

Prevention of occupational cancer

A different approach

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GOLDSMITH JR, LEMESCH C. Prevention of occupational cancer: A different approach. *Scand j work environ health* 8 (1982): suppl 1, 83-88. The dominant strategy for preventing occupational cancer in the United States is agent-based. An alternative set of preventive strategies based on a more healthful workplace can replace this approach, and not only provides practical guidance on what to do, but also criteria for the prevention of cancer from known or suspected agents and from suspected occupations, not now covered by agent-oriented strategies. The strategy is based on preventing the occurrence of any unfavorable health effect from known or possible carcinogenic exposures. All known occupational carcinogens have other effects detectable earlier than cancer and usually at a lower dose. The proposed strategy is built on the assumption that yet-to-be identified carcinogens will also have this property. Strategies for prevention once exposure to known carcinogens has occurred are also proposed. The benefits include the prevention of other diseases. One large industrial complex has already embarked on such an approach.

Key terms: epidemiologic monitoring, equitable compensation, industrial hygiene, suspect agents, suspect occupations.

The associations between occupational exposure and cancer in humans are both a social and personal tragedy, and a challenge to preventive medicine. The dominant strategy in the United States has been agent-focused, and it has its most articulate presentation in the report of the Interagency Liason Group, "Scientific Bases for Identification of Potential Carcinogens and Estimation of Risks" (8). The present paper will review the following four types of preventive strategies based on needed improvements in the workplace, where the risk of occupational cancer actually occurs: (i) prevention of further exposure to

known industrial carcinogens; (ii) prevention of cancer from agents or occupations not yet known but suspected to increase risk of human carcinogenesis (suspect agents or suspect occupations); (iii) reduction of the risk of cancer for persons known to have already been exposed to carcinogens, suspected agents, or suspect occupations; and (iv) reduction of the risk of other disease or injury from physical or chemical agents known or suspected to be carcinogens.

This different approach is based on an observed property of known human carcinogens, namely, that they also produce nonneoplastic health impairment with a much shorter latency, a lower dose, and usually greater specificity than it takes to produce excess cancer.

It is reasonable to assume that agents which may not yet be accepted as human carcinogens will have similar biological properties, and it follows logically that the prevention of detectable nonneoplastic impairments will make a large contribution to the prevention of occupational cancer as well. Decreasing (or holding down)

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workplace exposure so that suspect agents or work in suspect occupations does not result in detectable health impairment is the essence of this different approach.

Prevention of cancer by limiting exposures to known occupational carcinogens

There are a number of reviews which can be used to define known occupational carcinogens. The single most valuable source for the evaluation of the carcinogenic risk of chemicals is the series of monographs entitled *Evaluation of Carcinogenic Risks of Chemicals to Humans*, published by the International Agency for Research on Cancer (IARC) (7). Each monograph represents a synthesis of both epidemiologic and experimental data, and a judgement as to the consistency of the data concerning evidence for carcinogenicity in experimental animals and man. In addition recent reviews have been based on meetings (2, 12).

Most known human carcinogens were first identified by epidemiologic studies of occupationally exposed human populations. In view of the long latency period, this method of identification implies a great deal of cancer experience, not only in the population identified as having an excess for which the hazardous exposures have already occurred, but even more so for populations which have not been under observation because of rapid turnover of work or because the most hazardous work conditions are in places or circumstances in which diagnosis or documentation of cancer is least likely.

Cole & Merletti (5), working with assistance from the International Agency for Research on Cancer, have listed and classified known occupational carcinogens and have also tabulated the frequency of regulations of these substances among eight countries (Belgium, Federal Republic of Germany, Ireland, Japan, Sweden, United Kingdom, the Soviet Union and the United States) as of 1977.

The International Agency for Research on Cancer in its 1980 annual report summarizes the evaluation of 537 chemicals, groups of chemicals, industrial processes or industries from the first 25 volumes of

its monographs (6). The following list was derived from that source.

CHEMICALS, GROUPS OF CHEMICALS, INDUSTRIES OR INDUSTRIAL PROCESSES THAT ARE CARCINOGENIC FOR HUMANS

- I A Chemicals
 - 4-Aminobiphenyl
 - Asbestos
 - Benzene
 - Benzidine
 - N, N-bis(2-chloroethyl)-2-naphthylamine
 - Bis (chloromethyl) ether (and technical grade chloromethyl methyl ether)
 - Diethylstilbestrol
 - Melphalan
 - Mustard gas
 - 2-Naphthylamine
 - Vinyl chloride
- I B Groups of chemicals (not every member of the group need be carcinogenic)
 - Arsenic and its compounds
 - Chromium and its compounds
 - Soots, tars and oils
 - Conjugated estrogens
- II Industrial processes
 - Auramine manufacture
 - Hematite mining (?radon)
 - Isopropyl alcohol manufacture, using the strong-acid process
 - Nickel refining
- III Industries
 - Boot and shoe manufacture and repair
 - Furniture and cabinet making industry

CHEMICALS OR GROUPS OF CHEMICALS THAT ARE PROBABLY CARCINOGENIC FOR HUMANS

- IV Chemicals or groups with a *higher degree* of human evidence
 - Aflatoxins
 - Cadmium and certain of its compounds
 - Chlorambucil
 - Cyclophosphamide
 - Nickel and certain of its compounds
 - Tris (1-aziridiny) phosphadine sulfide, (thiotepa)
- V Chemicals or groups with a *lesser degree* of human evidence
 - Acrylonitrile
 - Amitrole
 - Auramine
 - Beryllium and certain of its compounds
 - Carbon tetrachloride
 - Dimethyl carbamoyl chloride
 - Dimethyl sulfate
 - Ethylene oxide
 - Iron dextran
 - Oxymetholone
 - Phenacetin
 - Polychlorinated biphenyls (PCBs)

Clearly, agents in group I A are the most suitable for preventive approaches based on the first strategy, while the second strategy may be more appropriate for the prevention for groups I B, II, III, IV, and V.

All the agents in group I A have non-carcinogenic effects. For at least some, such as beta-naphthylamine or mustard gas manufacture, a prohibitive regulation may indeed be all that is needed. But some of the materials are very widely used, or poorly specified, or have effects of other sorts compared to which the likelihood of cancer is trivial. Asbestos, lead salts, arsenic or chromium, and benzene present examples of the different types of regulatory problems. For many other industrial exposures, a threshold exposure is thought to exist and becomes the basis for an occupational health protection regulation. According to the Interagency Regulatory Liason Group "Much has been written about threshold doses for carcinogenic effect but unfortunately there is no recognized method for determining their existence [p 376]" (8). However, the 1981 threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists give TLVs for several substances and processes, as well as list more substances as "suspect of carcinogenic potential for man" (14).

In light of the wide use of some of the carcinogens, such as benzene and asbestos, there are the difficult problems of whether substitutes are not more hazardous and how to enforce the regulations eventually adopted. The recent reversal by the US Supreme Court of a regulatory decision on benzene on the basis of the government's failure to demonstrate an actual risk situation is an example of the difficulties that affect the establishment of enforceable regulations. Since benzene exposure is associated with bone marrow depression and risk of aplastic anemia is substantially greater on a statistical basis than is risk of leukemia, it would be practical to protect workers from the risk of aplastic anemia or associated evidence of bone marrow effects, and such a policy will nearly certainly protect the same workers from the risk of leukemia (15).

That such prevention is feasible is illustrated by the report of Doll et al (3) on the reduction of risk of lung and nasal sinus cancer in nickel workers as a result of changes in technical arrangements which reduced exposure by a substantial amount.

Rijkels (11) reports for the Epidemiological Project Study Group of the Royal

Dutch Shell Group of Companies on principles for monitoring both environmental conditions and worker health reactions in an industry with a variety of organic chemical exposure risks, not all of which are carcinogenic.

Prevention of cancer from agents or occupations not yet known but suspected to increase risk of human carcinogenesis

Two different types of situations require strategies for agents or occupations not yet known but suspected to increase the risk of human carcinogenesis. Either the agent is an animal carcinogen, under experimental circumstances, or the exposure in a certain type of occupation is associated with excess cancer occurrence, but the active agent has not yet been identified.

Tomatis (13), for example, lists 94 chemicals known to be carcinogenic for experimental animals only, based on the first eight volumes of the IARC monograph series, up to 1975. Of these, human exposure is known to occur for 89. It is occupational for 78 (including 15 polycyclic aromatic hydrocarbons present in soot, tar, and exhaust fumes), and medicinal for 16; a general environmental exposure occurs for 49 (including the 15 polycyclic aromatic hydrocarbons). For 39 of the 537 exposures evaluated in the IARC's 1980 report (6), a positive association or a strong suspicion of an association with human cancer was reported. Of the remaining 498 chemicals, groups of chemicals, industrial processes, or industries, epidemiologic evidence for the evaluation of human carcinogenicity was either insufficient or unavailable, but for 493 of the chemicals tested with experimental animals there was *sufficient* evidence of carcinogenicity for 130 and *limited* evidence for an additional 143. This information provides the bulk of the leads as to suspect agents or suspect occupations.

In all, 15 occupational categories have been reported (6) to be associated with excess cancer incidences without identification of a specific etiologic agent (table 1). The generic cancer regulatory policy introduced by Dr Bingham during her term as Undersecretary of Labor for Occupational Safety and Health in the United

Table 1. Selected occupations for which excess cancer incidence has been reported without identification of a specific etiologic agent.^a

Occupation	Cancer site	Percentage of excess
Cadmium production workers	Lung	135
Cadmium production workers	Prostate	248
Chemists	Pancreas	64
Chemists	Lymphomas	79
Coal miners	Stomach	40
Coke by-product workers	Large intestine	181
Coke by-product workers	Pancreas	312
Construction painters	Lung	39
Construction painters	Bladder	52
Electroplaters	Large intestine	192
Electroplaters	Lung	71
Foundry workers	Lung	50—150
Furniture workers	Nasal cavity & sinus	300—400
Metal miners	Lung	200
Leather workers	Bladder	150
Printing pressman	Mouth & pharynx	125
Rubber workers		
Processing	Stomach	80
Processing	Leukemia	140
Tire bulding	Bladder	88
Tire bulding	Brain	90
Tire curing	Lung	61
Shoe workers	Bladder	150

^a Sources: Report of the National Cancer Institute, National Institute of Environmental Health Sciences, and National Institute for Occupational Safety and Health on the "Proportion of Cancer Thought to be Related to Occupation," and the UK Office of Population Censuses and Surveys, Occupational Mortality 1970—1972, HMSO.

States is one type of strategy designed to improve the promptness and adequacy of control measures.

An even more important strategy derives from the monitoring and preventive principles already stated. Given that a person is employed in an occupation with an unusually high cancer incidence and that the individual has symptoms (such as abnormality of liver function) or some deviant laboratory tests (low blood count or lung function impairment or slowing of nerve conduction), it is essential for the worker's protection that the exposure be reduced or modified so that these abnormalities are no longer to be found. Without change, the evidence concerning occupational cancer indicates that the risk for cancer often increases; if the abnormalities are reversed, the application of common sense suggests that the risk for cancer decreases. Exactly the same principles hold for a person occupationally exposed to an agent known to be an animal carcinogen.

Every known occupational carcinogen has associated noncarcinogenic reactions that can be detected earlier than cancer

can. Given that a risk of cancer from occupational exposure is suspected, either because of animal studies of the agent or from nonspecific effects of the occupation, prevention of any associated health reaction is the essential step toward the prevention of cancer. The generalization of this strategy is that, in situations in which risk is suspected, the best cancer prevention strategy is to reduce any exposures associated with an unfavorable health effect. This strategy has the obvious secondary benefit of preventing other irreversible health problems as well. This strategy would be a supplement to and supported by regulatory efforts, not a substitute for them. It is best not to expose workers to agents which are animal carcinogens, if possible; it is not always practical or enforceable to prohibit their use or require substitutes, however.

We do not propose, nor do we believe, that the reduction of risk or of evidence of unfavorable health reactions alone should be accepted as the only or the best strategy for control efforts. Far preferable would be to reduce exposures to suspect agents or

in suspect occupations to the absolute minimum. Even so, one cannot under realistic situations or even under minimal feasible exposures avoid all risk of adverse reactions of a subtle nature, of which carcinogenesis is but the most distressing example. What we are proposing is a strategy for reducing identifiable risks based on known or likely mechanisms. We recognize that there may be carcinogens with no other identifiable effect to provide the "sentinel" function which such effects could have had in the past.

Thus, all known carcinogens should be regulated either by the prohibition of their use or the maintenance of exposure at a level as low as reasonably achievable (ALARA). Since all known carcinogens have noncarcinogenic effects as well, epidemiologic monitoring for such reactions should be undertaken to assure that they do not occur.

Prevention applied to persons exposed to known or suspected carcinogens

If one has as a patient, a man of 48 a of age, with symptoms of cough, finely granular pulmonary fields and a history of 6 a of shipyard repair work 25 a ago, one could conclude that he had been heavily exposed to asbestos. It follows that he has a high risk of respiratory cancer, especially if he is a regular smoker. What help can be offered him?

If the patient is a smoker, he must be urged, in the most persuasive way possible, to stop, for stopping will reduce his risks not only for cancer, but also for cardiovascular disease. Lung function tests will help with advice on future work capacity. Finally, he should avoid exposure to fumes, irritant gases, or other possible carcinogens.

Of all the possible steps, cessation of smoking is by far the most important, and nothing else will provide anything like its possible benefits (5, 10).

Compensation is not a satisfactory substitute for the prevention of the disease in the first place. But if preventive measures have failed, compensation of the worker or his family can prevent further economic hardship, and it is on this basis that it becomes an important part of the preventive program.

If the carcinogenic exposure occurred under circumstances in which the carcinogenic hazard had not yet been identified, it would seem equitable that public funds provide the compensation to those afflicted with cancer. If the opposite be true, that data were available to indicate the carcinogenic hazard at the time exposure began, it follows that some degree of negligence must be attributed to the employer; under these circumstances, it would be equitable that the full costs of the compensation be borne by the employer, directly and without subsidy. One expected consequence of this policy would be to provide a positive incentive for employers to institute the most protective systems, and also to keep themselves and their employees well informed of the risks they are engaged in.

Some ethical aspects of this problem have already been presented (4).

Prevention of other diseases based on occupational cancer

There are at least two different interacting types of prevention which are capable of benefiting from knowledge about occupational cancer. The first concerns the cancer risk for the same agents when they occur in other types of exposures, such as in medical treatment or in general community air, water, or food pollution. The second type is the prevention of other types of diseases associated with occupational carcinogens. The advantages of these secondary benefits are obvious.

In fact, one very good argument for an aggressive cancer prevention program is the by-product effect such an effort can have on work conditions in general. The chemical, petroleum, or metal processing industries carry with them a number of occupational disease and injury risks, and a program of prevention of occupational cancer within them is likely to prevent much more frequent diseases, and possibly accidents as well (9).

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