

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