CORNELL MEDICAL INDEX RESPONSE AS A PREDICTOR OF MORTALITY*

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The medical significance of self-reported symptoms and self-perception of health status has been incompletely studied to date. In most survey studies, self-reported symptoms of medical status are treated as surrogates for the more objective evidence of medical diagnosis or illness behaviour recorded in the files of physicians' offices, hospitals, and insurance programmes.

Interview or questionnaire response as a measure of health or medical status has usually been validated by tests of agreement with physicians' evaluations of the same subjects at a point in time. The self-reporting of symptoms has been used and tested as a screening-type index of the medical diagnoses which would have been obtained, given the more expensive and definitive set of procedures of professional history, physical examination, and laboratory tests. In survey circumstances, symptoms have been found to be of poor validity as surrogate measures of disease.

It is possible, however, that self-perception and self-reporting of symptoms in general populations, particularly in individuals who have not adopted the sick role, may tap a dimension not readily ascertained by the more objective measurements of physical examinations and laboratory tests or physicians' evaluations of health status. Validation requires a different set of criteria in these circumstances. We report here a study of a population of men healthy enough to be working, and present the relationship between their responses to the Cornell Medical Index (CMI), a standardized medical questionnaire, and subsequent mortality.

METHODS

The employees of a paper manufacturing plant, described in detail elsewhere (Cassel and Tyroler, 1961), comprised the population studied. Individuals well enough to be actively employed were offered voluntary, periodic comprehensive examinations

performed in a self-contained mobile van at the plant site during working hours (Occupational Health on Wheels, 1955). The participation rate was 93% of those employed during the three-month period of examinations ending in September 1959. Non-supervisory and non-executive white men aged 35-69, almost all of whom were hourly paid, were selected for this study. A total of 1,224 subjects satisfied these criteria and constitute the cohort for follow-up. A medical history was taken and physical examination was performed by two collaborating, board-qualified internists, each experienced in occupational health and periodic examinations. Approximately half the examinations were done by one of us (H.A.T.) and the medical records of all examinees were reviewed and evaluated by him. Radiographs, electrocardiograms, detailed laboratory tests, and medical diagnostic evaluations were performed, the results of which will be reported elsewhere. For the purposes of this study attention is restricted to the relatively standardized and reproducible coronary heart disease risk factor measurements of blood pressure, serum cholesterol, and weight/height indices, as coronary heart disease is the leading cause of death in middle-aged white men.

Examinees were seen in the mobile examination van during their regular working hours, or immediately before starting or completing their shift of work. This was done at the convenience of the plant work crews, and no attempt was made to standardize or randomize the time of day for examinations. Blood pressure was measured by each of the internists immediately before he conducted his interview with the subject in the sitting position, and was then repeated approximately 30 minutes later in the recumbent position during the physical examination. The lower of the two blood pressure values was used for the purposes of this study. Serum cholesterol determinations were performed on blood, drawn at the completion of examination, by the method of Abell, Levy, Brodie, and Kendall (1952). The technical error of measurement was 5.5 mg/100 ml. Weight was measured to the

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nearest pound, height to the nearest inch, and the Quetelet index ($wt/ht^2 \times 100$) derived for analysis. The CMI was self-recorded by each employee before the other examination and interview procedures were begun. This health questionnaire, originally designed to aid clinicians in identifying patients' health problems, contains 195 questions which are all answered yes or no by the respondent. It deals with both somatic symptoms and mood and behaviour patterns. The total CMI score, i.e., the number of positive responses to all of the 195 questions of this instrument, is used in this study as a risk factor predictor of mortality.

The status of each subject as of September 1970 was investigated for an 11-year follow-up period. We identified, with the assistance of the personnel department of the company, all members of the original cohort still actively employed, all separated from employment but known to be alive to the company through such mechanisms as receipt of benefits, all known to have died, and those of currently unknown status. A search of the death records in the Office of Vital Statistics, North Carolina State Board of Health was carried out for all not currently employed by, or not receiving benefits from, the paper company. The status of all but 63 of the original cohort of 1,224 men was ascertained as alive or dead. A comparison of the mean values of the study variables of the group of unknown status with the total cohort revealed no consistent nor significant differences. The 63 persons of unknown present status were considered to be alive for the purposes of this study.

Death rates for the 11-year follow-up period were calculated, classifying individuals by their CMI levels, age-adjusted by the Ordac method (Priore, 1964), and controlling for the levels of the coronary heart disease risk factors of blood pressure, serum cholesterol, and Quetelet index.

RESULTS

The 1970 status of the 1959 examination cohort is set out in Table I. Of the 1,224 employees, 730 (59.6%) were alive and still employed at the paper

TABLE I
1970 STATUS OF THE EXAMINATION COHORT

Status	No.	%
Alive and working at the paper company	730	59.64
Not working at the paper company, known to be alive	313	25.57
Status unknown	63	5.15
Dead	118	9.64
	1,224	100.00

manufacturing company, 313 (25.6%) were identified by company personnel as separated from employment but known to them as alive and receiving retirement or disability benefits, 63 (5.2%) were of unknown status (and there was no matching death certificate in the files of the North Carolina Office of Vital Statistics), and 118 (9.6%) were ascertained as dead with matching death certificates. An estimate of the completeness of ascertainment of deaths is obtained by calculating the expected number, applying the North Carolina white male, age-specific mortality rates for the study period to the employee population at risk in the study. By this method 132 deaths would be expected; 118 or 89% were actually observed. This figure is not too low for a working population such as ours which excludes those institutionalized and work disabled. In addition, our previous work (Tyroler and Cassel, 1964) has shown that the mortality experiences of residents of western North Carolina, where this paper manufacturing plant is located, is lower than that of the state of North Carolina, and therefore the observed number of deaths appears to indicate relatively complete ascertainment.

The CMI responses for all examined employees were ordinarily ranked within five-year age bands, and individuals were classified by whether their responses placed them in the first, second, or third tertiles, henceforth referred to as low, mid or high values, respectively. The CMI responses rose with age; the cut point for the first tertile was five in the youngest and nine in the oldest age group; the cut point for the third tertile was 12 positive CMI responses in the youngest and 19 in the older age groups. These values are within the range of normal customarily expected for the CMI.

Mortality rates for examinees classified by the level of CMI responses are displayed in Table II. The mortality rate for the employees aged 35-69 at examination was 96 per 1,000 for the 11-year follow-up period. Combining all the five-year age bands, the Ordac age-adjusted overall death rate

TABLE II
NUMBER OF SUBJECTS AND DEATH RATES
BY CMI LEVELS
(Rate Ordac age adjusted per 1,000 examinees/11 years)

	CMI Levels			
	Low	Mid	High	All
Age 35-69 at 1959 examination				
No. of decedents	29	41	48	118
No. of examinees	403	416	405	1,224
Death rate	72	99	119	96
Relative risk	1.00	1.38	1.65	

rose from 72 to 99 to 119 per 1,000 for the men with CMI responses ranging from the lowest to the highest third for their age group. The risk of death was 65% higher for men with high than for those with low CMI responses.

There was little association of the CMI with subsequent mortality for men aged 55-69 at intake, and for that reason the Ordac age-adjusted rates were also computed for the men aged 35-54 years at intake. Death rates rose from 43 to 55 to 99 per 1,000 for the younger group, with a resultant risk of death more than two times higher in men with high than in those with low CMI responses, i.e., a relative risk of 2.2.

There is the possibility that the increased mortality rate observed with increasing levels of CMI responses might merely reflect a secondary association of the CMI with other risk factors which predispose to increased mortality. To test this possibility, the examined population was classified by levels of systolic and diastolic blood pressure, serum cholesterol, and Quetelet weight index, and the effect of CMI levels on mortality was analysed, controlling for the risk factor levels. The data of Table III show a step-wise increment in mortality rates with increasing levels of both systolic and diastolic blood pressure. There is a gradient of increasing mortality with increasing CMI values at each level of blood pressure. The effect of increasing CMI values is more pronounced at low than at high blood pressure levels; for example, at low diastolic blood pressure levels the mortality rate

rises from 38 to 63 to 85 per 1,000 with increases of CMI, a relative risk of more than 2:1, while at high levels of diastolic pressure the mortality rate rise is from 115 to 132 to 168 per 1,000, a relative risk of 1.5:1. Similar findings are present for increases of mortality with increasing CMI values at each systolic blood pressure level.

For both the lean and the heavy individuals, as measured by the Quetelet index, increasing CMI scores were associated with increasing mortality rates.

Although there is little evidence of an independent effect of serum cholesterol on mortality rates from all causes in this study population, the CMI effect of a step-wise increase of mortality persists at each level of serum cholesterol, and the possibility remains that there is an interactive effect with blood pressure, a possibility to be tested later by use of a multivariate analysis.

We tested to see if there is any association between each of the risk factors and the CMI responses large enough to lead to systematically higher risk factor levels in the higher CMI response categories; none was found. CMI responses were generally independent of risk factor levels in five-year age-specific analyses.

In order to test the over-all differences among the mortality rates at the three CMI levels, a χ^2 test of homogeneity was performed and revealed significance with $0.05 < P < 0.10$. The differences among the mortality rates for low, mid, and high CMI scores within each subcategory of the four biological risk factors do not reach a significance level of $P = 0.05$ with the regular χ^2 test. This may be partially a result of the small sample size. However, the consistent increase in age-adjusted mortality rates from low to high CMI levels at each level of the biological risk factors points to an association of increasing CMI responses with mortality from all causes, independent of the standard coronary heart disease risk factors. In fact, there is an impressive additive effect; individuals with values in the highest third of both systolic blood pressure and CMI responses had a mortality rate of 156/1,000 contrasted with 53/1,000 for those individuals with low values of systolic blood pressure and CMI—a relative risk of 3:1, given the joint presence of these attributes. Comparable mortality figures for the joint effect of high diastolic blood pressure and CMI responses contrasted with low diastolic blood pressure and CMI responses are 168/1,000 and 38/1,000, a relative risk of 4:1.

The risk factors of blood pressure, cholesterol, and overweight are known to exert an interactive

TABLE III

DEATH RATES FOR EXAMINEES CROSS-CLASSIFIED BY CMI AND RISK FACTOR LEVELS, AGES 35-69 AT EXAMINATION

(Rates Ordac age adjusted, per 1,000 examinees/11 years)

CMI	Systolic Blood Pressure			Diastolic Blood Pressure			All Risk Factor Levels
	Low	Mid	High	Low	Mid	High	
Low ..	53	49	118	38	67	115	72
Mid ..	51	95	149	63	100	132	99
High ..	94	100	156	85	96	168	119
All Levels	65	80	142	60	88	140	96
CMI	Cholesterol			Quetelet Index			All Risk Factor Levels
	Low	Mid	High	Low	Mid	High	
Low	83	72	61	94	47	78	72
Mid ..	85	118	89	78	110	105	99
High ..	90	153	120	128	43	170	119
All Levels	86	113	90	101	68	120	96

effect on coronary heart disease. Therefore, individuals were classified by the number of elevations of these risk factors each had at examination in 1959, to determine if a high CMI response was associated with increased mortality at all such levels. Due to the large number of combinations it was not possible to preserve the three-level tertile analysis of risk factors. For the multivariate analyses, the mortality of individuals with values in the upper third of the risk factor distribution was contrasted with the combined grouping of those in the lower two-thirds. As there is an increase of mortality from the lowest to the mid third level of risk factors, the combining of the two lower groups makes the test more conservative; it is more difficult to demonstrate a difference comparing rates for individuals with risk factors in the highest third with all others.

The classification, nevertheless, of employees by the number of upper tertile elevations of the risk factors of systolic blood pressure, diastolic blood pressure, serum cholesterol, and Quetelet index present resulted in an orderly, sizeable increase in the risk of death in the next 11 years (Table IV and Figure). The Ordac age-adjusted death rates changed from 78 to 69, 106, 147 to 193/1,000 as the number of elevated risk factors rose from none present to all four present, for men aged 35-69 years at intake.

FIGURE—Mortality rates (Ordac age adjusted) at various numbers of elevated risk factors with and without high CMI scores—white males, aged 35-69, per 1,000/11 years.

In addition to this clear influence of the biological risk factors, there was a higher mortality rate for individuals with elevated CMI responses at each level of biological risk factors. The relative risk of an elevated CMI was 1.41 for the entire cohort and ranged from 1.05 to 1.72 for cohorts with different numbers of biological risk factors present; there was no evidence of any systematic effect of the number of risk factors present on the incremental effect of an elevated CMI response.

TABLE IV
MORTALITY RATES BY NUMBER OF RISK FACTORS PRESENT AND CMI LEVELS, AGES 35-69
(Rates Ordac age adjusted, per 1,000 examinees/11 years)

No. of Risk Factors Present	Numbers of Examinees					
	All CMI Levels		Negative CMI (lowest 2 tertiles)		Positive CMI (highest tertile)	
	PAR	No. of Deaths	PAR	No. of Deaths	PAR	No. of Deaths
0	386	30	265	19	121	11
1	346	24	232	13	114	11
2	265	28	173	18	92	10
3	170	25	111	14	59	11
4	57	11	33	5	24	6
	1,224	118	814	69	410	49

No. of Risk Factors Present	Death Rates			
	All CMI Levels (Col. 1)	Negative CMI (Col. 2)	Positive CMI (Col. 3)	Relative Risk (Col. 4 = Col. 3/Col. 2)
0	78	72	91	1.26
1	69	56	96	1.72
2	106	104	109	1.05
3	147	126	186	1.48
4	193	152	250	1.65
All levels of risk factors	96	85	120	1.41

The Wilcoxon Signed Rank test indicates that the differences in age-adjusted mortality rates for those with high CMI responses are significantly higher than for those with medium and low CMI responses at the $P = 0.05$ level of significance.

DISCUSSION

In this study the responses to the CMI were found to be predictive of mortality in men healthy enough to be actively employed in a paper manufacturing plant. The CMI, although developed originally as an adjunct to clinical evaluation of patients seen in medical practice (Brodman, Erdmann, Lorge, and Wolff, 1949), has been extensively tested by Abramson and others for its utility in population based studies of an epidemiological nature (Abramson, Terespolsky, Brook, and Kark, 1965; Abramson, 1966). As a result of his studies, Abramson has concluded that the CMI is of fair validity as an indicator of the presence and degree of general emotional disability and general health status. It is in this sense rather than as a clinical diagnostic adjunct that it has been analysed here. The predictive CMI values for these working men are not in the range customarily found to be associated with major illness; rather the analyses have disclosed a continuous relationship of increasing response scores and mortality within the range of values usually reported as normal. The predictive validity of increasing CMI responses is clearcut; however, the results are open to several possible interpretations. The CMI is a complex medical questionnaire tapping multiple dimensions. The 195 questions refer to: a cumulative, lifetime past history of both symptoms and diseases (e.g., have you ever coughed up blood? has a doctor ever said you had kidney or bladder disease?); a family history of disease (e.g., does heart trouble run in your family?); a present history of symptoms (e.g., is your skin very sensitive or tender?); a present sensory organ functioning (e.g., do you need glasses to read?); disorders of mood, feeling, and affect (e.g., do you usually feel unhappy and depressed?); behaviour (e.g., does your work fall to pieces when the boss or a superior is watching you?); and habits (e.g., do you smoke more than 20 cigarettes a day?). It is obvious that positive answers to these questions can reflect abnormalities including familial and genetic disease; acquired chronic, organic, categorical disease; multisystem psychosomatic disease; neuroticism; and the sequelae of trauma. High responder groups may also include non-ill individuals with a tendency towards acquiescence, i.e., those with a positive response set to questionnaires. Individuals with higher scores than their peers, in this study, may represent any one or a

combination of these entities. Feinstein (1968) has proposed a prognostic classification which, in addition to anatomical and laboratory findings, uses symptoms to grade the biological severity of disease. One possibility is that the CMI in this study has acted as a prognostic indicator by detecting individuals with subclinical target organ damage.

Although we have not ruled out alternative explanations, our working hypothesis is that individuals identified and grouped by high CMI responses shared in a generalized response of maladaptation across multiple physiological and psychological mechanisms. Their high CMI scores tapped a process, encompassing both physiological functioning and experienced, perceived, recognized, and communicated emotional symptoms, which, acting additively with the biological risk factors, increased either the likelihood of clinical emergence of disease or increased the likelihood of death once disease was clinically manifest. Either of these processes, increased incidence or increased case fatality rates, or both, would result in increased mortality rates. To choose among these alternatives will require more detailed analyses of the organ system scores of the CMI, use of the medical diagnostic information, and follow-up studies of examinees.

SUMMARY

A prospective survey of the relationship between self-perception of health, as measured by the CMI, and the mortality experience of a cohort of white male hourly-paid employees of a paper manufacturing plant over an 11-year period is reported. Death rates for the period from 1959 to 1970 were calculated, classifying persons by their CMI levels, age-adjusted by the Ordac method. There was a consistent rise in death rates with increasing CMI responses, particularly for men aged 35 to 54 years at intake.

To separate the effect of the CMI from other major risk factors, mortality rates were calculated for the population, cross-classified by CMI scores and levels of systolic and diastolic blood pressure, serum cholesterol, and Quetelet index. The effect of the CMI of a step-wise increment of mortality persisted at every level of the four coronary heart disease risk factors.

To judge the interactive effect of the coronary heart disease risk factors, and its relation to CMI levels, individuals were classified by the number of elevations of these risk factors each had at examination in 1959. In addition to a consistent increase in death rate as the number of elevated risk factors rose, there was an added risk of mortality for those

individuals with elevated CMI responses for each combination of biological risk factors.

Within the population strong evidence of the predictive power of the CMI in relation to mortality has been provided.

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