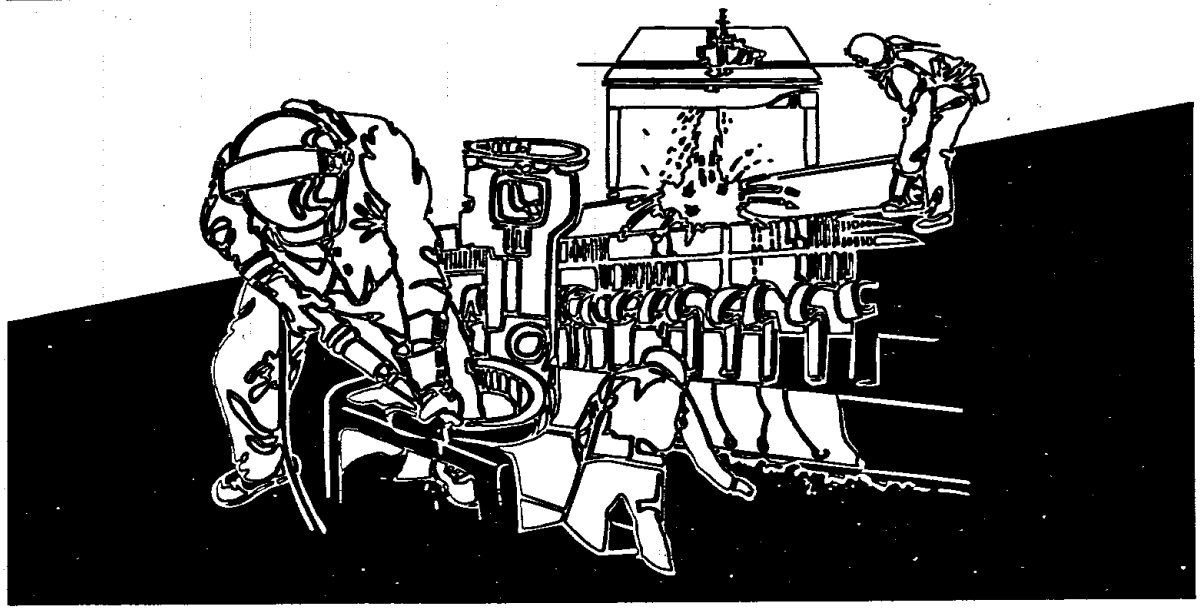
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 90-240-2259
THE CALDWELL GROUP
NORTH CAROLINA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 90-240-2259
OCTOBER 1992
THE CALDWELL GROUP
LENOIR, NORTH CAROLINA
CALDWELL INDUSTRIAL SERVICES, INC.
HUDSON, NORTH CAROLINA
CALDWELL SYSTEMS, INC.
HUDSON, NORTH CAROLINA
MITCHELL SYSTEMS, INC.
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I. SUMMARY

In July 1989, NIOSH received a report of disabling neurologic conditions in three former employees of Caldwell Systems, Inc. (CSI), a hazardous waste incinerator facility in Hudson, North Carolina, operated by The Caldwell Group (Caldwell) of Lenoir, North Carolina. The symptoms and findings included headache, irritability, memory impairment, hot flashes, nystagmus, ataxia, tremor, and labile blood pressure that were reported to persist and worsen even after employment at CSI had ceased. Based on reports that the disabled employees had heavy direct skin contact and inhalation exposures to hazardous waste materials, a local physician suspected that the findings constituted a syndrome related to occupational exposures at CSI. The local physician subsequently reported similar health problems among employees from two other facilities owned and operated by Caldwell: Caldwell Industrial Services, Inc. (CIS, a provider of hazardous waste transportation services) in Hudson, North Carolina; and Mitchell Systems, Inc. (MSI, a closed hazardous waste incinerator facility) in Spruce Pines, North Carolina.

Because of growing concerns about the risks of health effects from exposures to hazardous wastes, the North Carolina State Health Director requested technical assistance from NIOSH to study Caldwell employees. In September 1990, NIOSH investigators medically evaluated 14 former Caldwell employees reported by the local physician to have neurologic problems related to occupational chemical exposures. The primary purpose of these evaluations was to independently assess these workers' neurologic conditions and develop a case definition for an epidemiologic study to determine whether the reported neurologic disorders could be associated with work at Caldwell.

The most frequently reported symptoms were nonspecific (that is, they could be caused by any of a number of factors, including, but not limited to, chemical exposures). The most frequent finding of the neurologic examination was rapid or heightened response to hyperventilation. Similar, but not identical, movement disorders characterized by myoclonus (a type of repetitive muscle contractions) and tremor were noted in two participants. All participants had psychiatric symptoms, but the diagnoses with sufficient supporting information were not the same, and no specific work-related syndrome was observed. The most frequent finding on the mental status examination was diminished concentration.

The September 1990 evaluations did not demonstrate a high prevalence of any objectively quantifiable finding that could be used as part of a specific case definition to evaluate other Caldwell employees. Without such a case definition, a valid epidemiologic study to determine whether the reported health conditions could be associated with work exposures was not feasible. Screening examinations, however, were offered to address concerns that other Caldwell employees might have undetected or unreported neurologic disorders. All current and former employees who were not examined by NIOSH investigators in September 1990 were eligible to participate.

In November 1991, 54 current and former Caldwell employees participated in screening examinations directed at finding movement disorders. Despite multiple attempts to locate eligible participants and multiple contacts to confirm appointments, the participation rate was low (50% of 108 confirmed appointments, or 17% of 313 eligible for participation). None of the 54 participants showed evidence of a movement disorder characterized by myoclonus and tremor. The most frequent neurologic finding was a mild postural tremor in eight participants.

NIOSH investigators confirmed the finding of disabling movement disorders in two of 14 former Caldwell employees evaluated in September 1990. No additional cases of disabling movement disorders were detected during the November 1991 survey, but the participation rate was low. Although NC-DOSH found no evidence of hazardous chemical exposures during their 1987 investigation of CSI and 1989 investigation of CIS, some former employees' descriptions of environmental conditions and work practices at the Caldwell facilities suggest that substantial exposures, especially before 1987, might have occurred. The symptoms reported at the time of exposure were also consistent with overexposure to hazardous chemicals. NIOSH recommends that all workers at hazardous waste facilities or sites be educated about risks of exposure, trained to minimize exposure, and offered appropriate protection against exposure. In 1985, NIOSH, in collaboration with the Occupational Safety and Health Administration, the U.S. Coast Guard, and the U.S. Environmental Protection Agency, published guidelines to prevent worker exposures during hazardous waste site activities.

KEYWORDS: SIC 4953 (Sanitary Services, Refuse Systems), SIC 4959 (Sanitary Services NEC), SIC 421 (Trucking Services), SIC 4789 (Transportation Services NEC), hazardous waste materials, incinerator operations, organic solvents, propylene glycol dinitrate, torpedo fuel, neurologic disorders, movement disorders, myoclonus, tremor.

II. INTRODUCTION

In July 1989, NIOSH received a report of disabling neurologic conditions in three former employees of Caldwell Systems, Inc. (CSI), a hazardous waste incinerator facility in Hudson, North Carolina, operated by The Caldwell Group (Caldwell) of Lenoir, North Carolina. The symptoms and findings* included headache, irritability, memory impairment, hot flashes, nystagmus, ataxia, tremor, and labile blood pressure that were reported to persist and worsen even after employment at CSI had ceased. Although CSI employees handled a variety of hazardous materials (mostly solvent wastes from the local furniture industry), the disabled and other former CSI employees reported that their acute symptoms were worst whenever they handled wastes of a torpedo propellant, Otto Fuel II. Based on reports that the disabled employees had heavy direct skin contact and inhalation exposures to hazardous waste materials, a local physician suspected that the findings constituted a syndrome related to occupational exposures at CSI. This physician consulted an occupational physician, who suggested that the neurologic conditions could be related to propylene glycol dinitrate (PGDN), the principal component of Otto Fuel II.

The local physician subsequently reported similar health problems among employees from two other facilities owned and operated by Caldwell: Caldwell Industrial Services, Inc. (CIS, a provider of hazardous waste transportation services) in Hudson, North Carolina; and Mitchell Systems, Inc. (MSI, a closed hazardous waste incinerator facility) in Spruce Pines, North Carolina.

Because of growing concerns about the risks of health effects from exposures to hazardous wastes, the North Carolina State Health Director requested technical assistance from NIOSH to study Caldwell employees. In September 1990, NIOSH investigators medically evaluated 14 former Caldwell employees reported by the local physician to have neurologic problems related to occupational chemical exposures. Screening examinations for movement disorders were offered to the rest of the Caldwell workforce in November 1991 to address concerns that other Caldwell employees might have undetected or unreported neurologic disorders. Each participant of the September 1990 evaluations or the November 1991 screening examinations was notified of his or her own evaluation results by letter.

III. BACKGROUND

A. The Caldwell Group facilities

In 1975, Caldwell County built a facility to incinerate solvents, paints, and lacquer wastes generated by the furniture industry in Caldwell and three nearby counties. In 1976, the facility was idled

*See Appendix A for definitions of medical and epidemiologic terms.

after a fire. In 1977, CSI leased the facility from the county. CSI began incinerating wastes from sources outside the region and state, including waste Otto Fuel II from the U.S. Navy. CSI's lessee/operator subsequently built another incinerator facility, MSI, where operations began in 1980. In 1983, a local waste transportation and clean-up firm was acquired by Caldwell and renamed CIS. In 1986, laboratory activities were moved from the individual companies to a new laboratory facility. The MSI facility closed in 1985 and was subsequently dismantled. CSI's incinerator operations ended in May 1988 and the facility closed in December 1989. CIS was later sold.

Based on reports that several employees had possible work-related neurologic disabilities and that the workforce was heavily exposed to hazardous wastes, the North Carolina Division of Occupational Safety and Health (NC-DOSH) conducted an investigation of the CSI facility in 1987. During the time of the investigation, NC-DOSH found no excessive exposures to hazardous waste materials. In 1989, NIOSH notified NC-DOSH of the reports it had received of neurologic problems in former workers. Because incinerator operations had ceased and the facility was scheduled to close, and because of the findings of its 1987 investigation, NC-DOSH did not return to CSI. NC-DOSH, however, did investigate the CIS facility in October 1989 in response to reports of work-related illnesses received at NIOSH. NC-DOSH reported that no evidence of hazardous chemical exposures was found at CIS. Because of continued reports of health problems in CIS employees, NIOSH investigators made an unannounced visit to CIS in August 1990. Only four of the 18 employees were at the site at the time of the visit, since most activities (transportation and off-site decontamination) were not based at the facility. At the time of the visit, activities with potential for exposure (such as tank cleaning) were not being performed, and no hazardous wastes were seen on the property. NIOSH investigators subsequently collected personnel records and hazardous waste manifests for waste Otto Fuel II.

In response to local communities' contentions that the facilities were responsible for health-threatening incinerator emissions, waste run-off from properties, and improper use of the Caldwell County sanitary landfill, the U.S. Environmental Protection Agency (EPA) [NUS, 1990; NUS, 1991a,b,c] and Agency for Toxic Substances and Disease Registry (ATSDR)* conducted investigations to address environmental and community issues.

*A report on the ATSDR investigation has not yet been released.

B. Potential exposures of concern

1. Organic solvents

The term "organic solvents" refers to a group of volatile liquids that are used for extracting, dissolving, or suspending materials that are not soluble in water. Solvents are used in paints, adhesives, glues, coatings, and degreasing/cleaning agents, and in the production of dyes, polymers, plastics, textiles, printing inks, agricultural products, and pharmaceuticals.

The acute, transient neurotoxic effects of organic solvent exposure result from the action of the solvent within the central nervous system (CNS). Solvent inhalation by workers may result in effects ranging from alcohol-like intoxication to decreased level of consciousness and death from respiratory failure, with a spectrum of intermediate symptoms that include drowsiness, headache, dizziness, and nausea. Experimental exposures in human volunteers to specific organic solvents have resulted in acutely impaired psychomotor function as measured by performance of tasks such as reaction time, manual dexterity, coordination, and body balance [NIOSH, 1987].

The chronic neurotoxic effects of organic solvent exposure are less well established. Results of animal studies support the association of a limited number of organic solvents (for example, n-hexane, methyl-n-butyl ketone, carbon disulfide) with the peripheral neuropathy and mild toxic encephalopathy observed in workers exposed to those solvents [Spencer et al., 1985]. Epidemiologic studies of various groups of solvent-exposed workers have demonstrated statistically significant chronic worsening of peripheral nerve function that persisted for months to years following cessation of exposure. Some of the epidemiologic studies have also shown statistically significant increases in adverse neurobehavioral effects in workers chronically exposed to organic solvents. The extent to which CNS neurotoxicity is reversible remains to be established; peripheral nerves have the capacity to regenerate, but damage to the CNS is more often permanent [NIOSH, 1987].

Two international workshops have categorized solvent-induced CNS disorders according to their severity [WHO, 1985; Baker et al., 1986]. The mildest type is the organic affective syndrome or Type 1 disorder and is characterized by fatigue, memory impairment, irritability, difficulty in concentrating, and mild mood disturbance. The second level of disorder is described as mild chronic toxic encephalopathy or Type 2 disorder. This level involves abnormalities of performance on formal neuropsychological testing, as well as symptoms of the mildest type of neurotoxicity. The Type 2 disorder has been divided into Type 2A (sustained personality or mood changes such as emotional instability and diminished impulse control and motivation) and Type 2B (impairment in intellectual function, manifested by diminished concentration, memory, and learning

capacity). The third and most pronounced level of disorder is described as severe chronic toxic encephalopathy or Type 3 disorder. The condition is characterized by dementia (overall deterioration in intellect and memory) that may be irreversible, or at best, only poorly reversible.

Type 1 and 2 disorders are the most likely to be reported among workers with long-term exposure to solvents [NIOSH, 1987]. Type 3 disorders have been reported in organic solvent abusers and are characterized by irreversible dementia accompanied by structural CNS damage [NIOSH, 1987].

On the basis of the identified adverse health effects of solvent exposure, NIOSH recommends that employers use engineering controls, personal protective equipment and clothing, and worker education programs to reduce exposure to organic solvents - at least to the concentrations specified in the Occupational Safety and Health Administration (OSHA) standards (permissible exposure limits, PELs), or to NIOSH recommended exposure limits (RELs) or American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs®) if they provide a greater degree of protection [NIOSH, 1987].

2. Propylene glycol dinitrate

PGDN is the principal component of Otto Fuel II, a torpedo propellant. If a torpedo has not been shot, Otto Fuel II is recycled for use in training shots. Recovered training shots are the source of waste Otto Fuel II, which contains residual Otto Fuel II, sea water from certain torpedoes, and detergent used to flush out torpedoes.

PGDN is a nitrated ester and is chemically related to nitroglycerin (NG) and ethylene glycol dinitrate (EGDN). Nitrated esters are well known for their explosive properties and are used in the manufacture of munitions or as rocket or small arms propellants. In medicine, NG is best known for its use in the treatment of angina. Inhalation and skin contact are the major routes of occupational exposure to nitrated esters. Acute health effects of exposure to NG and EGDN include headache, dizziness, nausea, increase in heart rate, decrease in systolic blood pressure, and change in diastolic blood pressure [NIOSH, 1978]. Exposed workers develop tolerance to the vasodilatory effects [NIOSH, 1978]. Some workers develop nitrate withdrawal symptoms, such as angina, after exposure has ended [Kristensen, 1989]. Acute health effects of exposure to PGDN include headache, impaired coordination and balance, increase in diastolic blood pressure, and altered visual evoked response [Stewart et al., 1974]. Nitrate withdrawal symptoms were not found in a study of PGDN-exposed workers [Forman et al., 1987]. Although the number of cases were relatively few, one study found that workers exposed to PGDN had a higher incidence of angina and/or myocardial infarction (heart attack) than workers without exposure [Forman et al., 1987]. No

chronic neurologic diseases related to PGDN exposure have been reported in Navy workers who routinely handled Otto Fuel II [Horvath et al., 1981].

IV. SEPTEMBER 1990 EVALUATIONS*

A. Methods

The primary purpose of the September 1990 evaluations was to develop criteria for health outcomes (case definition) for an epidemiologic study to determine whether the reported neurologic disorders were associated with work at CSI, exposure to hazardous wastes, and, particularly, exposure to waste Otto Fuel II. The evaluations were designed to ascertain the nature of the reported illnesses and to characterize the symptoms and signs experienced in common by the identified workers. These evaluations were not designed to examine the causal relationship between occupational exposures and medical or psychiatric abnormalities.

As of September 1990, the local physician reported that 17 of his patients, including the three disabled workers reported to NIOSH in July 1989, showed health effects that he attributed to hazardous waste exposures. NIOSH investigators and the local physician were able to contact 15, all of whom were invited to participate.

The participants were offered standardized medical evaluations focused on the neurologic system and psychiatric status. Each participant was informed that the purpose was to collect information for occupational health research and that the evaluations were not intended to be part of a personal physician's evaluation and treatment plan. All participants were advised to continue to see their personal physicians for medical care.

The evaluations consisted of the administration of two questionnaires, a general physical examination by an internist, examinations by two neurologists, and an interview with a psychiatrist. Examiners were instructed to first identify positive findings and note pertinent negative findings, then indicate whether the findings were consistent with established or presumptive medical or psychiatric conditions or were without any apparent explanation. To limit observation bias, none of the examiners was given work or exposure histories. In addition, the examiners were instructed not to discuss a participant's findings before completing the evaluation forms.

*This section on the September 1990 evaluations was issued as an interim report in October 1991.

NIOSH interviewers administered medical questionnaires and work and exposure questionnaires. The medical questionnaire contained questions about demographic information; neurologic, neurobehavioral, respiratory (lung), cardiac (heart), gastrointestinal, genitourinary, dermatologic (skin), hemopoietic (blood-forming system), and musculoskeletal symptoms; medications; allergies; illnesses and injuries; family medical history; and tobacco, caffeine, and alcohol usage. The work and exposure questionnaire contained questions about type of work, job title, work exposures, and exposures from non-work-related activities.

An optional self-administered questionnaire about the participant's health was offered to close relatives or close friends who accompanied participants to the examination site.

Vital signs, including pulse and blood pressure measurements while lying and standing, and visual acuity (Snellen) were measured. A NIOSH internist reviewed the symptoms reported in the medical questionnaires, obtained additional medical history, and performed physical examinations of the skin, lymph nodes, face, eyes, nose, mouth and throat, thyroid, chest and lungs, heart, abdomen, and extremities. If the participant reported joint symptoms, the joints of the affected and opposite side were examined. The internist was instructed to note possible medical diagnoses and, specifically, the presence or absence of findings consistent with alcohol- or drug-related problems, thyroid disease, and diabetes mellitus.

To identify neurologic abnormalities, NIOSH retained two neurologists to perform independent neurologic evaluations. The neurologists reviewed the internist's evaluation forms, then performed standardized examinations of the cranial nerves, station and gait, motor function, sensation, coordination, reflexes, musculoskeletal system, and selected provocative tests (such as volitional hyperventilation, Nylen maneuver, tests for carpal tunnel syndrome). The neurologists were instructed to score all examination items on standardized forms, then clinically interpret the findings with the understanding that the impressions were considered tentative because of the limitations of the evaluation and the absence of information from previous neurologic evaluations. To assess agreement between the two independent examiners (interobserver agreement), ordinal results of the scored items were compared by Student paired t-test and dichotomous results by Wilcoxon sign-rank test. Unless otherwise specified, positive findings and impressions are reported here only if recorded by both neurologists.

The neurologists were given the option to videotape selected portions of the examination for review by other neurologists. A movement disorder specialist, who was given no information on exposure, medical history, or results of the examinations, was instructed to review the recording, describe the findings, and provide impressions.

A NIOSH psychiatrist conducted standardized limited psychiatric evaluations, including the mental status examination, history of

symptoms or diagnoses of psychiatric illness, history of alcohol and drug usage, educational history, and family history. The psychiatrist was instructed to clinically interpret the findings with the understanding that the impressions were considered tentative because of the limitations of the evaluation and the absence of information from the internal medicine and neurologic examinations.

At the end of each examination day, the examiners presented their findings and impressions to the other examiners, to determine whether each participant's findings were consistent with specific diagnoses or syndromes.

Each participant was notified by letter of his individual evaluation results.

B. Results

Fourteen of the 15 persons who were invited to participate completed all parts of the evaluation. One agreed only to a brief interview with the psychiatrist and a brief neurologic examination with both neurologists present. His findings are not included in this report.

1. Questionnaires

The demographic characteristics of the 14 participants are shown in Table 1. A summary of work histories is shown in Table 2. Participants reported that all of the jobs listed involved exposures to hazardous waste materials. Some former workers reported that "sludge/utility" workers had the heaviest exposures.

Symptoms reported on the medical questionnaire are shown in Table 3. Most symptoms were highly prevalent among the participants. All 14 participants reported daily or weekly headaches, positional lightheadedness or dizziness, and problems with memory.

Summaries of reported medical conditions and family medical histories are shown in Tables 4 and 5. Because only four of the 14 participants were accompanied by close relatives or friends, the results of the self-administered questionnaires completed by relatives or friends are not included in this report.

2. General physical examination

Findings of the general physical examination and the internist's impressions are shown in Tables 6 and 7.

One participant's blood pressure was not measured because muscle movements made determination by auscultation and palpation impossible. Two participants found to have elevated blood pressures did not report prior histories of high blood pressure.

Of the 12 participants reporting symptoms of indigestion, nausea, or abdominal pain on the questionnaire, four were noted to have epigastric (central area of the upper abdomen) tenderness on physical examination. Three of the four with epigastric tenderness gave histories of peptic ulcer disease.

3. Neurologic examinations

a. Findings

Neurologic findings independently documented by both neurologists are shown in Table 8.

Five of the 14 participants accounted for most of the abnormal neurologic signs (after excluding positive Tinel and Phalen signs, which are usually associated with musculoskeletal factors rather than toxic exposure). Two were noted to have abnormal station (inability to maintain a steady posture while standing) and gait, as well as movement disorders characterized by myoclonus (jerking movement caused by sudden contractions of one or more muscle groups), resting tremor, and postural tremor. The movement abnormalities were similar but not identical. The cause of the movement disorders could not be determined from these examinations. A third participant was noted to have abnormal station, but had no gait abnormality, myoclonus, resting tremor, or postural tremor. A fourth participant was noted to have postural tremor, but normal station and gait and no myoclonus or resting tremor.

Two participants were noted to have reduced distal lower extremity muscle stretch (ankle) reflexes. They also had the greatest decreases in sense of touch (indicated by the highest quantitative touch and vibration thresholds) recorded by the neurologists. The combined findings of abnormal ankle reflexes and diminished peripheral sensation are consistent with findings associated with mild sensory peripheral neuropathy.

End-gaze nystagmus was observed in three participants and considered to be physiologic (i.e., normal; a few rhythmic movements of the eyeballs on extreme gaze to the side is considered normal).

A positive Tinel sign (numbness and tingling over the distribution of an injured median nerve on tapping over the nerve) or Phalen sign (numbness and tingling over the distribution of an injured median nerve on flexion at the wrist) was noted in six participants. Only one of these participants was noted to have both Tinel and Phalen signs.

Neither of the two participants noted to have positive responses to the Nylen test had symptoms or other findings to support a

diagnosis of benign positional vertigo (sensation of spinning with changes in body posture).

Rapid or heightened response to brief hyperventilation (increased rate and depth of breathing greater than the body requires, which can result in characteristic symptoms) was noted in 11 participants. In many cases, brief hyperventilation reproduced some of the frequently reported symptoms (such as headaches, lightheadedness, numbness in the hands and fingers or feet and toes, palpitations).

b. Impressions

The frequencies of neurologic impressions independently recorded by both neurologists are shown in Table 9. The impressions were categorized according to the likelihood that the neurologic findings can be related to a specific syndrome or identifiable cause. The majority of positive neurologic findings appear to be unrelated to toxic exposure. A few of the findings could be related to toxic exposure, but no distinct syndrome was apparent.

c. Interobserver agreement

Overall agreement between the two neurologists appeared to be good. Discussions held by the NIOSH team of examiners after results were recorded indicated a similar agreement among all examiners. Differences in neurologic findings and impressions between the two neurologists are discussed in Appendix B.

d. A movement disorder specialist reviewed a video recording of four participants selected by the neurologist because of positive neurologic findings. The specialist was given no information about the participants' work and medical histories. He noted the presence of Parkinsonian-like movements (tremor, bradykinesia, impaired gait and balance) in the two participants identified by the neurologists as having similar but not identical movement abnormalities characterized by myoclonus and tremors. He noted less definite abnormalities in the other two. He neither suggested a toxic cause nor ruled out the possibility of a common cause for these findings.

e. Comparison with questionnaire responses

Two of the five participants who reported symptoms of positional vertigo (sensation of spinning with changes in body posture) were noted to have positive responses to the Nylen test. No asymptomatic (for positional vertigo) participants had positive objective responses to the Nylen test.

Only three of the thirteen participants reporting any muscle twitching or tremors, unsteady gait, trouble with balance, or

trouble with coordination had neurologic examination findings to verify their symptoms.

Eight of the ten participants found to have a rapid or heightened response to hyperventilation reported symptoms of numbness and tingling of the hands or feet on the questionnaire. Of the nine reporting these symptoms, only one did not exhibit a rapid or heightened response to hyperventilation.

4. Psychiatric findings

Table 10 shows the frequencies of psychiatric symptoms. The most frequent symptoms reported to the psychiatrist were irritability, sleep disturbances, aggressive outbursts, depressed mood, and problems with memory (which was not always objectively verified on mental status examination). Although 11 participants reported histories of violent behavior early in their lives, the history of prior violent episodes was quite limited. In every case, the magnitude of the aggressive episodes reported was grossly out of proportion to the triggering factor. Often, a triggering factor was not identifiable. At the time of the evaluation, almost all of those who reported a history of marked irritability and violent impulses were exercising good judgment in attempting to avoid situations likely to lead to violent episodes. Consequently, such individuals were leading isolated lifestyles, and several marriages were seriously threatened.

Table 11 shows the frequencies of abnormalities found on the mental status examination. Twelve participants were found to have diminished concentration as indicated by a subnormal digit span, the most frequent finding on the mental status examination. Decreased attention to a task and problems with recall were less common. Subjective memory problems were often more severe in nature than any impairment documented on mental status examination, a finding not uncommon in individuals reporting memory disturbance.

Table 12 shows the frequencies of impressions recorded by the psychiatrist. Almost all of the impressions with sufficient data available to make a diagnosis appear to be unrelated to occupational toxic exposure. Except for alcohol abuse or dependence, no more than two individuals were noted to have the same psychiatric diagnoses. Although 10 of the 14 participants showed some evidence of an organic (explained by an anatomic defect or pathologic process) personality syndrome, the data available were not sufficient to make this diagnosis with confidence.

C. Discussion

1. Medical and neurologic evaluations

In summary, the majority of symptoms and signs noted in the medical histories and neurologic examinations were either nonspecific and common in the general population, or probably related to identifiable syndromes or known causes other than work-related toxic exposures.

a. Unexplained significant findings

Of the five participants with at least one finding initially categorized as an unexplained significant finding (category 4 of Table 9), two had abnormal gait and movement disorders. A common causal factor for these abnormalities could not be established by these evaluations. Wilson's disease, a rare genetic disorder of copper metabolism, was identified by the neurologists as a potential cause for the gait and movement disorders. Although it is possible that one participant might have Wilson's disease, it is highly unlikely that both would have the same diagnosis, since the affected participants are not known to be related.

Two participants were observed to have abnormal ankle reflexes and diminished peripheral sensation, findings consistent with mild sensory peripheral neuropathy. Review of their medical histories suggested that their abnormalities might be related to non-work-related risk factors.

b. Possible carpal tunnel syndrome

Six participants had positive Tinel and/or Phalen signs, which are subjective findings suggestive of, but not diagnostic for, carpal tunnel syndrome (pain, numbness, and/or tingling over the distribution of an injured median nerve). Carpal tunnel syndromes are relatively common in workers whose jobs are associated with repetitive wrist motion or a forceful grip (for example, hand tool users such as electricians or carpenters, video display terminal operators). In addition, isolated Phalen or Tinel signs are found in approximately 10% of asymptomatic individuals without work-related risk factors or medical conditions potentially associated with carpal tunnel syndrome (for example, hypothyroidism, diabetes mellitus, rheumatoid arthritis, wrist fracture).

c. Potential medication effects

Prescribed medications are a common source of neurologic symptoms and signs, either as an adverse side effect or anticipated physiologic response. Although the relationship between medications and symptoms could not be further examined from the data collected, the neurologists noted that ten participants

reported taking medications with potential neurologic side effects which might have contributed to their symptoms. Both participants with abnormal gait and movement disorders reported use of multiple medications with potential effects upon the motor system.

d. Potential neurotoxic chemical exposures

Exposures to solvents, glues, and pesticides may be associated with neurobehavioral effects. All 14 participants reported chemical exposures during work at the Caldwell facilities. Seven participants also gave histories of exposure to potentially neurotoxic chemicals in jobs with other employers. Three of these seven were among the five with unexplained significant neurologic findings.

2. Psychiatric evaluations

Overall, histories of violent behavior and impulses were most striking. Aggressive behavior can be secondary to a number of psychiatric disorders, including psychosis, mania, substance abuse, antisocial personality disorder, and, possibly, temporal lobe epilepsy. None of the 14 participants, however, gave histories suggestive of psychotic disorder, mania, or temporal lobe epilepsy, and most histories were not consistent with antisocial personality disorder. Substance abuse could, at most, explain the irritability in a few cases. Assuming that the self-reports of aggressive behavior were accurate, such behavior can be consistent with a diagnosis of organic personality syndrome, explosive type. Organic personality syndrome refers to a persistent personality disturbance usually caused by structural damage to the brain, but can be related to nonstructural causes, such as toxic exposures, psychoactive drugs, or endocrine disorders. Therefore, a diagnosis of organic personality syndrome cannot be confirmed without more comprehensive medical and neurologic evaluations than were provided by these examinations and additional data on each participant's occupational and nonoccupational toxic exposures.

Diminished concentration as indicated by a subnormal digit span on the mental status examination was the only "objective" finding common to more than three participants that was potentially consistent with a health effect related to an occupational toxic exposure. However, interpretation of a subnormal digit span in the absence of other related objective abnormalities is difficult.

These psychiatric examinations did not rule out the possibility that the findings in this group of former hazardous waste workers may represent a spectrum of psychiatric effects resulting from neurotoxic chemical exposure [WHO, 1985; Baker et al., 1986]. Under this hypothesis, organic mood syndromes, characterized by depression, loss of interest, fatigue, and irritability would represent the mildest cases. Organic personality syndromes, characterized by affective

instability, outbursts of aggression, and suspiciousness would represent the more severe cases. Finally, dementia-like conditions with prominent memory disturbances would represent the most severe cases. These syndromes, however, are nonspecific, and the cause cannot be determined solely by the presence of the syndrome.

Five participants gave histories of extensive alcohol use, although two reported that they were not currently drinking alcohol. Excessive alcohol consumption could be an important contributory factor to some of the reported "mood swings." In some cases, increased alcohol consumption over the past few years might have been reactive (that is, a response to other problems such as depression) rather than primary.

The psychiatric symptoms reported by the workers were complicated by the complex legal and socio-political milieu surrounding this investigation. In addition, changes in behavior attributed to employment at the hazardous waste facilities could not be confirmed because objective characterizations of participants' behavior before beginning work at the Caldwell facilities would be difficult to determine.

3. Potential for selection bias

Because the participants in this phase of the study were selected by the local physician on the basis of having neurologic or neurobehavioral symptoms and signs, and not as a representative sample of workers at the Caldwell facilities, high prevalences of symptoms and possible neurologic and neurobehavioral abnormalities were expected (i.e., selection was biased toward detection of abnormalities). Therefore, inferences about the prevalence of abnormalities in other Caldwell workers cannot be made from these findings.

D. Conclusions

The evaluations did not demonstrate a high prevalence of any objectively quantifiable finding that could be used as part of a specific case definition. Without such a case definition, a valid epidemiologic study to determine whether the reported health conditions could be associated with work exposures was not feasible. Screening examinations, however, were offered in November 1991 to address concerns that other Caldwell employees might have undetected or unreported neurologic disorders.

V. NOVEMBER 1991 EVALUATIONS

A. Methods

All current and former Caldwell employees who were not examined by NIOSH investigators in September 1990 were eligible to participate. Three

hundred twenty eight current and former employees were identified from personnel records, through telephone calls to former employees attending U.S. EPA- or ATSDR-sponsored community meetings, and from calls to the NIOSH toll-free telephone number. Addresses were verified through the U.S. Postal Service (USPS) and Internal Revenue Service. Letters soliciting participation in the November 1991 survey were mailed to 294 eligible participants who had addresses in and around western North Carolina. Mail for 10% of the 294 addressees was returned by the USPS because of unknown addressee or lack of forwarding address. Although approximately 50% of the 294 addressees did not respond to two mailings, the letters were presumably delivered, since they were not returned by the USPS. Twenty-four respondents indicated that they would not participate, and none gave physical disability as the reason for nonparticipation. Appointments were made for all 108 respondents who were willing to participate and able to travel to the examination site. Appointments were confirmed by mail and telephone. Final confirmations were made by telephone a few days before the appointments. The examinations were conducted in Lenoir, North Carolina, on November 15 and 16, 1991.

Each participant was asked to complete a brief questionnaire which inquired about any health problem that he or she felt was related to work at the Caldwell facilities. Each participant was examined by a NIOSH physician who performed a physical examination of selected segments of the neurologic system. The examination was directed to finding resting and postural tremor, myoclonus, and abnormalities of pupillary reaction to light, eye movements, station and gait, coordination, and muscle strength. In an effort to standardize these examinations, the examining physicians were trained by a neurologist before the screening took place and instructed to refer participants with any possible abnormality to the neurologist for a more detailed examination.

Participants referred to the neurologist were asked to complete a second self-administered questionnaire. This questionnaire addressed work and exposure histories, preexisting medical and psychiatric conditions, medication use, personal habits, familial tremor, and factors that could affect results of a neurobehavioral examination (such as educational level). The Short Michigan Alcohol Screening Test [Selzer et al., 1973] was included in the questionnaire because chronic alcohol consumption is an important potential cause of neurologic abnormalities. Because use of illicit drugs was not found to be an important factor in the September 1990 evaluation of former employees, questions about illicit drug use were not asked.

The neurologist performed a neurologic examination directed at evaluating the possible abnormality identified by the initial examiner. Because this was a case-finding survey rather than an epidemiologic study, the neurologic examinations were not necessarily identical in content. The neurologist was instructed to include, as part of his evaluation, any additional items appropriate to the individual and to

omit any items that were not relevant. The neurologist was asked to interpret the findings, with the understanding that the impressions would be considered tentative because of the limitations of the evaluation (which did not include any diagnostic procedures beyond the medical history and physical examination).

At the end of each evaluation, the NIOSH project officer reviewed the questionnaire and examination data sheet. The project officer privately interviewed those who had concerns about work-related health problems. Participants were advised to seek medical attention from a personal physician for any identified abnormal findings.

For most participants, individual histories of employment at Caldwell facilities were abstracted from personnel files. If this information was incomplete, NIOSH investigators obtained it from the participant at the end of the evaluation.

Each participant was notified in writing of his or her individual physical examination results. Participants were again advised to seek medical attention from a personal physician for any identified abnormal findings.

B. Results

Fifty six of the 108 eligible participants with appointments kept their appointments. Three of the 56 subsequently refused to participate, and an additional eligible participant was seen without a scheduled appointment. Table 13 shows the duration of employment of the 54 participants compared with that of the September 1990 participants and all current and former Caldwell employees. Of the 54 who completed the screening examinations, 36 (67%) showed no neurologic abnormalities. The other 18 (33%) were referred to the neurologist for further evaluation.

Most of the 18 participants referred to the neurologist reported multiple symptoms, such as vertigo, clumsiness or poor coordination, unsteady gait or loss of balance, tremor or muscle twitching, and paresthesias (Table 14), as did the 14 participants of the September 1990 evaluations. Table 15 summarizes the medical histories reported on the questionnaire, and Table 16 summarizes the neurologist's findings. The most frequent neurologic finding was a mild postural tremor in eight participants. Table 17 shows some characteristics of these participants, based on their questionnaire responses. Two of the eight had no immediately identifiable possible causes for the tremor, and none had an intention tremor. None of the participants showed evidence of myoclonus, which was present in two of the 14 former employees evaluated by NIOSH investigators in September 1990.

Although the evaluation was limited to neurologic problems potentially involving the control of body movement, 11 of the participants receiving only the screening examination, and 14 of the participants examined by

the neurologist, expressed concerns about health risks related to their exposures at Caldwell. These concerns are summarized in Table 18. Most wanted to know whether their exposures to hazardous waste materials had caused particular health problems that they or their family members experienced. The most frequently expressed single concern was the future risk of developing cancer as a result of their exposures.

VI. DISCUSSION

Although NC-DOSH found no evidence of hazardous chemical exposures during their 1987 investigation of CSI and 1989 investigation of CIS, some former employees' descriptions of environmental conditions and work practices at the Caldwell facilities suggest that substantial exposures, especially before 1987, might have occurred. The symptoms reported at the time of exposure were also consistent with overexposure to hazardous chemicals. For example, reports of severe headaches and nausea on exposure to waste Otto Fuel II suggest that Caldwell employees might have had higher exposures to PGDN than Navy workers who routinely handled Otto Fuel II [Horvath et al., 1981].

Among the participants of the September 1990 evaluations, the persistence of symptoms even after exposure had ended suggests the possibility of chronic organic solvent toxicity. Most of the more frequently reported symptoms (such as headaches, irritability, poor concentration), however, are also frequently found in people who do not have occupational exposures to chemicals. Other reported symptoms (such as numbness and tingling of the hands or feet, abdominal pain, joint pain or stiffness) are less typically caused by chemical exposures. The high prevalences of symptoms in these participants were not unexpected, since they had already been identified by a local physician as having neurologic disorders.

Movement disorders have been described as a chronic effect of occupational exposure to specific solvents (such as n-hexane, methyl-n-butyl ketone, carbon disulfide) [Spencer et al., 1985] or heavy metals (such as mercury, manganese) [Parkinson, 1992; Wilkenfeld, 1992]. The presence of movement disorders in Caldwell workers, who were not known to have chronic exposures to these substances, raised concerns that this might represent a sentinel occupational health event – a disease, disability, or untimely death which is occupationally related and whose occurrence may provide the impetus for epidemiologic or industrial hygiene studies or serve as a warning signal that materials substitution, engineering control, personal protection, or medical care may be required [Rutstein et al., 1983].

NIOSH examiners confirmed the finding of disabling movement disorders in two of the 14 former Caldwell employees evaluated in September 1990, but did not detect such a movement disorder among the remaining 12 participants. Evaluations of these participants (who were identified by the local physician as having neurologic disorders) did not demonstrate a high prevalence of any objectively quantifiable finding that could be used

as part of a specific case definition for evaluating other Caldwell workers.

None of the 54 participants in the November 1991 survey showed signs of myoclonus or a disabling movement disorder. The most frequent neurologic finding was mild postural tremor in eight participants. Two of the eight participants with this finding did not have immediately identifiable possible nonoccupational causes. Postural tremor, however, is not necessarily a sign of disease and may represent a normal variant in the absence of associated findings which would support a specific diagnosis (for example, hyperthyroidism) as a cause of the tremor. In addition, postural tremors are frequently familial or otherwise unexplained (referred to as "essential tremor").

Despite multiple attempts to locate eligible participants and multiple contacts to confirm appointments, the participation rate in the November 1991 survey was low (50% of 108 confirmed appointments, or 18% of 294 invited to participate). Because only 21% of 328 identified current and former Caldwell employees participated in the NIOSH evaluations, and because of the potential for selection bias, these results cannot be interpreted to represent the entire Caldwell workforce or hazardous waste workers in general. These and other limiting factors diminish the likelihood that further attempts to study the Caldwell workforce would be of epidemiologic value. Other limiting factors include the complexity of exposures, with temporal variations in composition, quantity, and routes of exposure; the lack of quantitative environmental data; the lack of baseline health data; and the pre-investigation publicity about the health conditions attributed to work exposures.

Because of the limiting factors encountered during this investigation, the question of whether or not the symptoms or movement disorders are related to hazardous waste exposures during work at the Caldwell facilities remains unanswered. The absence of an indisputable medical explanation for the symptoms can increase a patient's anxiety, which in turn may exacerbate symptoms. For a similarly chronic and disabling condition that is difficult to diagnose and treat, Fiedler and coauthors have recommended psychological counseling to help patients cope with their symptoms [Fiedler et al, 1992]. The authors consider supportive counseling an essential part of the treatment program. They stress, however, that such supportive counseling should not be offered on the basis that the medical problem "is all in the patient's head," but rather, as a way to increase coping mechanisms for dealing with something that is not understood.

Concerns about the possibility that work exposures may be related to current health conditions or may cause future health risks to themselves and their family members indicate a need to effectively communicate information about risks to exposed and potentially exposed employees. Workers can best protect their health if they are informed about known and potential risks. Communication, however, is a complex process, and what is said is not necessarily what is understood by the intended receiver of the information [Schulte, 1991]. Several issues, including the uncertainty

inherent in determining most risks, and the clinical and public health significance of potential health effects, should be addressed in any such communication.

VII. RECOMMENDATIONS

Studies of other groups of workers may be warranted to determine health risks in hazardous waste workers, but the potential limitations of such studies (as were observed in this investigation) should be recognized and addressed before such efforts are undertaken.

Because of the inherent potential for adverse health effects related to hazardous waste exposures, NIOSH recommends that all workers at hazardous waste facilities or sites be educated about risks of exposure, trained to minimize exposure, and offered the fullest protection against exposure. In 1985, NIOSH, in collaboration with the Occupational Safety and Health Administration, the U.S. Coast Guard, and the U.S. Environmental Protection Agency, published guidelines to prevent worker exposures during hazardous waste site activities [NIOSH/OSHA/USCG/EPA, 1985].

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability can be obtained from NIOSH

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Caldwell County Health Department
Mitchell County Emergency Management Coordinator
Mitchell County Hazardous Waste Board
North Carolina Department of Labor, Division of Occupational Safety and Health
U.S. Agency for Toxic Substances and Disease Registry
U.S. Department of the Navy
U.S. Environmental Protection Agency

In order to comply with the NIOSH regulation that affected employees shall be notified about the determination of this health hazard evaluation (CFR, Title 42, Part 85, Section 85.11), the employer shall post copies of this report in a prominent place accessible to the employees for a period of 30 calendar days.

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Table 1

Demographic characteristics
of 14 former Caldwell workers

Age in years	mean	31
	range	23 - 45
Race	white	13
	black	1
Gender	male	14
Years of education	mean	12
	range	10 - 13

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Table 2

Work histories reported
by 14 former Caldwell workers

	Years
Duration of employment at Caldwell	
Mean	3.4
Range	<1 - 10
	Number
Job titles at Caldwell	
Sludge/Utility worker	9
Incinerator operator	4
Tank farm operator	4
Cowl operator	3
Inventory	3
Truck driver/tank cleaner	3
Currently employed	11
unemployed	1
disabled	2
Occupational exposures to chemicals (e.g., solvents, glues, pesticides) other than at Caldwell	7
Before employment at Caldwell	(3)
After employment at Caldwell	(5)

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Table 3

Daily or weekly symptoms
reported on the medical questionnaire
by 14 former Caldwell workers

Symptom	Number
Headache	14
Loss of consciousness	0
Positional lightheadedness	13
Positional vertigo	5
Changes in vision[a]	4
Decreased hearing	6
Noises in the ears	4
Reduced smell	3
Change in taste	5
Change in speech	7
Numbness or tingling in hands or feet	8
Weakness in hands, arms, or legs	5
Muscle cramps	2
Muscle twitching	5
Finger or hand tremor[b]	11
Clumsiness or poor coordination	10
Unsteady gait	9
Decreased balance	9
Increased sweating	11
Flushing	5
Heat intolerance	3

[a]Mostly blurred vision.
[b]The internist noted that the "tremors" reported in the questionnaire were not necessarily muscular and were sometimes described as sensations under the skin.

Table 3 continued on next page.

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Table 3 (continued)

Daily or weekly symptoms
reported on the medical questionnaire
by 14 former Caldwell workers

Symptom	Number
Trouble with memory	14
Trouble concentrating	10
Nervous or anxious	13
Depressed	10
Irritable	12
Trouble falling asleep	12
Early morning awakening	8
Cough with phlegm	5
Chest wheezing or tightness	7
Shortness of breath	8
Chest pain on exertion	4
Chest pain at rest	5
Palpitations or irregular heartbeat	9
Indigestion	10
Nausea	7
Abdominal pain	4
Diarrhea	6
Urinary incontinence	1
Decreased sex drive	0
Sexual dysfunction	0
Rash	0
Arthralgias	6

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Table 4

Current or past medical conditions
reported on the medical questionnaire
by 14 former Caldwell workers

Past medical history	Number
Asthma	2
Heart condition	1
High blood pressure	7
Peptic ulcer disease	6
Arthritis	2
Head or neck injury	2
Back injury	1
Depression	1

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Table 5

Positive family medical histories
reported on the medical questionnaire
by 14 former Caldwell workers

Family medical history	Number
Migraine headaches	2
Allergies and/or asthma	6
Cardiovascular diseases	11
Heart condition	(6)
High blood pressure	(6)
Stroke	(3)
Cancer	6
Diabetes	6
Thyroid disease	1
Peptic ulcer disease	1
Kidney disease	2
Myopathy	1
Arthritis	2
Depression or nervous breakdown	2
Alcohol dependence	1

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Table 6

Positive physical examination findings
in 14 former Caldwell workers

Finding	Number
Elevated blood pressures	6
Systolic pressures above 150 mm Hg	(4)
Diastolic pressures above 95 mm Hg	(4)
Changes in blood pressure with changes in position	0
Overweight	7
Extremely underweight	1
Thyroid abnormalities	0
Lung abnormalities (crackles)	1
Heart abnormalities (S4)	1
Abdomen abnormalities (tenderness)	4
Joint symptoms	8
Joint swelling or inflammation	(0)
Joint tenderness or pain on palpation	(2)
Skin lesions	3
Erythematous (red) eruptions	(1)
Fungus	(1)
Psoriasis	(1)

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Table 7

Internist's impressions of specific diagnoses which could affect the neurologic examination of 14 former Caldwell workers

Impression	Number
Thyroid disease	0
Diabetes	0
Alcohol dependence	2
Illicit drug use	0

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Table 8

Specific findings identified independently by both neurologists

Finding	Number
Physiologic end-gaze nystagmus	3
Decreased hearing, unilateral	3
Abnormal station	2
Abnormal Romberg	3
Abnormal gait, tandem walk, and hopping	2
Myoclonus and resting tremor	2
Postural tremor	3
Intention tremor	1
Reduced Achilles reflex, vibration sensation, and touch-pressure sensation	2
Nonphysiologic sensory examination	1
Positive Tinel and/or Phalen sign(s)	6
Positive response to Nylen test	2
Rapid or exaggerated response to hyperventilation	9

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Table 9

Neurologists' diagnostic impressions for 14 former Caldwell workers according to the likelihood that the symptoms and signs are related to a specific syndrome or identifiable cause

	Impression	Number
1.	Non-specific symptoms and signs common in the general population, often related to an individual's misinterpretation of normal physiologic activity, and not necessarily associated with neurologic disease.	
	Physiologic positional lightheadedness	2
	Exaggerated or rapid response to hyperventilation	9
2.	Symptoms and signs suggestive of specific identifiable syndromes or causes other than toxic exposure.	
	Muscle contraction and/or vascular headaches	13
	Mild postural tremor	1
	Possible carpal tunnel syndrome	6
	Musculoskeletal pain	3
	Radiculopathy ("pinched" nerve)	1
3.	Minor neurologic signs of unclear significance.	
	Physiologic end-gaze nystagmus	3
	Nonphysiologic sensory examination	1
	Positive palmomental reflex	1
	Unilateral decreased hearing	3
4.	Unexplained significant findings of unknown cause that could potentially be related to a variety of metabolic, degenerative, familial, or toxic causes.	
	Movement disorder characterized by tremor and myoclonus	2
	Unsteady gait and station	3
	Sensory polyneuropathy versus posterior column dysfunction	2

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Table 10

Psychiatric symptoms in 14 former Caldwell workers recorded on histories obtained by the psychiatrist

Symptom	Number
Irritable mood	14
Aggressive and/or violent behavior	11
Affective instability and/or labile moods	10
Uncontrollable crying spells	6
Sleep disturbance (primarily insomnia)	13
Depressed mood	9
Social withdrawal and/or loss of interest in activities	7
Suicidal ideation	6
Decreased energy	5
Appetite disturbance	4
Concentration and/or memory problems	11
Marked anxiety	4
Suspiciousness	3

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Table 11

Mental status examination abnormalities identified in 14 former Caldwell workers by the psychiatrist

Finding	Number
Diminished concentration (subnormal digit span)	12
Decreased attention to a task (serial 7's or "world")	4
Diminished recall (less than 3 of 3 objects after 3 minutes)	3
Diminished long-term memory*	1
Decreased ability to abstract	2
Decreased fund of knowledge	2
Less than fully oriented (time, place, person)	1
Paranoid (persecutory) ideation	6
Aggressive ideation (past month)	3
Irritability and/or angry mood	3
Markedly anxious mood	1
Depressed mood	4
Decreased psychomotor activity	1
Suicidal ideation (past month)	2

*Tested only in participants showing other evidence of diminished long-term memory. Not tested in most participants.

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Table 12

Psychiatrist's impressions
for 14 former Caldwell workers

Impressions with sufficient data available to make a diagnosis	Number
Alcohol abuse or dependence	5
Current	(3)
Remission	(2)
Adjustment disorder	2
Depressive disorder not otherwise specified	1
Dementia	1
Post-traumatic stress disorder	1
Unresolved grief reaction	1
Major depression	1
History of marijuana abuse	1

Impressions which could not be ruled out with available data	Number
Organic personality syndrome	10
Alcohol abuse or dependence	2
Subnormal intellectual functioning	2
Developmental reading and/or arithmetic disorder	2
Major depression	1
Adjustment disorder	1
Personality disorder	1
Malingering	1

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Table 13

Duration of employment of participants and all employees abstracted from personnel records

	September 1990 evaluations	November 1991 evaluations		All identified employees
		Screening	Neurologist	
CSI	14	30	10	215
< 1 mo		8	2	62
1 to < 6 mo		8	4	50
6 mo to < 1 yr		7	3	30
1 to < 5 yr	13	3	2	62
5 to < 10 yr	1	2		9
10 to < 15 yr		2		2
MSI		10	6	44
< 1 mo		3	2	22
1 to < 6 mo				4
6 mo to < 1 yr		2	1	8
1 to < 5 yr		5	3	10
5 to < 10 yr				1
CIS	1	15	3	50
< 1 mo		3		16
1 to < 6 mo		2	1	6
6 mo to < 1 yr	1			4
1 to < 5 yr		4		14
5 to < 10 yr		6	2	10
Other[a]		5		25
Not listed				4
< 1 mo				7
1 to < 6 mo				3
6 mo to < 1 yr		1		3
1 to < 5 yr		4		8
Total	15[b]	54[c]	18[c]	328[c]

[a]Caldwell Laboratory, Caldwell Group offices, or place of employment not listed.
[b]One participant did not complete the evaluation.
[c]A few participants worked at more than one facility. For those who were screened, combining the durations of employment would not have changed the categories to which they were assigned.

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Table 14

Symptoms reported on the medical questionnaire
by the 18 participants referred to the neurologist

Symptom	Number
Blurred vision	8
Vertigo	13
Clumsiness or poor coordination	11
Unsteady gait	11
Loss of balance	13
Tremor	12
Muscle twitching	11
Trouble moving fingers or holding things	7
Trouble buttoning clothing	5
Change in writing	7
Numbness of the hands or feet	11
Tingling of the hands or feet	13
Pins and needles sensation of the hands or feet	13
Burning sensation in the hands or feet	10
Cold sensation in hands or feet	10
Joint pain	9
Joint stiffness	10
Joint swelling	4

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Table 15

Medical history reported by
the 18 participants referred to the neurologist

History	Number
Asthma on medication	1
Diabetes on medication	1
Hypertension on medication	2
Seizure disorder on medication	1
Nervous breakdown	1
Medication for	
Pain	
Narcotic	3
Non-narcotic	8
Anxiety	2
Depression	2
Caffeine intake per day	
0-2 cups	5
3-5 cups	5
6-9 cups	3
10-12 cups	4
12+ cups	1
Short Michigan Alcoholism Screening Test[a]	
Probably no problem with alcohol[b]	4
Possible problem with alcohol[c]	3
Probable problem with alcohol[d]	5
Missing, incomplete, or invalid responses	6

[a]Selzer et al., 1973.
[b]Score of 0 or 1 on a scale of 0-13.
[c]Score of 2.
[d]Score $\geq$ 3.

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Table 16

Results of the neurologic evaluations
of 18 participants referred to the neurologist

Finding	Number
Symptoms consistent with muscle contraction headaches	4
Symptoms and findings consistent with depression	5
Physiologic end-gaze nystagmus	4
Postural tremor	8
Resting tremor	2
Intention tremor	0
Myoclonus	0
Hyperreflexia	2
Nonphysiologic sensory examination	2 or 3
Subnormal intelligence	2

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Table 17

Characteristics of the 8 participants found to have postural tremor[a]

	Number
Duration of employment	
CSI, < 1 month	1
6 months to < 1 year	1
MSI, < 1 month	1
6 months to < 1 year	1
1 to 5 years	3
CIS, 5 to 10 years	1
Medical condition or medication use could result in tremor	2
Caffeine intake in the 24 hours before the examination	
0-2 cups	3
3-5 cups	1
6-9 cups	1
10-12 cups	2
12+ cups	1
Short Michigan Alcoholism Screening Test[b]	
Probably no problem with alcohol[c]	1
Possible problem with alcohol[d]	2
Probable problem with alcohol[e]	2
Missing, incomplete, or invalid response	3

[a]All of the tremors noted were rated 1 or 2 on an intensity scale of 0 (normal) to 4.
[b]Selzer et al., 1973.
[c]Score of 0 or 1 on a scale of 0-13.
[d]Score of 2.
[e]Score $\geq$ 3.

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Table 18

Health concerns expressed by 25 participants
(11 with screening examination only
and 14 examined by neurologist)

Concerns	Number
Future risk for developing cancer	5
Acute episodes of occupational exposure resulting in adverse health effect[a]	4
Relationship of medical or surgical problem[b] to work exposures	4
Skin rash	3
Relationship of family member's medical problem[c] to work exposures	3
Inability to father children	2
Future risk to child for developing health problems	1
Problems with gums and teeth	2
Inability to afford medical care	2

[a]Loss of consciousness, chemical spill; one person's episode was unrelated to Caldwell.
[b]Peptic ulcer, seizure disorder, orthopedic surgery, panic disorder.
[c]Birth defects, cancer, neurologic symptoms.

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Appendix A

Glossary of medical and epidemiologic terms*

adverse:	Harmful, as in adverse health effects.
angina:	Chest pain related to coronary artery disease.
asymptomatic:	Without symptoms.
ataxia:	Unsteadiness or inability to coordinate muscle movements.
bradykinesia:	Extreme slowness of movement.
carpal tunnel syndrome:	Pain, numbness, and/or tingling over the distribution of an injured median nerve of the hand.
case definition:	Criteria for categorizing someone as having the health effect(s) to be studied. A combination of certain symptoms and objective findings often constitutes all or part of the case definition.
central nervous system (CNS):	The brain and spinal cord. Damage to the CNS may be irreversible, unlike damage to peripheral nerves, which are capable of regenerating. See also peripheral nervous system.
dementia:	Overall deterioration in intellect and memory.
demographic:	Of the characteristics of a population, such as age, race, gender, and educational level.
digit span:	A test of concentration.
distal:	Located away from the center of the body (for example, the hand is distal to the elbow). See also proximal.
encephalopathy:	Disorder affecting the brain.

*Adapted from the following sources:
Stedman's medical dictionary [1976]. 23rd ed. Baltimore, MD: The Williams and Wilkins Company.
Last JM, ed. [1983]. A dictionary of epidemiology. New York, NY: Oxford University Press.
The new Lexicon Webster's dictionary of the English language [1989]. 1990 ed. New York, NY: Lexicon Publications, Inc.

epidemiology:	The study of the causes and prevention of disease in populations.
epigastric:	The central area of the upper abdomen; when noted to be tender on physical examination, may be an indication of gastritis or peptic ulcer disease.
gait:	Manner of walking.
impairment:	Anatomic damage or deterioration of function as a result of injury or disease.
inference:	Generalization developed from observations of samples of a larger population.
inhalation:	Breathing in.
interobserver agreement:	The degree of agreement between or among independent examiners.
hyperventilation:	Increased rate and depth of breathing, out of proportion to the body's needs. Hyperventilation can result in characteristic symptoms (e.g., lightheadedness, breathlessness, chest tightness, heart palpitations, numbness of the lips or in the hands and fingers or feet and toes).
labile:	Unstable, not steady, as in labile blood pressure.
lower extremity:	Legs and feet.
muscle stretch reflex:	Involuntary reaction of a proximal muscle in response to the stretching of a distal tendon, such as knee jerk or ankle jerk reflexes.
myocardial infarction:	Heart attack.
myoclonus:	Jerking movement caused by sudden contraction of one or more muscle groups; if sustained, usually irregular.
neuropathy:	Disorder affecting a part of the nervous system.
nonspecific:	May be related to any of a number of factors, including, but not limited to, chemical exposures. See also specific.
Nylen maneuver:	Test for positional vertigo. A positive test elicits symptoms of vertigo (spinning sensation) and mixed rotatory and vertical nystagmus related to change in posture from sitting to lying with the head turned to a shoulder.

nystagmus:	Sustained rhythmic movements of the eyeballs on extreme gaze to the side. A few beats (end-gaze nystagmus) is considered to be normal.
objective:	Physical examination findings or test results observed by an examiner. See also subjective.
organic:	In psychiatry, explained by an anatomic defect or pathologic process. In chemistry, pertaining to carbon-containing compounds.
palpitations:	Irregular and pronounced heartbeats caused by heart disease or from physical or emotional stress.
pathologic:	Diseased or resulting from disease.
peripheral nervous system:	The part of the nervous system located outside the brain and spinal cord that involves sensation and motor control. See also central nervous system.
peptic ulcer:	Ulcer of the lining of the stomach or duodenum.
Phalen sign:	Numbness and tingling over the distribution of an injured median nerve on flexion at the wrist.
physiologic:	Normal, as opposed to pathologic.
positional vertigo:	Sensation of spinning with changes in body posture.
prevalence:	The number of instances of a disease or condition in a given number of people at a particular time.
proximal:	Located toward the center of the body (for example, the shoulder is proximal to the elbow). See also distal.
specific:	Related to a particular identifiable factor, and not to other factors. See also nonspecific.
station, abnormal:	Inability to maintain a steady posture while standing.
subjective:	Symptom (such as headache) perceived by the individual experiencing it and not necessarily evident to an examiner. See also objective.
symptom:	Condition perceived to be abnormal by the individual experiencing it.

syndrome:	An aggregation of symptoms and objective findings associated with a particular disease process which together constitute a characteristic picture of that disease.
Tinel sign:	Numbness and tingling over the distribution of an injured median nerve on tapping over the nerve.
tremor, intentional:	Involuntary, relatively rhythmic, purposeless shaking that occurs when a voluntary (intentional) movement is made.
tremor, postural:	Involuntary, relatively rhythmic, purposeless shaking that occurs when the limbs and trunk are actively held in certain effort-requiring positions (such as holding the arms outstretched).
tremor, resting:	Involuntary, relatively rhythmic, purposeless shaking that occurs mainly during relaxation and decreases or disappears with voluntary movement.
upper extremity:	Arms and hands.
vertigo:	Spinning sensation.
volitional:	Voluntary, as in volitional hyperventilation.

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Appendix B

Interobserver agreement between the neurologists

The overall subjective agreement between the two neurologists on individual neurologic measures appears to be good. Comparison of quantitative sensory examination scores demonstrated no significant differences, and the mean values were almost identical, within the technical limits of the instruments. Comparison of the muscle stretch reflex data using both parametric and nonparametric statistical comparisons demonstrated a significant difference in the recorded means for the brachioradialis and triceps reflexes. While statistically significant, the magnitude of the difference was small (less than 0.5 grade) and of questionable medical significance. Of importance, these two reflexes are of limited importance in identifying polyneuropathy, where lower extremity muscle stretch reflexes represent a much more sensitive index of abnormality. For the Achilles and quadriceps reflexes, no significant examiner differences existed. The recorded difference for the brachioradialis and triceps reflexes seems to reflect a fixed difference in scaling, in that the examiners scores correlated significantly (correlation coefficient of 0.7). Evaluation of the remaining portions of the clinical examination demonstrated few other substantial or significant differences. There was a significant difference in the grading of ocular nystagmus, with one examiner recording a greater number of subjects with physiologic end gaze nystagmus, a finding of no pathologic significance.

Initial impressions were independently recorded immediately after each neurologic examination. In general, agreement appears to be good, particularly with regard to specific neurologic impressions, and there was agreement for 57 items, with an additional 6 items representing similar impressions (e.g. positional lightheadedness vs symptoms consistent with hyperventilation; mechanical back pain vs. possible hip arthritis). Of the 30 items that were mentioned by only one of the examiners (17 by examiner A and 13 by examiner B), few relate to a specific diagnosis or sign recorded by one neurologist but not the other. Rather, the items usually are interpretations of a subjective response reported by the participant or a report of inconsistent responses during sensory testing. These results were only compared subjectively. The discussions between both neurologists and the remaining NIOSH investigators after the impressions were recorded demonstrated a similar consensus among the examining physicians.