

Relationship between work environment and anamnestic health status

Use of predictors, indicators and indices for the evaluation of medical and environmental factors

by PAUL HALL, M.D.,¹ GUNNAR AXELSSON, B.Sc.,² and JERRY SEBAG, B.A.³

HALL, P., AXELSSON, G. and SEBAG, J. Relationship between work environment and anamnestic health status: Use of predictors, indicators and indices for the evaluation of medical and environmental factors. *Scand. j. work environ. & health* 1 (1975) 233—242. Experience with computerized medical record systems in handling medical data in hospital and health screening environments has led to the development of a new approach to the evaluation of medical data. Predictors and indicators quantify the "information value" of medical data and can, theoretically, do so for all types of data. This paper describes the methodology and presents the results obtained when the technique was applied to the anamnestic data of the medical history and environmental data about the conditions in the work environment. Over 4,000 individuals who underwent multiphasic health screening were used as a data base for this study. From these 4,000 persons 3,164 were used for the calculation of anamnestic predictors and indicators and 1,013 for the environmental predictors and indicators. Anamnestic and environmental indices were calculated upon 77 test individuals so as to correlate the association and dependence of the two indices.

Key words: Predictors, indicators, anamnestic health index, environmental health index, self-administered questionnaires, information value.

In 1959 the American Industrial Hygiene Association adopted the following definition for industrial hygiene: "The science and art devoted to the recognition, evaluation, and control of those environmental

factors of stresses, arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among citizens of the community." The existence of a relationship between the work environment and the health status of an individual is thus recognized and has for many years been an accepted concept.

The present paper describes the use of a self-administered questionnaire for ascertaining the conditions present in the work environment of 1,013 employees of the Stockholm County and Community. The responses to this questionnaire were evaluated by predictors and indicators so

¹ Department of Medicine, Karolinska Hospital; Multiphasic Health Center; Sophiahemmet; Stockholm, Sweden.

² Multiphasic Health Center; Sophiahemmet; Stockholm, Sweden.

³ College of Physicians and Surgeons, Columbia University, New York, N.Y., U.S.A.

Reprint requests to: Dr. Paul Hall, Departments of Internal Medicine and Medical Information, Karolinska Sjukhuset, 104 01 Stockholm 60, Sweden.

that the risk of diagnoses and the likelihood of health posed by the conditions in the work environment could be determined. Predictors and indicators were summarized into an index intended to reflect the overall acceptability of the work environment for an individual — an ENVIRONMENTAL HEALTH INDEX (EHI). This index was correlated with an ANAMNESTIC HEALTH INDEX (AHI) derived from another self-administered questionnaire concerning the present symptoms and complaints of 3,164 individuals.

BACKGROUND

In 1928 the Industrial Fatigue Research Board in Great Britain was renamed as the Industrial Health Research Board. The word "health" was intended not only to mean the antonym of disease but also to include all that concerns a worker's fitness, productivity, and comfort within the sphere of his work (11). Recent trends in environmental medicine and occupational hygiene have strayed from this emphasis on health. An increasing number of articles appearing in the literature have confined themselves to rather restricted or limited, disease-oriented fields of research, e.g., the relationship of asbestos and rubber to carcinoma (1, 10), the relationship of dust and particles to respiratory disease (7). There is a need within environmental medicine and medicine in general to reorient towards health and preventive care. The need also arises for more efficient methods to evaluate the work environment vis-à-vis both health and disease.

A method for the evaluation of medical data from a clinical and symptomatology-oriented perspective has been described in theory (2). The use of this method to aid both health and disease-oriented decision-making on the basis of anamnestic data obtained by a self-administered questionnaire has been presented (8). The method has also been applied to paraclinical (laboratory) data (9).

The study described herein has applied the same approach to the evaluation of data concerning the conditions present in the work environment. A comparison and

correlation of the work environment and an individual's health status has been performed.

MATERIALS AND METHODS

Multiphasic health screening

Since 1971 the Stockholm County and Community have operated a Multiphasic Health Screening Center for their employees. The service is used by approximately 70,000 individuals and consists of various questionnaire examinations, laboratory tests, X-ray investigations, physical examinations, etc.

Work environment questionnaire

Since 1973 the Screening Center has undertaken the development of a questionnaire concerned with the conditions present in the work environment.⁴ The questionnaire consists of 78 questions which fall into the following two categories:

I. Corporeal⁵ work environment factors, e.g., "Do you often lift heavy objects?" "Do you often climb stairs?" "Do you spend most of your time seated?"

II. Physical⁶ work environment factors, e.g., "Is there much dust in your work environment?" "If so — What type?" "Is there much machine noise in your work environment?"

Twenty-eight questions are of the corporeal nature (category I), and 50 questions address themselves to the physical factors present in the work environment (category II).

Medical history questionnaire

During the past 12 years questionnaires used to obtain data about present symptoms and complaints have been designed and redesigned at the Seraphimer and the Karolinska hospitals. Some results of the

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⁵ Factors directly affecting the body.

⁶ Factors indirectly affecting the body.

use of these self-administered questionnaires have been presented by Mellner (5). An evaluation of the self-administered questionnaire using predictors and indicators has been presented in some detail in an earlier study (8).

Computer medical record library

Data acquired from the Multiphasic Health Screening Center is stored in a semi-problem-oriented computerized medical record format. Each problem is described in free text, and the corresponding diagnosis is coded according to the expanded Nordic version (5 digits) of the ICD 7. Questionnaire data is maintained by storing the code numbers for questions with affirmative responses. The J5 computer system operating on an IBM 360 model 40 at the Karolinska Hospital provided the storage and retrieval functions for all data (3, 4, 6).

Predictors and indicators

The use of predictors, indicators, and health indices for the evaluation of medical data has been previously described in detail (2, 8, 9). In brief, "yes" answers to questions such as "Do you experience chest pain when climbing stairs?" or "Is there much dust in your work environment?" are considered "positive responses" and "no" answers, "negative." Positive and negative responses are classified as true and false on the basis of the diagnostic outcome (table 1).

The numbers of true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN) are then used to calculate the predictor and indicator for a question. The predictors and indicators are defined in the following way:

$$\text{Predictor} = \frac{\text{TP}}{\text{TP} + \text{FP}} = \frac{\text{Only diagnosed symptomatic individuals}}{\text{All symptomatic individuals}}$$

$$\text{Indicator} = \frac{\text{TN}}{\text{TN} + \text{FN}} = \frac{\text{Only nondiagnosed asymptomatic individuals}}{\text{All asymptomatic individuals}}$$

Table 1. Classification of "yes" and "no" answers.

Answer	Diagnosed	Nondiagnosed
Positive + (Yes answers)	True positive	False positive
Negative - (No answers)	False negative	True negative

In this way the predictor reflects the risk of diagnosis(es) on the basis of a "yes" answer to a question of the type previously described, whereas the indicator reflects the likelihood of health [no diagnosis(es)] on the basis of a "no" answer. In effect, predictors and indicators are evaluations based upon a retrospective analysis of previous decisions about diagnoses and health. In the case of work environment questions, the predictor reflects the risk that a "yes" answer means the working condition in question poses a risk for diagnosis (thus presumably disease) to the individual, while the indicator reflects the likelihood that an individual will not receive a diagnosis on the basis of a "no" answer.

Health indices

A questionnaire health index is defined as

$$\text{HI} = \sum_{i=1}^n I_i \cdot V_{I_i} - \sum_{i=1}^n P_i \cdot V_{P_i}$$

where n = number of questions, I_i = indicator of i^{th} question, P_i = predictor of i^{th} question, and the value functions for the indicator and predictor variables are defined respectively as

$$V_{I_i} = \begin{cases} 1 & \text{for "yes" answer to } i^{\text{th}} \text{ question} \\ 0 & \text{for "no" answer to } i^{\text{th}} \text{ question} \end{cases}$$

$$V_{P_i} = \begin{cases} 1 & \text{for "no" answer to } i^{\text{th}} \text{ question} \\ 0 & \text{for "yes" answer to } i^{\text{th}} \text{ question} \end{cases}$$

In the case of the AHI $n = 122$, and in the case of the EHI $n = 78$.

Patient material: predictors and indicators

Anamnestic predictors and indicators. A total of 3,164 individuals (73 % with at least one diagnosis; 27 % with no diagnosis) were used as a data base for anamnestic predictor and indicator calculations. This material was used in an earlier study (8), and the same predictors and indicators have been used for this study. Information concerning the distribution of diagnoses in this population has been reported elsewhere (8).

Work environment predictors and in-

dicators. In all 1,013 individuals were used as a data base for calculating the environmental predictors and indicators. Of these, 629 (63 %) recieved at least one "certain" diagnosis, while 384 (37 %) recieved no diagnosis.

Health index material

Seventy-seven randomly selected individuals were used for the calculation and correlation of the anamnestic and environmental health indices.

Table 2. Questions relating to conditions in the work environment which pose high risks for diagnosis(es) or disease.

No	Question	Predictor value (≥ 0.75)
48	Have you at any time during the past 10 years been exposed to poisoning?	1.00
109	Is there a great risk of other ^a types of infection present in your work environment?	.82
121	Is there very weak lighting present in your work environment?	.78
73	Is there much street dust present in your work environment?	.77
83	Is there much explosive gas present in your work environment?	.77
71	Is there much granite particle dust present in your work environment?	.76
94	Is there much lubrication grease present in your work environment?	.76
25	Do the conditions in your work environment place any particular strain on your hands?	.75
93	Does your skin come in contact with plaster or mortar in your work environment?	.75
131	Is there much machine vibration present in your work environment?	.75

^aOther than hepatitis, tuberculosis, or colds.

Table 3. Questions relating to conditions in the work environment which pose low risks for diagnosis(es) or disease.

No	Question	Predictor value (< 0.55)
86	Are there any anesthetic gases present in your work environment?	.25
49	Have you had an accident as a result of violence from a patient?	.38
44	Have you had an accident as a result of handling manual hand tools?	.44
75	Is there much soot in your work environment?	.45
99	Does your skin come in contact with other ^a types of irritants?	.45
74	Is there much plastic particle dust in your work environment?	.46
123	Is there bright lighting in your work environment?	.46
96	Does your skin come in contact with fumes from organic fluids or the like?	.51
139	Are there other ^b types of vibration present in your work environment?	.53
82	Is there much fumes or steam from fluids in your work environment?	.53
30	Do you by and large sit while you work?	.53

^aOther than detergents, cement, limestone, grease, disinfectants, organic compounds.

^bOther than machine vibration.

Table 4. Questions relating to conditions in the work environment with high likelihood for health or no diagnosis(es).

No	Question	Indicator value (≥ 0.40)
10	Does your work require good physical condition?	.46
32	Do you by and large carry on physically active work?	.46
109	Is there a great risk for infectious contact of any other ^a type present in your work environment?	.43
20	Do you experience any especially strenuous activities in your work environment?	.41
21	Do the conditions in your work environment place any particular strain on your back?	.41
24	Do the conditions in your work environment place any particular strain on your arms?	.41
26	Do the conditions in your work environment place any particular strain on your legs?	.41
23	Do the conditions in your work environment place any particular strain on your shoulders?	.40
25	Do the conditions in your work environment place any particular strain on your hands?	.40
11	Do you often lift heavy objects?	.40
73	Is there much street dust in your work environment?	.40
90	Are there any irritants that come in contact with your skin present in your work environment?	.40
91	Does your skin come in contact with detergents?	.40

^aOther than hepatitis, tuberculosis, or cold infections.

RESULTS

Anamnestic questionnaire

The results of high and low predictors and indicators for the anamnestic questionnaire have been presented in an earlier paper (8).

Environmental questionnaire

Table 2 presents the questions in the work environment questionnaire that had predictors equal to 0.75 or greater. These questions concern the work conditions that in this population of 1,013 individuals posed the greatest risk. The factors found in this group of questions are acceptable in terms of the risks they might pose to the working individual. The use of this approach, however, quantifies the degree to which these factors pose a risk for diagnosis(es).

Table 3 presents those questions with predictors ≤ 0.55 . These questions concern the working conditions which pose the least risk. It must, however, be pointed

out that the low predictors for these questions may be the result of the type of population used in this study. It is conceivable, for example, that very few workers in this population encounter accidents as a result of patient violence or are street workers who would be exposed to soot.

The results in tables 2 and 3 point out some interesting aspects about the relative risks posed by conditions in the work environment. Very weak lighting, for example, poses a far greater risk for diagnosis (predictor = 0.78) than bright lighting (predictor = 0.46).

Table 4 presents those questions with the highest indicators (≥ 0.40). The absence of these work environment factors signifies a relatively strong likelihood of health. The absence of particular strains on the various parts of the body, no lifting of heavy objects, and no risk of infections or contact with skin irritants understandably bode well for health.

Table 5 presents the questions with the lowest indicator values (≤ 0.37). The absence of these factors does not signify a strong likelihood of health. This, how-

Table 5. Questions relating to conditions in the work environment with low likelihoods for health or no diagnosis(es).

No	Question	Indicator value (≤ 0.37)
30	Do you by and large sit while you work?	.35
75	Is there much soot present in your work environment?	.37
95	Does your skin come in contact with disinfectants?	.37
96	Does your skin come in contact with fumes from organic fluids or the like?	.37
99	Does your skin come in contact with other ^a types of irritants?	.37
101	Is there a great risk for infectious contact with hepatitis?	.37
114	Is there very dry air present in your work environment?	.37
115	Is there insufficient ventilation present in your work environment?	.37
123	Is there bright lighting present in your work environment?	.37
149	Is there any other ^b type of disturbing noise present in your work environment?	.37

^a Other than detergents, cement, limestone, grease, disinfectants, organic compounds.

^b Other than machine or traffic noise.

Table 6. Contingency table for environmental and anamnestic health indices.^a The figures in parentheses are the percentage of AHI groups (A, B or C). The figures in brackets are the percentage of the EHI classes (I, II or III).

Categories of AHI	Categories of EHI			Total I—III 30→ -49
	I 30—23	II 22—12	III 11→ -49	
A 34—27	12 (50) [46]	12 (50) [39]	00 (0) [0]	24 (100)
B 26—17	10 (32) [39]	13 (42) [42]	88 (26) [40]	31 (100)
C 16→ -100	4 (18) [15]	6 (27) [19]	12 (55) [60]	22 (100)
Total	26 [100]	31 [100]	20 [100]	77

^a The expected frequencies ($\hat{e}$) for the nine categories are: $\hat{e}_{AI} = 8.1$; $\hat{e}_{AII} = 9.66$; $\hat{e}_{AIII} = 6.23$; $\hat{e}_{BI} = 10.46$; $\hat{e}_{BII} = 12.48$; $\hat{e}_{BIII} = 8.05$; $\hat{e}_{CI} = 7.42$; $\hat{e}_{CII} = 8.85$; $\hat{e}_{CIII} = 5.71$. The sampling fraction ($\frac{n}{N}$) is equal to 0.05. The degrees of freedom = 4. The table value of $\chi^2_{0.01} = 13.277$. The test value for the table is $\chi^2 = 18.1$.

ever, may again be the result of the type of population used in the study. Soot, organic fluid fumes, and risk of hepatitis infection probably have a very low incidence in this population. On the other hand, the absence of disturbing noise, bright lighting, very dry air, and insufficient ventilation may legitimately not have great importance for the health of an individual.

Anamnestic and environmental health indices

The AHI for the questionnaire about present symptoms and complaints can attain a maximum value of +34.0 ("no" answers to all questions, i.e., no symptoms present and therefore the sum of all indicators) and a minimum value of -99.8 ("yes" answers to all questions, i.e., all

symptoms present and therefore minus the sum of all predictors).

The environmental questionnaire used could attain a maximum value of +30.0, the sum of all indicators, and a minimum of -48.8, the sum of all predictors.

The 77 individuals were divided into three groups on the basis of their AHIs and EHIs. The intervals used can be found in table 6.

The individuals in each AHI group, A, B, and C, were broken down according to the EHI class into which their environmental index fell (table 6). As can be seen, the 24 individuals in group A were all in EHI classes I and II, whereas, of the 22 individuals in AHI group C, less than 50 % were in the same classes.

Of the individuals with a poor anamnestic health status, i.e., many symptoms and complaints presented, more than half had an unacceptable work environment. Furthermore, of the individuals with a good anamnestic health status, i.e., few symptoms or complaints presented, no one had an unacceptable work environment.

The individuals in each EHI class, I, II, and III, were also broken down according to the AHI group that their anamnestic index fell into. Out of 26 individuals in EHI class I, 12 or 46 % were in AHI group A, 10 or 39 % were in group B, and only 4 or 15 % belonged to group C. On the other hand, of the 20 individuals in EHI class III, none were in group A, 8 or 40 % were in group B, and 12 or 60 % belonged to group C.

The degree of dependence between a good AHI and an acceptable work environment is thus very high; i.e., $\chi^2 = 18.1$; $p < 0.01$. The opposite is also true — a bad or unacceptable environment is dependent upon a poor AHI.

The overall picture is that in a randomly selected working population, 24 individuals or 31 % had a good AHI, 31 individuals or 40 % had an intermediary AHI, and 22 individuals or 29 % had a poor AHI. These same individuals felt that the environment was good or acceptable in 26 instances or 34 %, medium in 31 instances or 40 %, and bad or unacceptable in 20 instances or 26 %.

It is of interest to examine the relative representations of the ratios of individuals in a given AHI group (A, B or C) as they vary across the EHI range. Less than

half of the individuals with an acceptable work environment (EHI class I) had a good health status (AHI group A), fewer of the individuals with a moderately acceptable work environment (EHI class II) had a good health status, and no individuals with an unacceptable work environment (EHI class III) had a good health status. Individuals with an intermediary health status (AHI group B) had little differences with respect to the work environment. Less than one-fifth of the individuals with acceptable or moderately acceptable work environments (EHI class I and II, respectively) had a poor health status (AHI group C). However, more than half of the individuals with an unacceptable work environment (EHI class III) had a poor health status.

Similar findings exist for the relative representations of ratios (table 6) for a given EHI class (I, II, III) across all AHI intervals (A, B, or C). Half the individuals with a good health status (AHI group A) had an acceptable work environment (EHI group I), one-third of the individuals with an intermediate health status (AHI group B) had an acceptable work environment, and only one-fifth of those with a poor health status (AHI group C) had an acceptable work environment. Half of the individuals with a good health status (AHI group A) had a moderately acceptable work environment (EHI class II), less than half who had an intermediary health status (AHI group B) had a moderately acceptable work environment, and approximately one-fourth of the individuals with a poor health status (AHI group C) had a moderately acceptable work environment. No individuals with a good health status (AHI group A) had an unacceptable work environment (EHI class III), one-fourth of the individuals with an intermediary health status (AHI group B) had an unacceptable work environment, and more than half of the individuals with a poor health status (AHI group C) had an unacceptable work environment.

The EHI and AHI were used as the coordinates of a point for each individual, plotted onto a set of axes where the ordinate represented AHI, and the abscissa, the EHI. The linear least squares regression method was applied to the data from 77 randomly selected individuals (fig. 1). The square of the correlation coefficient

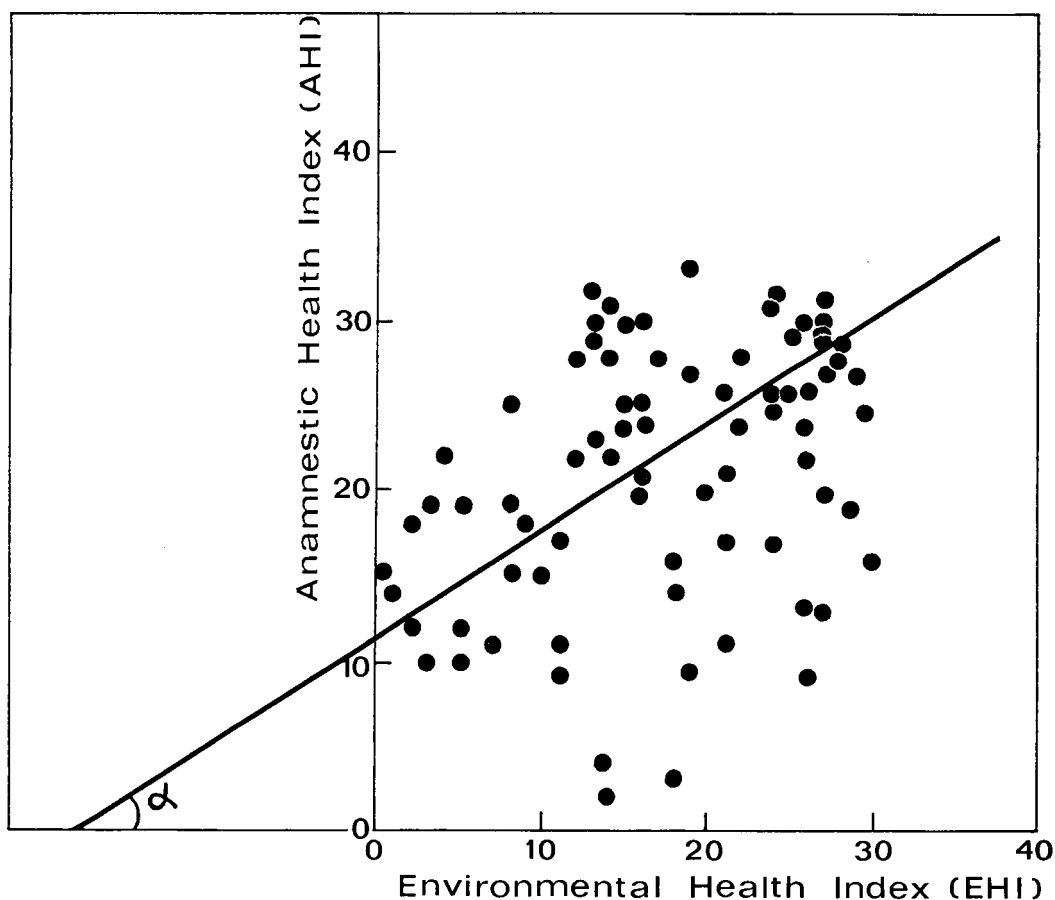


Fig. 1. Linear least squares correlation of AHI versus EHI. The graph shows the results of regression upon 72 individuals (five extreme values omitted). The results obtained when all 77 individuals are employed are: $\alpha = 22^\circ$; $a = 14.6$; $b = 0.4$; $r^2 = 0.19$.

between AHI and EHI for this group of individuals was 0.19 which agrees well with the values obtained for the $\chi^2/77 = 0.24$ in table 6.

DISCUSSION

During past decades there has arisen a need for effective methods of statistical analysis and evaluation in medicine. The addition of environmental factors to medical data increases the number of variables and introduces the need for more efficient methods. The approach presented herein is based upon a retrospective study of the symptomatology and the diagnostic outcome in a pilot study of multiphasic health screening. The method is not based upon the Gaussian concepts of "normality."

The two main groups of variables used in the study are the symptoms, signs, and tests as obtained by a self-administered questionnaire (122 questions) and the conditions in the work environment, obtained in the same way (78 questions). The study presented is an attempt to quantify the importance of each question and to correlate the health status and the work environment (via correlation coefficient calculations). The primary objective was to present a methodology for the previously mentioned evaluations of data and summations of their "information" value into indices.

The evaluative approach used provides a concrete, straight-forward method that can be used to establish the validity of known or accepted concepts. The approach can, furthermore, be used to investigate

the relative significance of various similar types of conditions present in the work environment. Consider, for example, the significance of various types of particle dust. Granite particles and street dust have relatively high predictors (0.76 and 0.77, respectively), i.e., risks for diagnoses. Paper particle dust has an intermediary risk (predictor = 0.64), whereas plastic particle dust and soot present the lowest risks for diagnoses (predictors = 0.46 and 0.44, respectively). Another example can be seen in the significance of lighting for the risks of diagnoses. Very weak lighting poses a relatively high risk for diagnoses (predictor = 0.78); weak lighting, an intermediary risk (predictor = 0.64); and bright lighting, a very low risk (predictor = 0.46).

The approach used in the study can also evaluate how work conditions affect certain parts of the body and what roles they play vis-à-vis both health and disease. For example, strains placed on the hands pose a relatively high risk for diagnoses (predictor = 0.75), while the absence of this condition yields a relatively high likelihood for health (indicator = 0.40). Stresses placed on arms and legs likewise pose a relatively high risk for disease (predictor = 0.73), whereas the absence of such stresses has a high likelihood for health (indicator = 0.41).

In the past dangerous working conditions were detected primarily by medical and hospital sources. The alarm signals for possible causal relationships between a certain diagnosis and the work environment came from physicians, e.g., high incidence of silicosis of the lung in certain dusty mining industries, high incidences of cancer in the rubber industries, the high incidence of eczema in construction industries, the high incidence of respiratory disease in coal mining industries. It has been the case that in most instances there was one toxic substance, e.g., lead, and one or a few diagnoses or syndromes involved. In many instances the detection of risk groups and diagnoses have come very late in the natural history of that specific disease. It should naturally be of interest to governments, industries, and public health administrators to detect dangerous work conditions as early as possible — ideally prior to the event

when general medical personnel, the sick care system, sound the alarm.

The use of indices such as the Anamnestic Health Index (AHI) and the Environmental Health Index (EHI) will aid the evaluation of the regression or progression of the work environment vis-à-vis health. The results obtained in this study show a good correlation between the AHI and the EHI. The same method can be used for a few variables related to specific syndromes or diagnoses, and not only for the decision-making problem: "health/no-health" or "no-diagnosis/diagnosis." An index, however, does allow hundreds of data to be summarized into one number — a straightforward information synthesis. Most importantly, however, indices enable a comparison of one individual or a group of people from time to time. Dynamic indices may be used to monitor changes in the status of an individual or a group over a period of time (8). Thus an individual or group known to be exposed to certain risks can be followed with cumulative and dynamic indices. This type of approach may give early warning signals that provide a sound basis for preventive medical care.

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