

Chemical contamination, precariousness, illness and death at work: benzene in Brazil

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Abstract *The toxicity of benzene is widely known, and types of illnesses linked to it have been increasing. This article traces the historical trajectory and the findings related to the diseases, combined with the displacement of industrial activities from central countries to peripheral ones. In this process, there are correlations in prevention of benzene exposure. In Brazil, the application of regulations was analyzed to identify their impact because information on environmental contamination and diseases is very precarious. Formal legislation prevailed without records of its application. Only when workers and technicians mobilized did advances occur.*

Key words *Benzene, Health surveillance, Occupational cancer*

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Introduction

The risks of benzene exposure have been known for some time, and have received different treatments in Brazil and throughout the world. The importance given to benzene is mainly due to its toxicity and the spread of its use, because of its manufacture from petroleum, from coal, and its presence in natural gas condensate. It is a hemotoxic and carcinogenic substance which, furthermore, is extensively used in the production chain of petroleum extraction and refining and the making of iron, mostly on account of its presence in the raw materials of these processes^{1,3}. It is, thus, a complex and intricate issue, since at the same time that more is known about the toxic characteristics of this product, its presence and utilization still forms part of essential processes in the world.

The main illnesses related to benzene are linked to its hemotoxicity and genotoxicity caused by its metabolism. The mechanisms of actions are complex, and have not been completely established. Hemotoxicity manifests principally in the decrease of blood cells, which can result in different types of drops in blood element quantities: anemia, leucopenia, thrombocytopenia, or in a drop of all three in series, in the form of pancytopenia. When related to benzene, these hematological changes are considered an early indicator of acute myeloid leukemia and myelodysplastic syndromes (AML and MDS), although they do not constitute a necessary stage for the development of these diseases. Significant pancytopenia can constitute a specific, serious condition called bone marrow or aplastic anemia²⁻⁵.

Benzene also causes chromosomal alterations that are considered the most plausible explanation for its carcinogenicity. In addition to AML and MDS, studies point to a correlation of exposition to benzene with a broad spectrum of malignant diseases of the hematopoietic and lymphatic systems: Non-Hodgkin's Lymphoma, chronic or acute lymphoid leukemia, and multiple myeloma. It should be further emphasized that organic solvents - the chemical group of which benzene is a part and that is almost always present in the form of a mixture of products - are demonstrably associated with various other types of cancer such as breast and brain cancer⁶⁻⁸.

Benzene and other chemical contaminants become increasingly important in light of the rapid and intense changes in recent decades, with a huge impact on the workplace, the environment, and on health. Such changes include the

growth of global commerce; of industrial production and wealth; the increase in the number of people in the workforce; new information technologies and new processes of chemical, biotech, and pharmaceutical production that increase low-cost production options; and low energetic output and recycling strategies that generate new types of employment. For the vast majority of workers in the less industrialized countries, the liberalization of commerce was accompanied by the transfer of technology, chemical products, obsolete and dangerous processes and waste, many of them no longer utilized in their countries of origin, that cause difficult to recognize diseases⁹.

In spite of many of these situations being recognized as a problem in industrialized countries, this is more difficult in the countries of late industrialization, as researcher Rene Loewenson argues. Loewenson points to a combination of different factors common to this type of development: the chronicity of many of these diseases, which are rarely detected due to the instability of jobs; the exaggerated difficulty in separating occupational from environmental factors, principally when related to the degrees of poverty that lead to social breakdown; and poor oversight and inefficient regulatory systems, that imply under-reporting of occupational morbidity, particularly of the chronic diseases linked to chemical, ergonomic, and psycho-social factors⁹.

The grouping of social, economic, and environmental problems belonging to the different economic sectors involved with chemical substances, especially workers and the innumerable environmental effects related to the many types of interaction with these substances, constitute what is known as "The Chemical Question", the backdrop for the discussion of benzene. In addition, a shift in the productive processes that also effect the chemical industry takes place. The growth of these industries in the peripheral countries does not mean a loss of market share or increase in competition for the companies of central, core countries. To the contrary, it is the same corporations that are established or being established in the peripheral countries. While happening in the entire world, in Latin America this productive restructuring has a particular dimension related to the production of oil: the significant growth of the extraction of oil and gas, the resulting increase in the production of raw material, and the potential expansion of the petro-chemical sector in Brazil, Venezuela, Ecuador, Bolivia, and eventually other Southern Cone countries¹⁰.

The first legislation regarding benzene in Brazil emerged in the 1930s, well before the most important industrial activities related benzene production had begun in the country: the steel industry in the 1946, and oil and petrochemicals in the 1950s. In spite of the initiation of these activities and of existing legislation, there are no known reports of significant exposure to benzene or of the health risks related to this exposure, although certainly both must have occurred.

Thus, the guiding question of this article is: did the legal restrictions imposed on exposure to benzene in Brazil have an influence on the prevention of health risks arising from exposure to this substance in the country?

The international experience

The cycles of benzene use

There is an important comparison between the international and national experience of benzene use, with significant similarities and differences. As we are dealing with extended periods in which many changes occurred, we decided to classify them into cycles. We initially used the international experience as a basis, owing to the greater number of extant references, as well as the greater stability of this historical process of almost 190 years, from 1820 to 2008. In order to define the cycles of the international experience, information on the type of production and use of benzene were used as criteria, as well as the existing data on exposure and risks to health.

The four periods of the international experiences

The first cycle spans 1820 until the end of the nineteenth century, when benzene is discovered and begins to be known about and used in a restricted way, but its potential damage to health already appears. The most notorious initial and powerful signs appeared in the finding of Santensen and his colleagues in Sweden in 1896, when the first cases of death by benzene exposure were identified in four workers in the bicycle tire industry, who developed bone marrow aplasia by exposure to a solvent containing elevated concentrations of benzene⁴.

The second cycle, from the beginning to the middle of the twentieth century, encompasses a great broadening and diffusion of benzene's industrial use, and the consolidation of knowledge of its characteristics as a notoriously toxic and carcinogenic chemical substance. In this cycle,

exposures to extremely elevated concentrations predominate, and there is little control or restrictive measures placed on its use. Bone marrow aplasia is the most significant illness, and occurred with relative frequency. It is in this period that the first steps were taken in the prevention of benzene exposure, with particular emphasis on the proposals of Alice Hamilton in the United States^{3,4}.

In the third period, from the 1950s until the end of the 1980s, benzene use both broadens and modifies. In various countries, important restrictions are introduced regarding its utilization, and there is a substantive decrease in the environmental concentrations, which, however, remain elevated. These regulations will define the first "exposure limits" for benzene, and will include the prohibition of benzene in commercialized solvents. The causal relation to leukemia is emphasized, on account of the decrease of concentrations and consequently to this type of illness, according to the experiences of Italy, Turkey, and the United States, the principal reference points in this period^{4,11}.

In these "golden years" of great expansion of industrial production and consumption of a large portion of the planet, oil became the main base material, as a combustible and raw material for the petrochemical industry and its principal chains of production: the chemical, rubber, and plastics industries. In this period, there was great technological development and a significant valorization of labor and of workers, with a corresponding increase in the preoccupation with implementing risk prevention measures in work activities and protection of workers, in particular in Europe, the United States, and the then-existing Soviet Union. Even today, this period is called the "golden era" because of the great increase in the production and consumption of the mass population, especially of oil and its chain of production, and the political-ideological confrontation of the so-called "Cold War" also has much to do with this process^{12,13}.

In the fourth period, the question comes to revolve around the risks related to the exposures to low concentrations of benzene that come to prevail in the work environment, in which there is still potential exposure. Studies undertaken principally in China, but also in other countries outside the circuit of post-industrial societies, indicate the existence of health risks even with increasingly smaller exposures, identifying damage with occupational contamination next to environmental risks.

The principle international experiences: Italy, Turkey, and the United States

Beginning in the 1950s, findings that connected the exposure to benzene to leukemia increased, and studies intensified. Among them, those carried out in Italy by Vigliani and Forni (cited in Bartololucci¹⁴) and in Turkey by Aksoy^{2,11,15} stand out, which constituted the most significant case studies until the dawn of the 1970s, and contributed in a decisive way to the recognition of the existence of the myelotoxicity and leukemogenic properties of benzene. In the 1970s and 80s, the production of epidemiological cohort studies in the United States became the principle reference regarding the carcinogenicity of benzene^{4,16}.

Because of exposures to extremely high benzene concentrations in Italy as early as the 1920s, veritable epidemics of severe and chronic benzene poisoning had been identified. In a review done by Vigliani and Forni in 1976, data from the first identified cases in that country were recovered, and in 1989 Paci et al. (cited in Minoya¹⁶) complemented these studies further.

The legal restrictions in Italy expanded rapidly: in 1963, with a limitation on its use; in 1965, with its classification as a pathogen and carcinogen; and in 1976, with the labor ban on women and adolescents in situations of risk of exposure to benzene. In 1968, the International Labor Organization, principally influenced by these Italian actions, published guidelines regarding the use, risks, and substitutions of benzene¹⁶.

The environmental concentrations at that time were very high, above 600ppm. With the legislative changes, there was a substantial decrease in the exposure standards, estimated to be up to a factor of ten, which resulted in new types of pathology findings, and subsequently a decrease in the findings¹⁷. The decrease of the concentrations and of the finding of cases reduced the importance of benzene; research on its health impact in Italy practically ended, being substituted for studies on the exposure to multiple solvents.

In the 1990s, a new preoccupation arose, emphasizing the environmental contamination of the air by benzene and other volatile organic compounds expelled by the combustion of automotive vehicles. In this new context, in which elevated levels of occupational contamination gave way to the advance of a much smaller concentration, the emphasizing of contamination by benzene caused by environmental or individual sources, such as cigarettes, acquired new importance¹⁸.

The studies between the 1950s and the beginning of the 1980s owed much to the great expan-

sion in benzene use as a solvent in the post-war era, with the strong Italian industrialization process. This was combined with the significant intervention and diagnostic technical capacities for existing cases in the Italian Occupational Health Clinic, in the particular case of Milan and Pavia, and with the strength of workers' social organization in that period.

It is worth mentioning that, after the removal of lead from gasoline in Italy in the 1980s, the loss in potency of this combustible was compensated for by the addition of aromatic hydrocarbons, including benzene. Gasoline came to have up to 10% benzene in its composition, and eventually more. Apparently, there were no protests or criticisms over this change. To the contrary, it is possible to find evaluations from renowned technicians affirming that there was no major risk in this gasoline with 10% or more benzene content¹⁶.

In Turkey, the clinician and hematologist Muzaffar Aksoy (Istanbul School of Medicine) investigated the impact of the introduction of a type of glue containing benzene in the production and repair of shoes, which began to be used from 1955 onward because of its efficiency and cheapness. The findings of this study, disseminated beginning in the 1960s, constituted the first epidemiological studies that proved the relationship between benzene and leukemia^{2,11,15}.

The studies of Aksoy and his collaborators in Istanbul, as well as those developed in Italy, are classics, fundamental in proving the relation between exposure to benzene and leukemia, and are considered a worldwide reference even today. The impact that the introduction of benzene use had on Istanbul is notable, principally with artisan shoemakers, and this is one of the main reasons for the importance of these studies: the visibility of these illnesses in the city of Istanbul, which was also made possible by the clearly qualified hematological training of Professor Aksoy and his team. It is also quite curious that issues that were at the center of a fierce dispute in the core industrialized countries came to have a base of evidence in a peripheral country with little industrialization (Chart 1).

In the 1970s, many significant things happened in the United States, especially the definition of the acceptable tolerance threshold for this substance. In the post-war period, a change in the standards of benzene usage occurred, which came to be predominantly of a petrochemical origin, having a vast utilization as a raw material for innumerable products in this chain of production. The environmental concentrations and exposures diminished, and new issues arose^{5,19}.

Chart 1. Hematological illnesses related to benzene exposure in Italy and Turkey recorded in academic studies, 1929-1984.

Period investigated	Type of study	Clinical-epidemiological findings	Types of industry involved	Authors
1928-1938	Case report	60 cases of Aplastic Anemia (AA)	Shoes, printing presses, and others	Vigliani & Forni
1942-1975	Case report	66 hemopathies, 7 deaths from AA and 11 leukemias in Milan		<i>ibid.</i>
1959-1974		135 cases of benzene poisoning with 3 deaths by AA and 13 leukemias in Pavia		<i>ibid.</i>
1939-1984	Cohort study	Increase in mortality by AA and leukemia	Shoe factory	Paci et al.
1961-1972	Case report	40 cases of AA	N/A	Aksoy et al.
1967-1975	Case report	40 cases of benzene exposure in leukemic patients	N/A	Aksoyet al.

Researchers conducted epidemiological studies demonstrating an excess of leukemia in workers exposed to low concentrations of benzene. In 1977, the results of the first cohort study of works exposed specifically to benzene were published, identifying them as being at 5 to 10 times more at risk to develop leukemia. Based on this study and other data in the literature, the Occupational Safety and Health Administration (OSHA) established an exposure limit of 1 ppm. This was challenged by corporations and the American Supreme Court suspended it, deciding that before promulgating any permanent standardization, the Secretary of Labor would need to define the limits in which a locality would not be safe, clarifying what significance the risks present would have, and if they could be eliminated or reduced by changes in practices. The Supreme Court did not quantify what would be “significant,” leaving the criteria to the Department of Labor to define these parameters. In 1987, the Court accepted the argument brought by OSHA to justify the reduction of the limit to 1 ppm, extending, however, the determination of the legal justification regarding the significance of risk to all OSHA decisions^{4,11}.

Issues remaining in globalization

In the fourth period beginning in the 1990s, the discussion will continue, as the innumerable conflicting studies regarding the possible environmental concentration that would permit exposure without harm do not arrive at consensual conclusions. The main focus was thus the relation between benzene and cancer (leukemia), but because of the various uncertainties that permeate these investigations and by the nature of ex-

posure in itself, which has surpassed the bounds of the occupational discussion, the question also became an environmental one.

The tendency to prioritize the studies on benzene, leukemia, and its correlation with exposure levels comes to be the main issue treated in studies from this period onward, with the principal ones conducted in the United States, and previously in China, where group studies were developed from the end of the 1980s until the present, with a cohort of 74,000 workers tracked since the 1970s. In addition, there are numerous case studies linked to this same cohort or complementary to it, among which we emphasize the article published by Lan et al.²⁰ in 2004, identifying the occurrence of hematological alterations in workers exposed to less than 1 ppm²¹.

Beginning in the 1990s, however, the problem of occupational exposure to benzene begins to be confused with the discussion on environmental exposure. The issues come to revolve around the risks related to exposures to increasingly reduced concentrations of benzene, which come to prevail in environments where there is still risk of benzene exposure. The studies shift principally to China and the Far East, but also appear in some other countries outside the circuit of post-industrial society, and indicate the existence of health risks with increasingly smaller exposure, identifying harm with occupational contamination alongside environmental contamination.

The Brazilian experience

The four periods of the Brazilian experience

Similar to the international experience, the Brazilian experience in relation to benzene can be divided into four periods or cycles. Among

the particularities that differentiate them - which may possibly be similar to other societies with late-developing economic and industrial standards like Brazil - is the fact that these periods also begin later: in the case of benzene, they begin only in the 1930s. Their cycles are extremely short, owing to the repercussions of the economic and technological determinants of the core countries, and there is almost a repetition of what occurred in those countries in a different, accelerated form. Many things can be unraveled from the slogan "fifty years in five" from the mythical years of President Juscelino Kubitschek (or "JK")¹⁰.

Owing to the lack of data on exposure and health risks in Brazil, however, the criteria which were satisfactory for classifying the cycles of international experience with benzene were difficult to apply to the Brazilian experience. To overcome these gaps, the criterion chosen was defined as the central objective of the study: the legislation on restricting exposure combined with the data of production and utilization of Benzene in Brazil. In light of these difficulties, the route chosen for the classification of the periods was based on the combination of the creation of legal instruments for protecting workers with the development of industrial production, and the adequacy of these legal instruments to this process. Whenever possible, data on morbidity and environmental contamination were used^{10,22}.

First cycle

The first period, from the 1930s until the middle of the 1960s, was when the first legislation regarding benzene was made in Brazil, some years before most important industrial activities related to its production: steel working in 1946, and oil and petrochemicals in the 1950s. In spite of the beginning of these activities and of the existing legislation, there are no reports in these period on exposure to benzene or its related health risks, although both certainly must have occurred²²⁻²⁴.

Most notable is the lack of references to occupational exposure to benzene during this period. There are no records or reports of work situations in spite of the significant and systematic presence of labor regulations looking to limit exposure or monetarily compensate for the risk of such exposure, showing a disconnect between the legal and the real.

The Ministry of Labor published all three regulations about benzene in Brazil. Two of them pertained to limiting exposure, prohibiting the

labor of women and minors, and one concerned financial compensation for the risk: hazard pay. There is no record concerning the application of these laws. Neither is there information about the circumstances of workers' exposure during this period - all we know is that industrial manufacturing of benzene started (from coal in 1946 and petrochemicals in 1956), and that production gradually increased over the years, without any references to the occurrence of illnesses related to benzene. While there was already material about the manner in which to proceed to perform this type monitoring, there is no record that it occurred. No indications of any kind of actions related to benzene were encountered, aside from the aforementioned legislation and some theoretical articles^{10,22,25}.

Benzene was an abstract problem between 1930 and 1960, which had not materialized in the everyday life of Brazilian society. Perhaps this is because it did not have a significant presence from a quantitative perspective, and there was no culture of risk prevention for workers during this period, which can be explained by the fact that illnesses provoked by benzene remained invisible up to that point, without, for that matter, the record of a single case.

There is very little information about what occurred in this period, suggesting a disconnect between the regulation, that dates back to the 1930s, and the ability to find illnesses that were attended without being identified, in spite of existing knowledge about the evils of benzene. Perhaps this is because this knowledge was restricted to only some circles, and the eventual cases occurred in a dispersed way, in an insufficient number to call attention and form a critical mass of knowledge in the health services that would result in diagnostic capacity and intervention. It is unlikely that no cases had occurred at all¹⁰.

Second cycle

The second period is a cycle of rapid broadening of the production and utilization of benzene: its use as part of a mixture of solvents, which spreads in the 1960s and will be prohibited in 1982, and the beginning of the hegemony of the petrochemical production of benzene, consolidated afterwards. The first cases appear in hematological studies and occupational research, and new legislation introduced important changes^{22,23}.

There are no records regarding the application of existing legislation (prohibition of exposure of women and minors), but the main group

exposed to benzene in activities that involved solvents studied in this period was comprised precisely of women and minors. It could be direct, insofar as it involved work activities or by the shifting of work activities to the interior of homes; or it could be indirect, by the contamination of these households with consequent exposure of the residents^{26,27}.

The first cases related to benzene exposure in Brazil appear in two theses about Acquired Aplastic Anemias^{28,29}. In 1971, the first study about the presence of benzene and toluene in solvents advised about the toxicity of these substances, calling attention to their risks and proposing preventative measures³⁰. In 1973, the Outpatient Clinic of Occupational Diseases of SESI would make an investigation of four cases of bone-marrow aplasia following the death of young workers in the same factory²⁶. In the same year, the Ministry of Labor granted special retirement for those exposed to benzene.

In 1978, the Tolerance Limit (TL) for benzene was established in Decree 3214. This decree was an attempt to respond to the problems that were manifesting in increasingly significant ways in the field of workers' health, including in relation to benzene. Its repercussion was rather localized in that moment, visible only in some restricted activities. With time, the practice of "hazard pay" prevailed for many years as the main alternative of the companies to risk prevention, and the main reason for the concession of "hazard pay" was the non-observance of this tolerance limit by the companies^{22,23,31}.

The data pertaining to exposure are very diffuse and usually found in case studies. The first study that showed the presence of benzene in solvents in 1971 found that, for the majority of solvents, benzene quantities were relatively low. Ten years later, the study that formed the basis for the legislation that prohibited benzene in solvents analyzed seventy-four products, and found benzene above 1% in twenty-two of them, with some having benzene content above 90%. In this period (1970/80), Brazilian production of benzene grew from 25,000 tons per year to more than 300,000 tons/year²².

A tendency to use biological indicators to identify exposure in place of environmental evaluations is notable, such as in the case of urinary phenol. These environmental evaluations, when made, have poor descriptions and many times are carried out using only hand pumps of instantaneous measurement. Even so, very elevated concentrations were proven. Until the beginning

of the 1980s, exposure to benzene was certainly diffused through all of Brazil, occurring in a significant way not only in the industries that produced and utilized it, but also in the large chain of production in which it was present mixed with other solvents²².

The study by Celina Wakamatsu²⁷ was undertaken in 1976, and in 1978 Decree 3214 was published by the Ministry of Labor. Soon after this decree, corporations undertake their first works in this area, presenting data about their findings and their actions for preventing benzene exposure, albeit in a preliminary and case-by-case way. At the beginning of the 1980s, the most notable study is one carried out by Fundacentro ('Fundação Centro Nacional de Segurança, Higiene e Medicina do Trabalho') about the presence of solvents, and the legislation of the Ministries of Health and of Labor prohibiting the presence of benzene in solvents.

The only recognized cases of poisoning by benzene published in the country in this period are four cases of bone-marrow aplasia, identified in the academic studies of Cillio and Oliveira, and the four cases of bone-marrow aplasia with 106 compatible cases with benzene poisoning of the SESI Outpatient Clinic. Between 1973 and 1983, no new cases were identified.

Third cycle

In the third period, the main concern comes to be occupational exposure in the second generation of the steel-working, petrochemical, and chemical industries. Like in the international experience, throughout this period there was a change in the standards of exposure (which remained high, even while lesser than before), and there was much polemic and controversy about the meaning of the alterations found and the illness that were or were not attacking the workers. This was a period of great transformation in the sphere of labor in Brazil, and the struggle for workers' health will have an important contribution to this process. One prominent part of this struggle will be fought around the exposure to and the diseases provoked by benzene, which are finally unraveled. The main preoccupation came to be poisoning by benzene in light of its hematotoxicity^{32,33}.

In spite of the sparse data, the prohibition of benzene in solvents was very successful. Research in 1982 verified a downturn in the market for formulated products in relation to the use of benzene, although there persisted some products with elevated levels of benzene, which was con-

firmed in 1988 in a new survey that showed an important reduction of benzene presence in the country's products²². Various reports on the findings of industrial solvents with benzene levels above 1% show a different situation in the factories. Even today, there are no public means of verification of benzene levels or other substances in the composition of either industrial solvents or products sold to consumers^{22,23}. In spite of the possibility of a worsening of the health situation, no national research was done to provide a clinical and epidemiological monitoring of these workers, and the majority of this group does not even have regional follow-up.

The most remarkable aspect of this period was the great number of cases of benzene poisoning diagnosed via the development of activities by workers' unions and various public health services in the field of worker health. In opposition to the sparse number of cases found in the previous period, in this third period close to 3000 cases of benzene poisoning were diagnosed (Table 1), and the first cases of malignant diseases of the lymphatic and hematopoietic systems related to benzene exposure²³. Already indicating a change in the profile of exposure, we have 1 registered case of bone-marrow aplasia for 5 cases of Acute Myeloid Leukemia and 4 cases of Myelodysplastic Syndrome (Table 1). This assessment is in large part encountered in large corporations, especially the steel industry and petrochemicals, where there was crucial activity in this period by unions, almost always in conjunction with public agencies³³⁻⁴³.

It is reasonable to suppose that innumerable activities of risk were not covered owing to the limitations of health surveillance in the country. The most apparent case of an absence of surveillance is with workers at gas stations and those who transport these products.

The seriousness of this situation led to the creation of a number of legal instruments. Twelve regulations produced between 1982 and 1994 were identified, aiming at the classification of health risks related to benzene exposure, and the definition of diagnostic and follow-up procedures for the affected workers. These standardizations, which had not existed up to that point for any other occupational illness, were fundamental for the characterization of hematological alterations and the perfection of criteria, which over time permitted the training of responsible groups of technicians, principally in the public sector, which guaranteed more efficiency, safety, and coordination on this point that was so crit-

ical, polemical, and contested by the corporations. The synergistic action of the unions also enhanced the unification of the public agencies.

There were important changes in the exposure profile in this third period. However, many methodological difficulties impeded a better appreciation of the information that could be extracted from the small amount of quantitative data. It is possible to say that here was a decrease in environmental concentrations. The practice of utilizing urinary phenol as the main indicator of exposure was widespread in the industries, with the practice of quantitative environmental evaluations done on a case-by-case basis. There is little quantitative data in the published studies and reports, and those that exist do not indicate methodologies. Even so, the concentrations that were measures between 1980 and 1985 are very high. In the following years this number fell, and there are reports of environmental improvements, but they are insufficient to conclude that there had ceased to be exposure at important levels. At the end of this period, there are numerous criticisms of the use of urinary phenol in the way it was being utilized, and to its appropriateness to the concentrations of that time, apparently much lower in 1994 than they had been in 1982 at these corporations.

Fourth cycle

The fourth period begins in 1994, when the Ministry of Labor recognized benzene as a carcinogenic substance. There is a significant change of approach, in both the point of view regarding benzene exposure in itself, as well as the way that risk surveillance and the environmental importance of the substance were treated, leading to new challenges, the better part of which have not been dealt with. This period is characterized by national agreement that was innovative for the time, involving national representatives of three sectors of society: an important contingent of public authorities, entrepreneurs of the steel-working and petrochemical sectors, and workers' representatives³².

The agreement came together around certain principles, among which are: the prohibition of benzene use, permitting its use only in some industrial sectors and with specific permission; the abandonment of the concept of a tolerance limit, and the adoption of a principle of non-exposure, with the use of Variable Rate Technology (VRT); the valuing of the participation of workers as effective strategies in risk prevention. Almost two dozen regulatory laws were passed, principally

Chart 2. Illnesses related to benzene exposure identified in Brazil up to 2012.

Diagnosis	Number of cases	Place/Company	Data Recorded	Record	Reference
Aplasias	2in30	São Paulo	1966	Doctoral thesis	Cillio, 1966
Aplasias	2in 23	São Paulo	1971	Doctoral thesis	Oliveira, 1973
Aplasias	4cases 1(?)	São Paulo	1973	Trab.Conpat	Morrone, 1974
Aplasia	1(?)	São Paulo	1978	Master's thesis	Wakamatsu, 1978
Aplasia	1	Nitrocarbono/Ba	1990	Rel.DRT-Ba	Sindiquim/Ba, 1992
Aplasia	5	Posts/Brazil	2006	INSS	Costa, 2009
Total Apasias			13+2(?)		
Poisoning	106 (?)	São Paulo	1973	Trab.Conpat	Morrone, 1974
Poisoning	8 (?)in 151	São Paulo	1978	Master's thesis	Wakamatsu, 1978
Poisoning	34 in 60	Matarazzo/SP	1984	Proc.DRT-SP	Costa, 2009
Poisoning	2200	Cosipa/SP	1991	INST	Carvalho, 1995
Poisoning	66/472(?)	Copec/Ba	1991	DRT-Ba	Miranda, 1997
Poisoning	12/30(?)	CST/ES	1991	DRT-ES	Costa, 2009
Poisoning	97	MG	1992	Fundacentro	Carvalho, 1995
Poisoning	8	PQU/SP	1992	Master's thesis	Galvanese 1999
Poisoning	351	Copec/Ba	1993	Fundacentro	Carvalho, 1995
Poisoning	56(?)	Cosipa/SP	1996	DRT-SP	Machado, 2003
Poisoning	14	Cosipa/SP	2001	STIMMES	Costa, 2009
Poisoning	76	CSN/RJ	2001	CSN	Costa, 2009
Poisoning	8	Açominas	2001	Açominas	Costa, 2009
Poisoning	15	RPBC/SP	2004	DRT/SP	Costa, 2009
Poisoning	9	RS	2008	Master's thesis	Correa, 2008
Total Poisonings			2812+672(?)		
AML	1	Matarazzo	1984	Proc.DRT-SP	Costa, 2009
AML	1	Cosipa/SP	1984	Diesat	Giraldo, 1999
CML	1	Nitrocarbono/Ba	1990	Rel.DRT-Ba	Sindiquim/Ba, 1992
CML	1	PQU/SP	1991	Master's thesis	Galvanese, 1999
AML+MDS	1+3	Cosipa/SP	1994	HC/Unicamp	Ruiz, 1994
AML	1	PQU/SP	1997	CEBz/SP	Costa, 2009
AML	1	RPBC/SP	2004	DRT/SP	Costa, 2009
AML	1	RPBC/SP	2006	DRT/SP	ACP/MPT, 2011
CML+AML+CLL	3	Cosipa/SP	2007	DRT-SP	Costa, 2009
Leukemias	14	Posts/Brazil	2006	INSS	Costa, 2009
Total Leukemias			29		

between 1994 and 2005, and a structure of permanent negotiation was created beginning with Appendix 13-A of NR-15³².

It is a fertile period for regulations. Its beginning is demarcated in 1994 by the Decree recognizing benzene as carcinogenic substance. Until then, only four practically unknown substances of very limited and localized use were recognized as carcinogens. This legislation was, therefore, innocuous. The introduction of benzene in Appendix 13 of NR 15 was very positive, and the removal of the environmental and biological tolerance limits had a great impact, as the limits functioned as juridical-administrative mechanisms of

the corporations. When they ceased to exist, the corporations came under pressure, because they could no longer maintain the justification that their facilities were "within the legal limits."

From the point of view of benzene exposure, various elements suggest that important changes occurred in this period. The difficulty of collecting systematized information about this situation from a quantitative perspective, in spite of the detailed breakdown of the regulations produced in relation to this point, was not overcome in the experience of the fourth period. After many attempts to make corporations present data regarding the situation of benzene contamination in the

companies registered, there was a workshop on environmental evaluation, in which employers identified the non-homogeneity among corporations, with each doing its own evaluation according to different standards. The follow-up done by the public services, even while not allowing for a precise understanding of the situation, demonstrated a substantive decrease in the exposure standards compared to twenty years earlier.

In the steel-working industry, the control over environmental contamination is admittedly more difficult. Nonetheless, the situation in this sector evolved favorably in relation to the 1980s, especially with the closure of the benzene factories that operated in the carbochemical areas in the majority of the steel mills. The petrochemical and chemical sectors were receptive to the proposals for best practices, a tool of the public sector for implementing the policy of non-exposure. The reduction of exposure in these sectors is significant and can be perceived by the quantitative indicators in various corporations, but it is most evident by the implementation of the principal best practices in the vast majority of these companies: online monitoring of benzene in critical areas of exposure, loading of trucks from underneath in a closed “bottom-load” system; programs of pump replacement; and measurement of tanks with radar to avoid opening them, among other initiatives.

There was a substantial drop in the identification of work-related illnesses in this period. The changes that took place partially explain the reduction in the number of cases by the reduction of exposure. However, an important portion of the cases continue to not be identified, and others, while diagnosed, do not get official recognition by the Social Security system.

The importance of the evolution of the diagnostic criteria for benzene poisoning beginning with the Normative Instruction 1 of 1995, which resulted in the Health Surveillance Standard of Workers Poisoned By Benzene (Decree 776/MS) and in the Protocols of Chemical Risk. It also resulted in attention to the health of works exposed to benzene and the Protocol of Work-related Cancer: Acute Myeloid Leukemia and Myelodysplastic Syndrome due to benzene exposure. These instruments constituted an important part of the progressive path initiated with the characterization of “leukopenia” as a finding requiring compulsory notification of the Cubatão Health Center in 1984 and, with advances and regressions, has been a fundamental element for the public service’s intervention into illnesses provoked by benzene^{1,44,45}.

At the same time, this experience has served in Brazil as a reference for the health surveillance of workers exposed to chemical risks in general. Among the most significant advances are the broadening of the scope of the sectors included in surveillance, with emphasis on the business sector of fuel resale, the gasoline stations. With discussions that have been taking shape since 2005, this sector is currently one of the busiest in this respect, broadening the discussion of worker health and the chemical risks outside the walls of the factories, and becoming a model for health surveillance action in the whole country⁴⁶.

The insertion of the “petroleum sector” in the strict sense (Petrobrás - Brazil’s state-owned oil company – its subsidiaries and contractors) passed through many transformations in this period. Distant from the discussion about benzene in Brazil until practically 1995, with rare and specific exceptions, this situation begins to change with the entrance of oil workers in the Commissions created by the agreement. There was special importance in the worker training process developed by the unions together with the public sector beginning in 1997, to qualify the worker representation that trained the Benzene Workers Groups (*Grupos de Trabalhadores do Benzeno*, or GTBs), a right created in 1995 and appropriated especially by the oil workers. The so-called “getebistas” (from the initials GTB) inserted a dynamic of discussion into the oil industry that has made this sector the most mobilized when it comes to the issues of chemical contamination³².

In this process, innumerable critical situations were unraveled in refineries, warehouses, and other Petrobrás units. The most notorious of these situations was encountered at the President Bernardes Refinery in Cubatão (a city in São Paulo state), where the oldest and worst benzene factory in the country was found, inaugurated in 1956. Due to the Civil Public Inquiry, later transformed into a Civil Public Action, a diagnostic investigation was carried out about the health of the workers exposed to benzene in this factory, which is certainly one of the most detailed group case studies using cluster analysis in our country that showed significant exposure and poisoning in all investigated cases with varying degrees of severity¹⁰.

Final considerations

There has been an important evolution in the way workers’ health is treated in Brazil. In spite

of advances, innumerable challenges persist, and the possibility of setbacks – sectorial or diffused – is always present.

Social dynamics with greater participation of workers, the populace, and public authorities favor the implementation of positive changes. In these scenarios, the negation of the existence of worker and environmental contamination, and the policies of artificial management of risks – tendencies that predominate at the corporations – encounter more difficulties in establishing themselves.

The importance of technical-scientific production as the basis of actions of public service and an element of cooperation with social movements is crucial in the consolidation of a supra-corporate dynamic.

The precariousness of existing information, as much in relation to situations of environmental contamination as to the illness of workers, is among the principal obstacles to be overcome.

It is important that quantitative surveys and studies are made, but the limitations of them continue to be enormous.

Collaborations

DF Costa and M Goldbaum participated in the conceptualization, production, and revision of the text, which was written by Dr. Danilo Costa.

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Article submitted 07/07/2016

Approved 20/02/2017

Final version submitted 22/02/2017