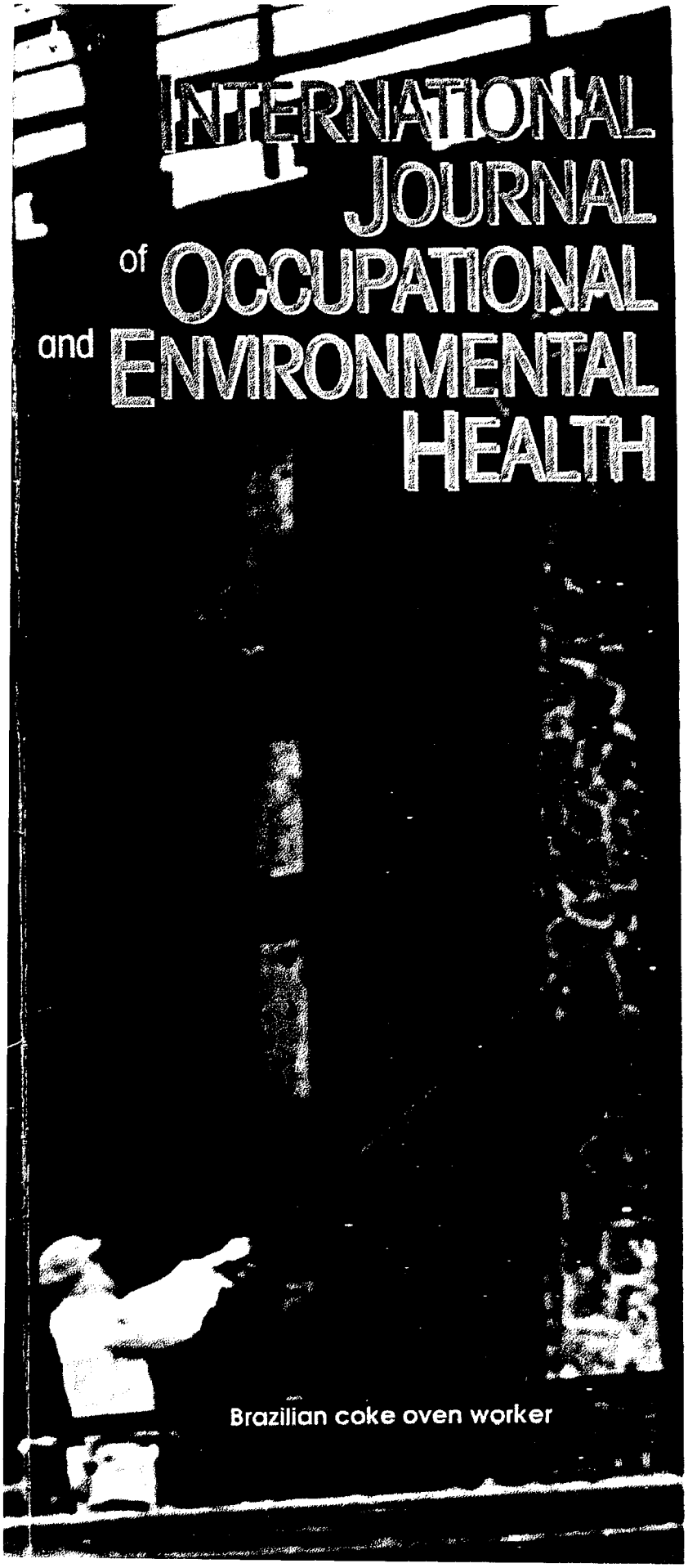

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Socio-medical Intervention in Occupational Health: Benzenism in Brazil

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This review describes the authors' experience with 2,000 cases of benzene poisoning reported between 1983 and 1995 in Cubatão, an industrial section of São Paulo, Brazil. investigated through die integration of epidemiology and clinical research. Conflicting economic interests were reflected in disputes about medical criteria for evaluation of poisoned workers. about proper means of conducting workplace hygiene evaluations, about benzene exposure standards. and about compensation for chronic bone-marrow damage.
Key words: benzenism; hematologic alterations; social medicine; occupational health.

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A cluster of cases of benzene poisoning was identified among steel workers of a coke-oven operation in the city of Cubatão, Brazil (near São Paulo), in 1983. The initial cases had only nonspecific symptoms of fatigue and headache, but were found upon hematologic referral to have peripheral blood abnormalities (macrocytosis,giant platelets, and leukopenia/neutropenia). In 1985, more than 800 cases were reported in this region. From coke-oven operations in Cubatão alone, we diagnosed nearly 2,000 cases between 1983and 1995. The exposed workers were principally coke-oven operators and maintenance people, but the levels of benzene contamination were so high that some administrative personnel were probably exposed.

The identification of benzenism in Cubatão was an important event in the community. Intense industrial pollution of the air and water in Cubatão had been previously studied, but the associated health problems had not been considered in depth. As the workers became aware of the extent of the poisoning, the epidemic became a national issue, and implementation of preventive measures began to occur. The national importance of the outbreak was underlined by the wide industrial use of benzene in Brazil and its production for export. Although the bone-marrow toxicity and carcinogenicity of benzene haw been recognized internationally for many years, these effects of benzene were not officially recognized in Brazil until 1994.

Recognition of the outbreak of benzenism also produced discussion and some conflicts about the way to control the problem from an epidemiologic and environmental point of view. What was the best means of establishing a causal relationship between work in the steel industry and the occurrence of bone-marrow depression? How should epidemiologic surveillance and individual health surveillance be conducted? What were the most practical methods for environmental and biological monitoring? Of course, the most controversial question was: how would workers receive compensation and social security measures be implemented?[1,2]

It was in this context that we studied the effect of benzene on the hematopoietic system, the reasons for the extensive human exposure to benzene in the steel-and-iron industry,[1,3] and the economics of the benzene production process in Brazil.? The participants in rhese studies included scientists from different fields: physicians specialized in public health and occupational medicine, clinical hematologists, analytical chemists, biochemists, producrion engineers, and safety specialists.

EPIDEMIOLOGIC SURVEILLANCE

In 1983, the Health Department of São Paulo's newly-elected state government launched initiatives to monitor the health of industrial workers. The Baixada Santista region. which includes the town of Cubatão[4] became an early focus of this effort. % pilot project was designed in response to this request. Its initial strategy was based on epidemiologic surveillance. The legal instruments available at the time were the National and State Sanitary *Codes,* providing quite limited authority to intervene in workplace health problems. The Brazilian Ministry of Labor legitimated the latter's monopoly in public intervention and regulation of labor–management relations—which included risks and health damages as well as preventive measures. For this reason, we had to define intervention instruments, supported by the health authority of the State Health Deparunent,[5]

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jat classified workers' health problems and diseases as ancommon events" and therefore an appropriate subject for public health surveillance. This allowed worklace inspections to extend beyond ventilation and hyiene evaluations of bathrooms, dining areas, lodgings, nd other physical spaces. Air monitoring data were not xtensive, but several times documented levels in excess f 1,000 ppm (parts per million) of benzene. Qualitative bservation also showed visual contamination of the air vith coke-oven emissions.

We then developed an information system that included: 1) mandatory notification of health problems 'or some specific high-risk situations, taking into account the type of industrial production and known workplace hazards in Cubatão; 2) epidemiologic investigation of notified cases; and 3) provision of full medical assistance to the affected workers. For case identification, we adopted the same notification instruments used for infectious diseases. We also employed a hospitalization bulletin as a secondary source of information, and created a new bulletin for registering the workers' general morbidity, obtained from the companies' ambulatory medical services. The case definition employed was based on clinical reports of hematologic illness, screening blood counts, or the results of bone-marrow biopsies (Table 1).

From 1983 to 1995, over 1,000 workers employed in a steel-and-iron factory in Cubatão, São Paulo, were relieved of their work because of hematologic alterations that followed occupational and environmental exposures to benzene.[1,4,6,7]

A follow-up of 61 typical patients with chronic neutropenia secondary to chronic occupational benzene exposure from the steel industry of Cubatão city was performed between 1985 and 1990. All patients were men between 20 and 60 years of age, and 80% were millwrights (maintenance workers). The mean duration of exposure was 65 months. Bone-marrow studies of this group showed histologic or cytologic abnormalities in 98.6%. Granulocyte precursors were reduced in 93.0%; erythroblasts were reduced in 24.5%; megakaryoblasts were reduced in 43.8%, with atypia in 87.7% of the formed cells. One patient had global hyperplasia. By the life-table method, the probability of normalizing the peripheral blood count was 52% five years after removal of the environmental and occupational exposure. The normalization of the blood count appeared to be physiologic compensation rather than a return to normal hematopoietic function, since bone-marrow studies of workers with normalized blood counts still showed central granulocytopenia.

TABLE 1 Protocol for Evaluation of Benzene Effects in Workers with Benzene Exposure and Abnormal Blood Counts

Prior hematologic tests were evaluated to estimate the date of probable onset of the abnormal peripheral blood count.

When no prior blood count was available for comparison, a clinical history and examination were done to evaluate the presence of other conditions that could cause the identified hemotologic abnormality. If no such condition was identified, the abnormal blood count was attributed to benzene exposure.

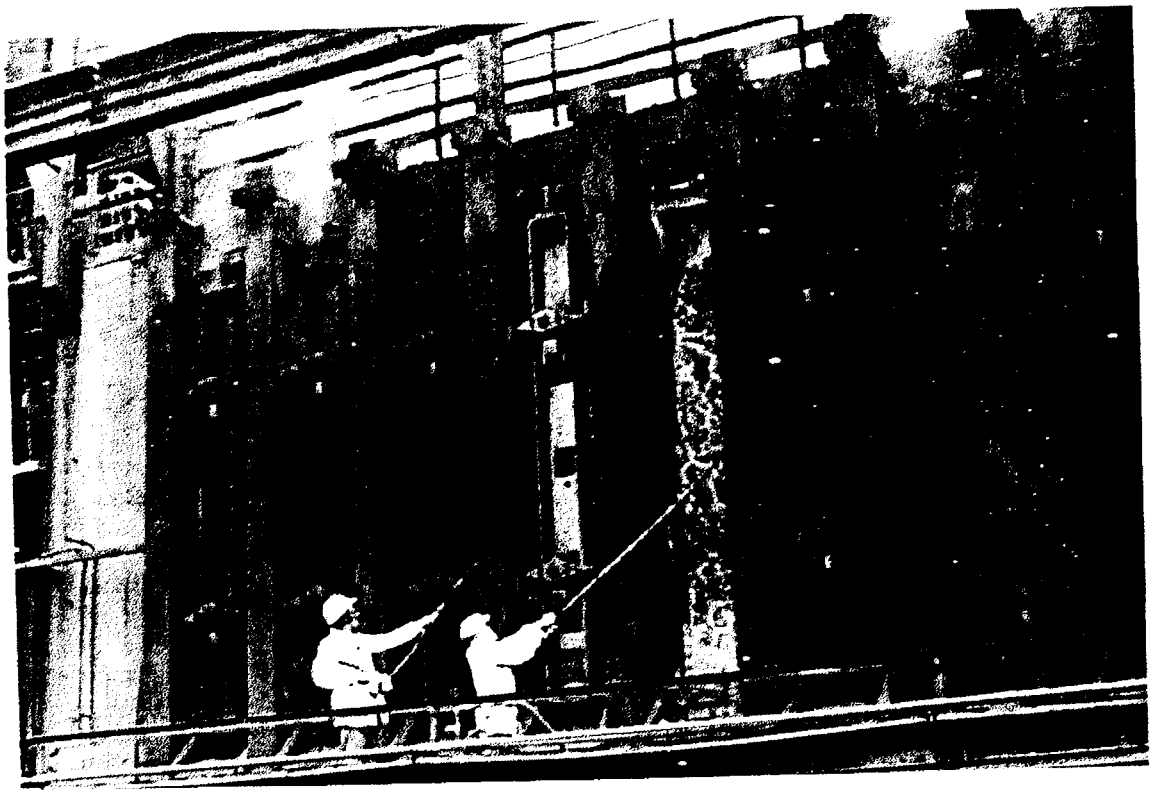
When (an)other disease(s) was (were) identified, a biopsy was conducted to evaluate the presence of bone marrow aplasia.

HEMATOLOGIC SCREENING AND WORKER PARTICIPATION

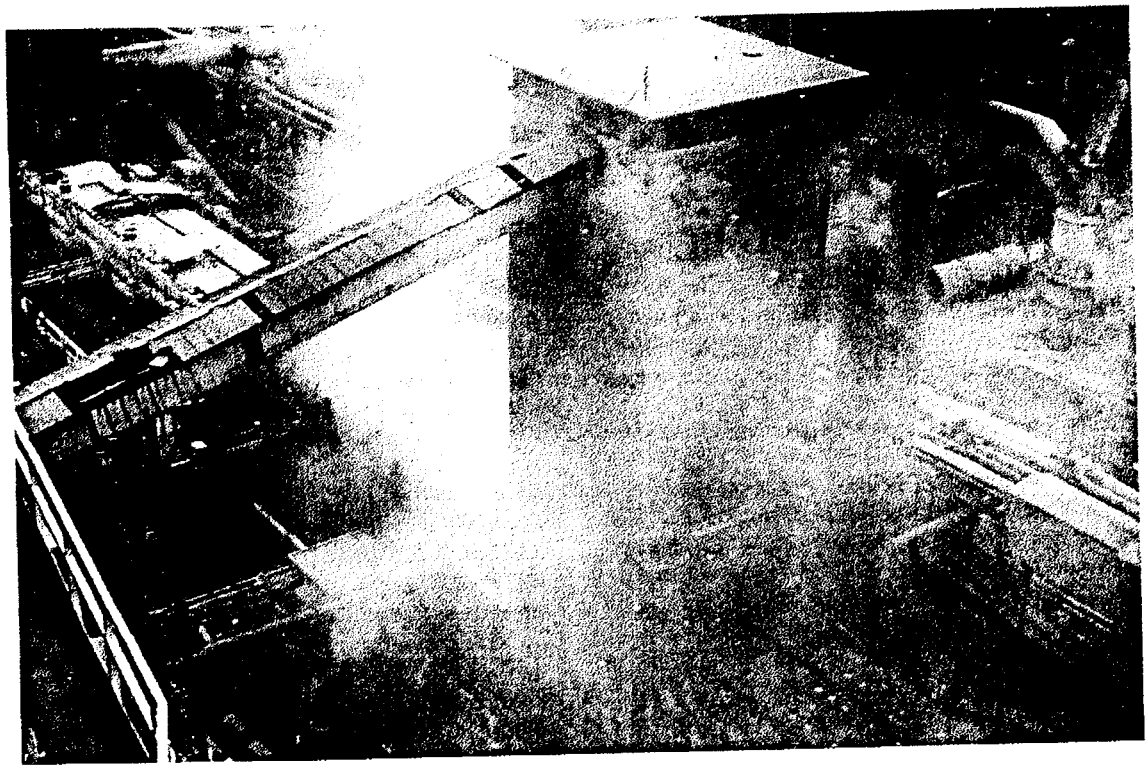
At the beginning of case identification, the diagnostic effort was concentrated on observed alterations in the peripheral blood cells. Although qualititative alterations of platelets and erythrocytes were frequently observed, neutropenia was the most common finding and quickly became recognized as a hallmark of benzene poisoning. This suggested that screening based on peripheral blood counts might be possible. Screening also occurred outside the workplace under the jurisdicuon of labor union medical services, with active participation of the workers in the process. This was necessary because it was unfortunately common for plant occupational physicians to conceal from the workers the damage caused by benzene exposures.

The recognition of quantitative alterations in the blood count as a manifestation of benzene poisoning in 1983 was a major step. Up to that time, the only condition recognized as related to benzene exposure was aplastic anemia, which was generally fatal. Even though the leukemogenic effect of benzene is well recognized in the literature, leukemia cases in workers who had experiencetl constant exposures to benzene were recognized by the Brazilian compensation (social security) system only in exceptional cases. Emphasizing the peripheral blood alterations made it possible, for the first time, for affected workers to obtain compensation through the social security system for hematologic injuries. Benzene-exposed workers who had hematologic alterations compatible with benzene intoxication, and who did not have other pathologic conditions that could explain them, were considered as "compensated hypersensitives" and were prohibited from further exposure.[8,9] This policy was reinforced by the findings of the follow-up study (described above) demonstrating persistent bone-marrow abnormalities in workers whose peripheral blood counts had returned to normal.

Economic interests also influenced the debate regarding the significance of the observed hematologic abnormalities. Even confronted with irrefutable evidence of benzene hematotoxicity and of serious environmental pollution within the workplace,[10] some occupational physicians and plant managers insisted that there was a simply a problem of incorrectly applying "normal hematologic values" to the plant workforces.

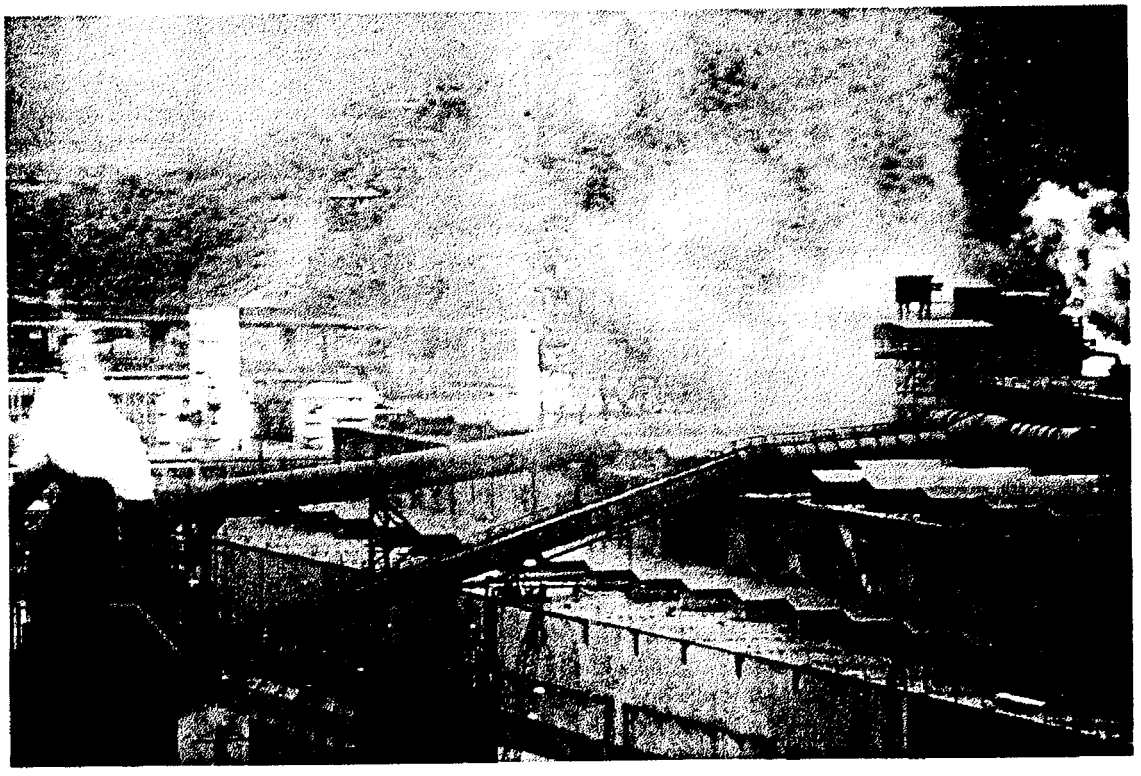


Coke oven workers with no respiratory protection.



Coke oven gasses reach all working areas at the plant.

Maintenance worker without respirator and protective clothing



Air pollution migrates into surrounding community

These managers and physicians suggested that, in fact, the reductions of leukocytes and neutrophils were related, in the majority of cases, either to an ethnic (black race) factor or to an endemic disease (schistosomiasis, HIV infection, or tuberculosis) in the workers' home regions.[11] This creared more confusion than clarification. but did allow factory management and the social security system to deny the existence of a public health problem in work environments where benzene was present.

Follow-up studies refuted the hypothesis that neutropenia was a sensitive early sign of benzene poisoning. Because of the large functional reserve present in the bone marrow, biopsies or aspirates frequently showed that central damage was present even when peripheral blood alterations in benzene-exposed subjects were minimal. Typically, the bone marrow exhibited decreases in leukocytes, erythrocytes, and platelet stem cells, but the effects on the leukocytes, particularly granulocytes, were the most severe.[1,3] According to Snyder et al.,[12] the physiologic process compensating for loss of central cells is more efficient for erythrocyte and platelet precursors than for granulocytic line. The findings of these follow-up studies underlined the importance of recognizing the earliest alterations in the peripheral blood—even small decreases in the count of neutrophils.[1,3] Neutropenia in benzene-exposed workers also became identified bv the Program of Epidemiologic Surveillance of the São Paulo State Health Department as a Sentinel Health Event (sentry event). This allowed identification of high-risk exposure situations, in particular steel-making operations, and identified potentially exposed co-workers for purposes of screening, using serial blood counts. However, this policy had some unfortunate results: occupational medicine physicians and other experts focused exclusively on evaluation of the peripheral blood, often disregarding effects of benzene on the central nervous system, manifested as headache, drowsiness, fatigue, and nausea.

EFFECTS ON MEDICAL SERVICES AND MEDICAL PROVIDERS

One unintended effect of the diagnostic criteria was the massive number of hematologic examinations, to rhe extent rhat testing laboratories actually enjoyed increased revenues and profits. There were also frequent invitations to pathologists to discuss normal hematologic values. A seminar was held in the town of São Roque-SP, in 1987, organized by the Brazilian Society of Hcmatotherapv and Hematology and the Brazilian College of Hematology. Various hematologists and public health physicians who attended the event and who had a strong ethical and social commitment presented arguments contradicting those physicians and company managers seeking to reduce the standards for hematologic normality. This seminar pointed out a series of options lo collectively solve the problem. Discontented, the company physicians organized a meeting at the São Paulo Medical Association, in 1993, in order to once again question the criteria for diagnosis of benzene poisoning endorsed by the Brazilian public organs of Social Security, Labor, and Health. Our position is that not only should hematologic evaluation be maintained as central to identifying benzenism cases, but also an evaluauon of neuropsychological, immunologic, and cytogenetic damages should be included. Up to now the latter disorders have been largely ignored.

EXPOSURE STANDARDS

Brazilian legislation, until 1994, allowed exposure to 8 ppm (parts per million) of benzene for 48 hours each week.[13] This legislation permitted exposure, based on environmental evaluation[2,14] at excessive levels. Since 1976, other countries have recommended reducing the benzene-exposure limit to 1 ppm,[15] or even to altogether eliminate allowable exposure. with the justification that benzene is a human carcinogen.[16]

Brazilian legislation with respect to occupational medicine is still supported by the so-called "risk-factor model," whose main characteristic is a monocausal approach, and, in the case of chemical risks, relies on environmental and biological exposure limits, mostly derived from experimental toxicologic studies.[17] This does not take into account the superposition of various environmental factors in the work process, work organization aspects, biological variability and individual susceptibility, or other pre-existing illness factors.

This model of environmental evaluation based on isolated quantitative measures was first challenged in 1982 by technicians from Fundacentro (Center of Research of the Brazilian Labor Ministry) with regard to the question of benzene, and in 1993 a new regulatory directive for health surveillance was issued in São Paulo. which in its turn inspired other regulatory instruments at the federal level.[18-21]

CONCLUSION

This rare example of worker empowerment in Latin America demonstrates the power of education in the political arena. More than 3,000 benzene poisoning victims asserted their right to occupational health and safety. By so doing, they forever changed the social climate of work in Brazil.

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