An Epidemic of Psychogenic Illness in an Electronics Plant

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We investigated an outbreak of illness in electronics plant workers. Questionnaire data revealed that 98 employees experienced symptoms, including light-headedness, headache, sleepiness, and numbness/tingling of the face or extremities. Attack rates by work station followed no apparent pattern. Extensive medical and environmental evaluation, including air sampling for numerous solvents and gases, provided no physical or chemical explanation for the epidemic. Compared with well employees, ill employees were more commonly female, complained more frequently of bothersome odors, and believed that greater danger existed of the illness recurring. Blood gas analyses of seven of 11 ill workers showed respiratory alkalosis, consistent with hyperventilation. The poorly defined nature of this illness, the absence of exposures to environmental contaminants in concentrations exceeding recommended limits, and the evidence of hyperventilation suggest that this outbreak was an incident of industrial psychogenic illness.

Psychogenic illnesses, also referred to as "psychosomatic" or "psychophysiological" disorders, are physical conditions that either result from or are exacerbated by conflict between an individual's perceived stresses and coping capacities.[1,2] Diseases traditionally considered to have a psychogenic component include hypertension, peptic ulcer, rheumatoid arthritis, asthma, and dermatitis.[2] Outbreaks of psychogenic illness have been described among schoolchildren[3-5] and, less frequently, in industrial settings.[6,7] The phenomenon typically has been reported in plants with a largely female, relatively uneducated workforce doing routine, repetitive work.[6-8] Faust and Brilliant[9] have questioned whether attributing an outbreak of illness to psychogenic phenomena is sometimes an excuse for a superficial study. Certainly, a thorough evaluation to exclude other possible etiologic factors is an essential requisite for making the diagnosis of psychogenic illness.

In this report an investigation by the National Institute for Occupational Safety and Health (NIOSH) of an epidemic of apparent industrial psychogenic illness in an electronics plant is described. The plant had been closed twice, and newspaper and television reports referred to a "mystery illness." Our investigation included analysis of extensive environmental monitoring data, some of which were obtained coincident with workers becoming ill; a detailed questionnaire survey with a 97% response rate; and analysis of medical records.

Background

The outbreak occurred at an electronics plant whose employees manufacture, assemble, and test electromagnetic components. The plant, located in a semirural area in the Northeast, is independently owned and operated. The workforce is relatively stable and is not unionized. Production employees, paid on an hourly basis, are stationed at fixed work areas and repeatedly perform the same limited operation. Work is self-paced, but break times are regimented.

On April 21, 1982, three of the approximately 220 employees experienced nausea, headache, and "disorientation." Suspecting a defect in the air-conditioning system, which had been turned on several days previously, the company checked for refrigerant leaks, but none were found. On April 26, diesel fumes accidentally entered the production area of the plant from an engine tested in the anechoic chamber, a vaultlike test area. This apparently aroused concern among employees who, unaware of the source of the diesel odors, suspected they might be exposed to dangerous levels of unknown toxic chemicals.

A representative of a manufacturers' association completed air sampling for carbon monoxide, toluene, trichloroethylene (TCE), and ethyl acetate on April 27. No air levels exceeded current occupational health standards, and the representative reportedly told employees that the illness was "all in their heads." A repeated check of the air-conditioning system on April 28 again failed to detect any refrigerant leaks.

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During May, six more incidents of employee illnesses occurred, closing the plant on two occasions. Ill employees were either sent home or to hospital emergency rooms, depending on the severity of illness, as judged by a paramedic.

Representatives from several private consulting firms and the Occupational Safety and Health Administration (OSHA) performed extensive air sampling over several days in May for carbon monoxide, methane, hydrogen sulfide, toluene, TCE, ethyl acetate, "Freon," and a variety of other halogenated hydrocarbons. They found no chemicals at potentially hazardous concentrations (Table 1), no bacterial contamination of water supplies, and no deficiencies in ventilation systems. Although no clear-cut cause of the outbreaks of illness was found, a local medical center team postulated that TCE, being heavier than air, formed "clouds" near the floor, which, combined with inadequate exhaust ventilation, resulted in the outbreaks. Recommendations that the use of TCE be discontinued and that exhaust ventilation be improved were implemented, and the air-conditioning system was shut down.

No illness was reported for a period of 10 days, but on Friday, May 21, an outbreak of illness affecting 19 employees began less than 45 minutes after the air-conditioning system was restarted. Common complaints were dizziness, an odor of dry cleaning fluid, metallic taste in the mouth, burning eyes, and numbness around the lips. Although no defects could be found in the air-conditioning system, it again was shut down as a precautionary measure. Ten employees became ill on Monday, May 24, and several employees were ill on each of the next three days. A NIOSH investigation was requested on May 25.

Materials and Methods

On May 27 and 28, NIOSH investigators reviewed the findings of representatives from OSHA, private environmental consulting firms, and the local medical center. The investigation also included detailed observation of production processes and work practices, review of emergency room records from the two local medical centers at which ill employees had been seen, and informal interviews with a number of employees at the plant. In light of the previous extensive environmental sampling conducted at the facility by OSHA and private consultants, the removal of TCE from the facility prior to the NIOSH visit, and the apparent lack of any other source of airborne chemicals that could possibly have caused the epidemic, NIOSH collected no environmental air samples.

Table 1 – Airborne Levels of Chemicals Measured by OSHA and Private Consultants[10]

Chemical	Concentration (ppm)*	OSHA Standard
Carbon monoxide	<15	50
Hydrogen sulfide	<0.5	20†
Methane	<25	No federal standard
"Freon"	<5	1,000
Toluene	<1-6	200
TCE	<1-17	100
Ethyl acetate	<1-16	400

* ppm indicates parts of chemical substance per million parts of air

† Acceptable ceiling concentration

Since our initial findings suggested the possibility of a psychogenic component to the outbreak, we returned to administer a questionnaire to all employees on June 21. The questionnaire, an abridged and modified version of a survey designed for investigations of outbreaks of apparent psychogenic illness,[8] contained sections pertaining to the outbreak of illness, general medical questions, the physical work environment, nonphysical work conditions (e.g., overtime and job security), and socioeconomic variables (education and income). Most of the data were categorical and were statistically analyzed using χ^2 tests. Differences were considered to be statistically significant if the p value was less than .05.

Results

Of 30 emergency room visits made by plant employees between April 21 and May 24, twenty-two were made on May 6 and 7. Eighteen of the diagnoses suggested environmental exposure to an unknown chemical agent, by history. Treatment consisted of monitoring of vital signs, administration of oxygen, several precautionary intravenous lines, and occasionally a tranquilizer. Several individuals first became ill hours after leaving the plant. One such individual was reportedly mute and unable to voluntarily move any part of her body when seen in the emergency room. Examination revealed no objective neurologic abnormalities or other organic cause for the muteness or paralysis, both of which resolved spontaneously.

Toxicological analysis of blood and urine specimens obtained from nine ill employees on May 4 and 5 and May 21 for volatiles (ethanol, acetone, methanol, and isopropanol), ethyl acetate, TCE and its metabolites, toluene and its metabolites, and fluoride revealed that concentrations of all chemicals were well below the toxic range. Blood carboxyhemoglobin levels of 14 workers seen in emergency rooms ranged from 0.8% to 7.4% (median, 3.5%; mean, 2.8%), all within the expected range, taking smoking history into consideration.[11] Eleven workers had arterial blood gas determinations, all of which had been interpreted as normal. However, our evaluation of these results, using a nomogram designed by Arbus,[12] indicated that while none of the results were strikingly abnormal, seven results showed respiratory alkalosis, while the other four were normal (Table 2).

Two hundred thirteen individuals, representing 97% of all employees, responded to our questionnaire. For purposes of analysis, we included in the "ill" group all symptomatic workers who sought medical attention (hospital emergency room and/or private physician) or who were sent home early from work after being seen by a paramedic between April 21 and May 31. Asymptomatic workers were classified as "well"; all others were classified as "intermediate."

Of 56 nonproduction employees interviewed, 54 were classified as "well" and two as "intermediate." We therefore restricted subsequent data analysis (except as noted) to questionnaires completed by production employees, and compared the responses of the 41 ill employees with responses of the 59 well employees. Ill employees had a

Table 2 – Arterial Blood Gas Analyses of 11 Ill Employees*

pH	pCO_2 (mm Hg)	pO_2 (mm Hg)	Authors' Interpretation of Blood Gases†
7.48	30	89	RA
7.43	31	105	RA
7.46	37	76	NL
7.44	32	81	RA
7.43	32	124	RA
7.44	37	79	NL
7.48	30	89	RA
7.41	36	91	NL
7.44	32	106	RA
7.42	41	95	NL
7.48	32	100	RA

* All samples collected with patient breathing room air, according to emergency room records; some patients may have received oxygen while in transit to the hospital

† RA indicates respiratory alkalosis; NL, normal

mean age (38 years), mean time at current job (2.9 years), and mean time employed at the plant (6.1 years) that were not statistically significantly different from those of the well group (36 years, 2.7 years, and 5.3 years, respectively). The two groups were also similar with respect to race, personal income, total household income, and educational levels (most had completed 10th to 12th grade). Attack rates by work station varied from 10% to 50%, with no apparent pattern. Symptoms reported are listed in Table 3.

Ill and well groups were similar with respect to average days per year absent from work because of illness, use of medications, and frequency of several common health problems. A series of questions relating to job satisfaction also failed to show differences between the two groups. Several statistically significant differences did, however, emerge:

1. A higher percentage of females than males were classified in the ill and intermediate categories. Of 144 females, 40 (28%) were classified in the ill, 56 (39%) in the intermediate, and 48 (33%) in the well category. In contrast, 11 of 13 (84%) males were classified as well, with one (8%) ill and one (8%) in the intermediate category ($\chi^2 = 13.3, df = 2, p < .01$).

2. On a scale of 1 to 5, ranging from "never" to "very often," ill employees complained of bothersome odors significantly more frequently than well employees ($\chi^2 = 21.7, df = 4, p < .001$).

3. The percentage of workers who believed that the direct cause of the outbreak of illness was chemical fumes, the ventilation system, or the air-conditioning system was highest in the ill group (71%), lowest in the nonproduction well group (19%), and intermediate in the production well group (44%). Conversely, the percentage of workers who believed that psychological factors played a role in the outbreak was highest in the nonproduction well group (41%), lowest in the ill group (0%), and intermediate in the production well group (19%) ($\chi^2 = 23.3, df = 2, p < .001$).

4. A significantly higher percentage of ill than of well workers believed that danger of the illness recurring existed (32% *v* 22%) ($\chi^2 = 6.37, df = 2, p < .05$).

Table 3 – Symptoms Most Frequently Reported on NIOSH Questionnaire by 41 Ill Employees

Symptom	No. (%) Reporting Symptom
Light-headedness	35 (85)
Headache	34 (83)
Sleepiness	28 (68)
Bad taste in mouth	27 (66)
Numbness or tingling of face or extremities	27 (66)
Dizziness	25 (61)
Weakness	25 (61)
Nausea	22 (54)
Dry mouth	21 (51)
Blurred vision	20 (49)
Difficulty swallowing or lump in throat	17 (42)
Racing heart	16 (39)
Abdominal pain	14 (34)
Tightness in chest	13 (32)
Diarrhea	13 (32)
Chest pain	10 (24)
Couldn't catch breath	9 (22)
Watery eyes	8 (20)

Discussion

The poorly defined nature of the employees' illness, the absence of exposures to environmental contaminants in concentrations exceeding, or even approaching, current occupational standards and criteria, and the evidence of hyperventilation suggest that this outbreak was an incident of industrial psychogenic illness.

It is sometimes hypothesized that the symptoms occurring during outbreaks of psychogenic illness may be due to hypersusceptibility to low levels of environmental contaminants. Occupational exposure standards take into account the phenomenon of individual variation in the dose needed to produce a given effect, and are ordinarily set to prevent at least overt adverse effects from occurring in most people. Therefore, if exposures are well below such standards, it would be unlikely that low levels of contaminants could account for relatively severe, acute symptoms of sudden onset in a large proportion of people, particularly when symptoms begin after people have left the source of exposure. Admittedly, when an investigation of outbreaks of this type takes place after the fact, exposures cannot be directly measured if the circumstances at the time of the outbreak were atypical. In this case, however, the major outbreaks of illness occurred on May 6 and 7, coincident with air sampling.

Prior to the NIOSH investigation, several chemical or physical causes for the outbreaks of illness had been suggested. These included reflection of sunlight off vertical blinds; exposure to agricultural chemicals from the surrounding farmland; unseasonably high temperatures and exposure to excessive levels of TCE from hypothetical low-lying chemical "clouds." We rejected each of these hypotheses, because either exposure to the presumptive offending agent could not be documented, or the variety of symptoms reported by ill employees was not compatible with usual effects of such exposures.

Emergency room medical records provided no objective evidence of chemical toxicity. Symptoms were in some cases suggestive of the hyperventilation syndrome,[13] in which the major complaints commonly are light-headedness, dizziness, an "out-of-touch" feeling, and paresthesias. Seven of 11 arterial blood gas measurements showed respiratory alkalosis, which is consistent with hyperventilation, a condition most commonly associated with anxiety. While we would be reluctant to diagnose individual cases of hyperventilation syndrome solely on the basis of such minimally abnormal blood gas results, taken together they support the epidemiologic diagnosis, which was based primarily on the medical histories.

Although it is conceivable that some initial cases of illness could have been the result of toxic effects of transiently high levels of chemicals in the plant, our data suggest that most of the subsequent illness reflected psychogenic phenomena. Irritating or offensive vapors or fumes, from the diesel engine test or various solvents, for example, may have been the precipitating factor. Compared with well employees, a statistically significantly higher percentage of ill employees did, in fact, complain of bothersome odors.

Definition of a case in a syndrome with a variety of clinical manifestations and no pathognomonic findings is difficult. Our approach was to include in the ill group all symptomatic workers who sought medical attention or who were sent home early from work after being seen by a paramedic. All other symptomatic workers were placed in an intermediate group and were omitted from the analysis. The well group contained only asymptomatic individuals. By these criteria, over 95% of ill individuals reported five or more symptoms, whereas nearly half of individuals in the intermediate group had fewer than five symptoms.

While this approach undoubtedly excludes some truly ill individuals from the analysis, it avoids the disadvantages of a case definition based on number of symptoms. The latter makes the tenuous assumption that the number of symptoms correlates with the severity of illness, and implicitly assigns equal weight to each symptom.

If, nevertheless, one wished to construct a case definition based on number of symptoms, in our study it seems reasonable to define anyone with five or more symptoms as ill, and all other individuals as well. Using this case definition, we recalculated all differences that had been found to be statistically significant. All remained statistically significant; because of the increased number of individuals, the χ^2 values increased in all but one case.

The more sensitive case definition, based solely on a minimum number of symptoms, may be useful in generating hypotheses regarding the etiology of mass psychogenic illness in industrial settings. These hypotheses could then be tested in investigations of future similar incidents. In contrast, our conservative approach, using a case definition with greater specificity, may be more applicable in field investigations whose primary goal is to ascertain less equivocal factors in a particular plant that may be related to the outbreak of illness under investigation.

A characteristic of epidemic psychogenic illness is that one is affected not necessarily because of being in proximity to the source of a putative exposure, but rather only after learning of either the suspected exposure or the fact that someone else is exhibiting signs of illness. An even better sign, although not always easy to specifically ment, is the association of illness with actually seeing someone else exhibiting signs of illness.[7] Therefore, as part of our questionnaire survey, we included questions pertaining to time of onset of symptoms, location of the worker at this time, and whether the worker had heard about or had witnessed other workers becoming ill prior to becoming ill himself. Thus, we hoped to establish a chain of transmission for time of onset of illness in affected individuals that could be explained along lines of verbal or visual contact.

Respondents to the questionnaire were, however, frequently unable to specify the date of onset of symptoms, rarely able to specify hour of onset, and almost universally unable to provide valid information as to having seen or heard about other affected individuals prior to their own onset of symptoms. This may be explained by (1) the fact that the illnesses did not occur as a discrete outbreak, but rather as a series of outbreaks occurring over a one-month span, and (2) the fact that the questionnaire was administered six weeks after the major outbreak. Thus, while lack of any apparent pattern to attack rates by work stations may very possibly be explained by a verbal or visual chain of transmission,[14] a detailed analysis of responses to questions designed to clarify this point was not possible.

Physically ill individuals may find the concept of psychogenic illness difficult to accept, since they may perceive this idea as confirmation that the problem was "all in their heads" and, therefore, not a "real" illness. Indeed, no ill employees believed that psychological factors played a role in the outbreak of illness. In general, the etiology of psychogenic illness involves a complex interaction of environmental, physiological, and psychosocial variables. Symptoms occurring during outbreaks of psychogenic illness are not imaginary, due to malingering, or indicative of psychiatric illness.

Although male and female employees were stationed in the same work areas of the plant and were not subject to different chemical exposures, the outbreak of illness affected female employees almost exclusively. However, the *association* of sex and educational level with epidemics of psychogenic phenomena does not necessarily imply that these are *causative* factors. That is, if a factor (in this case, psychological stress) is common to both a specific characteristic (sex, educational level) and to a specific disease (epidemic psychogenic illness), an *indirect* statistical association may occur between the disease and the characteristic.[15] Women without higher education are likely to find employment in stressful, low-paying, highly routine jobs, and this may explain, in part, why outbreaks of psychogenic illness are usually associated with unskilled or semiskilled female work forces. In the plant we investigated, the median personal income of female production workers ($10,000 to $12,999) was significantly lower than that of the male production workers ($16,000 to $18,999). This reflects the difference in job titles: of the 13 male production workers, eight had supervisory duties, and the work of the remaining five was not of the same tedious, monotonous nature as that of most female employees. In addition, working women may be exposed to higher levels of psychosocial stress from factors outside the workplace environment.

Potential stressors at the plant we investigated included

(1) the routine, highly repetitive nature of the operations, which require careful concentration and fine manipulations of small parts; (2) employees' lack of knowledge of the sources and health effects of a variety of odors; (3) media reports of a "mystery illness," combined with the nearly simultaneous arrival of large teams of OSHA and medical center investigators; and (4) continual paging of the plant paramedic over the loudspeaker system and the use of ambulances with flashing lights and sirens to transport employees to medical centers.

Suspicion reportedly existed among certain employees that the company had been testing new chemicals on them. Some workers perceived that supervisors, an outside consultant, and even some unaffected employees disparaged their illness. Sensing that communication between management and employees was not optimal, we held a group session with all employees at the conclusion of our initial site visit. We emphasized that preliminary analysis of environmental measurements showed no toxic levels of chemicals, explained that the number and severity of cases had markedly diminished since implementation of various environmental controls by the company, and attempted to refute sensationalistic media accounts of the outbreak. We also stressed that employees should continue to inform supervisors of all illnesses, and that NIOSH would keep employees informed of all subsequent results. No unusual employee illness occurred at the plant subsequent to this meeting, and the air-conditioning system was restarted two weeks later without incident.

In the event of similar outbreaks, we recommend that symptomatic individuals be removed to a quiet room out of sight of other employees. Unless trained medical personnel or lifesaving equipment are required, transportation for medical evaluation does not require an ambulance. If an ambulance must be called, the use of sirens and flashers should be avoided in the vicinity of the plant.

Response to outbreaks of possible psychogenic illness may involve personnel from medical centers, health departments, and regulatory agencies. All participants n keep in mind the possible connotations of the word "psychogenic." A successful investigation may decrease the length of the outbreak, prevent its spread to unaffected employees, pave the way for more open communication between employees and management, and, ideally, add to our knowledge of this poorly understood phenomenon.

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Mid-Life Passage

A young man's ambition to get along in the world and make a place for himself, half your life goes that way . . . . Then, if you're lucky, you make terms with life, you get released.

– From an interview of William Penn Warren in "About Men: Vanities to be Tamed" by Carey Winfrey in *The New York Times Magazine*, November 6, 1983.