An Evaluation of the Health Hazard Appraisal Based on Survey Data From a Randomly Selected Population

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THE HEALTH HAZARD APPRAISAL (HHA) is a counseling tool used to inform people about how their health habits and lifestyles affect their probability of dying within 10 years from potentially preventable causes (*1,2*). It personalizes mortality and risk factor data by combining them with a person's risk factors. Knowing how much their high risk factors increase the probability of premature death is expected to help motivate people to reduce them.

A person's HHA is based on risk factor values and mortality statistics for people of the same age, sex, and race. For every major cause of death, special mortality tables for each combination of age (expressed in 5-year intervals), sex, and race (white or black) indicate the principal risk factors and the average probability of dying within 10 years (*1*). The HHA quantitatively adjusts each of these average probabilities for the effects of a person's risk factors, which include health behaviors, physiological measures, and personal and family health histories. For someone with high blood pressure who smokes, for example, the HHA calculation may show that the person has 3.2 times the average probability for his or her age, sex, and race of dying within 10 years of heart disease. If that person does not drink alcohol and always wears seatbelts, he or she may have 0.6 times the average probability of dying in a motor vehicle accident within 10 years, and so on. The HHA-adjusted probabilities are summed over all causes of death to equal the current probability of the person's dying within 10 years. Achievable probability is calculated similarly, but the risk factor values used are those that could be achieved if the person's modifiable, high risk factors were reduced. The achievable probability adjusts for the effects of changes in health behaviors—for example, quitting smoking or wearing seatbelts—and changes in physiological measures, such as lowering blood pressure. Of course, no reduction is possible for risk factors of personal or family history of disease. In counseling, the current and achievable probabilities can be contrasted to show how much a person's current probability of dying within 10 years could be decreased if his or her high risk factors were reduced. Thus, the HHA (*a*) identifies a person's most likely causes of death within 10 years, (*b*) lists the risk factors affecting these causes, and (*c*) provides a means for calculating the effects of reducing high risk factors.

Because of the HHA's appeal as a counseling tool, it has become a part of many preventive health care programs in the United States and Canada, despite a lack of evidence of its effectiveness in motivating changes in health habits and in reducing premature deaths (*3*). To make policy decisions about using the HHA, the Special Projects Division of the Milwaukee Health Department initiated a survey to identify the population most likely to benefit from health-risk analysis and counseling. Using a shortened version of the HHA questionnaire, interviewers surveyed a random sample of Milwaukee residents by telephone. (Telephone surveys have been shown to produce results that are as accurate as face-to-face interviews (*4*).) Since about 4 percent of

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the occupied households in Milwaukee do not have telephones, relatively few residents were excluded (*5*).

Study Methods

Respondents were asked about their health risk factors—such as smoking, alcohol use, signs of cancer, and wearing seatbelts—that are used to compute a person's HHA. Data on age, sex, race, educational attainment, family income, and residential area also were obtained. Of the 79 health-related questions, 54 were health-risk questions adapted from the HHA for use in a telephone survey; the other 25 dealt mainly with nutritional and environmental health factors, which are not part of the HHA. Each respondent was assigned an average value for blood pressure based on Midwest norms (*6*) and an average value for cholesterol based on national norms (*7*), according to age, sex, and race. The interview took about 15 minutes, and all interviews were conducted during December 1978 and January 1979. The interviewers—seven female public health nurses or educators—completed five supervised practice telephone interviews with strangers. Thereafter, I monitored the interviewers periodically to ensure that they asked the questions uniformly.

A total of 268 persons were interviewed; this number allowed for a maximum sampling tolerance of 6 percent (*8*). Interviewers called telephone numbers composed of a three-digit exchange plus a computer-generated, random four-digit suffix. The number of calls for each telephone exchange was proportional to the number of city of Milwaukee households with that exchange, as determined by a random sample of residential telephone numbers from the municipal directory (*9*). This method yielded a random sample of households, which included households with unlisted and unpublished numbers.

The interviewers, who identified themselves as representatives of the Milwaukee Health Department, initially asked each respondent whether they had called a residential number in the city of Milwaukee. After obtaining the approximate address, the interviewer determined the number of men and women in the household and, by using prepared random tables (*10*), selected one respondent. This procedure was designed to provide a sample having the correct proportion of male and female adults in all age groups. Each nonresidential telephone number, number not in the city of Milwaukee, unanswered number, or refusal was replaced by another number having the same three-digit exchange. Before an unanswered number was replaced, the interviewers called it at least 12 times, on 5 different days, at various times of the day and evening and on weekends. Respondents who initially refused to be interviewed were called at a later date and were replaced after a second refusal.

A computerized version of the HHA (*11*) calculated each respondent's current and achievable probabilities of dying within 10 years and the percentage of reducible risk, that is, $[(\text{current} - \text{achievable}) \div \text{current}] \times 100$. This quantity represents the percentage reduction in the current probability of dying within 10 years for someone who accomplishes all his or her achievable changes. Since the achievable probability is always less than or equal to the current probability, the percentage of reducible risk can range between 0 and 100. Persons or groups can be compared to determine which ones have the greatest percentage of reducible risk in their current probabilities. The larger the percentage value, the greater would be the potential benefit of risk analysis and counseling.

Results

Sample characteristics. Of the 1,005 telephone numbers called by the interviewers, 668 were numbers for businesses or for telephones not in service or not in the city. Of the remaining 337, no answer was obtained at 28 after at least 12 attempts, the randomly selected household member was not available at 6, and the respondent refused to participate at 35. Interviews were completed with 268 respondents (80 percent) out of the net sample of 337 households. A comparison with data from Milwaukee's 1975 special census (*12*) demonstrated that the sample accurately represented the adult population for all six sociodemographic predictors shown in the table.

Citywide results. The results were within the 6 percent sampling tolerance limits when compared with results from larger national or regional surveys. For example, 39 percent of the sample reported smoking cigarettes compared with 33 percent in national samples (*13*), and 69 percent reported consuming alcoholic beverages compared with 72 percent of midwesterners (*14*). The percentages on these and other questions were similar to those obtained in a 1978 health survey of Milwaukee residents conducted by Consumer Health Consultants, a private agency (*15*).

The mean current probability of dying within 10 years for a Milwaukee resident was 2.24 percent greater than the average probability for a person of the same age, sex, and race nationally. This amount

Percentage of reducible risk for the six sociodemographic predictors found in the Health Hazard Appraisal survey of Milwaukee residents, December 1978–January 1979

Predictors	Number of respondents (N = 268)	Reducible risk (percent)[1]
Age		
18–24	41	9.85
25–39	89	11.61
40–59	63	30.84
60 and over	75	32.03
Sex		
Men	107	25.68
Women	161	18.84
Race		
Blacks	42	19.98
Whites	214	22.13
Others	12	17.25
Education (years)		
0–8	46	29.87
9–11	46	23.17
12	86	20.94
13–15	54	19.37
16 and over	36	13.75
Income[2]		
$0–$5,000	43	26.00
5,001– 7,000	35	25.83
7,001–10,000	42	26.50
10,001–15,000	45	18.29
15,001–20,000	46	18.02
20,000 and over	42	16.86
Location[3]		
Inner north	56	17.68
Inner south	35	23.63
Noninner-city	173	22.14

[1] Total reducible risk 21.57.
[2] 15 respondents refused to answer.
[3] 4 respondents refused to answer.

does not differ significantly from 0 percent ($P>0.1$). Hence, Milwaukee residents had an average probability of dying within 10 years. This finding provides some validation of both the values in the HHA and the representativeness of the sample, since a representative sample should not differ significantly in risk from the average.

The mean percentage of reducible risk was 21.57 percent, which defines the maximum potential of a risk reduction program. Theoretically, 216 (±19, based on 95 percent confidence intervals) of every 1,000 deaths in the next 10 years among Milwaukee's adult residents could be postponed if all these residents were to reduce all their modifiable health risk factors (see table).

Sociodemographic predictors of the percentage of reducible risk by age, sex, race, education, income, and location of residence follow.

Age. Age was positively correlated with the percentage of reducible risk ($r=0.61$, $P<0.001$). The mean percentage for the four age ranges were 9.85 (under 25 years), 11.61 (25–39), 30.84 (40–59), and 32.03 (60 and older). Stated briefly, persons under 40 years old might reduce their current probability of dying within 10 years by about 10 percent, whereas persons 40 years and older might reduce their current probability of dying within 10 years by more than 30 percent.

Persons in different age groups varied significantly in the HHA. Generally, being older was positively correlated with being heavier than ideal weight, not getting sufficient exercise, and having high blood pressure or heart trouble. Age was negatively related to some risk-increasing behaviors. People under 40 drove more miles per year; people under 60 smoked more tobacco and were more likely to drink alcohol.

Reducible risk was much greater in persons over 39 because all their high risk factors predicted the same cause of death—arteriosclerotic heart disease. The probability of dying of a particular cause goes up substantially when multiple high risk factors are present. Conversely, reducible risk is substantial when the multiple high risk factors are lowered. Because persons under 40 generally do not have multiple high risk factors for a single cause of death, they have neither the resulting substantial increase in their current probability of dying within 10 years nor the potential for substantial risk reduction.

Sex differences. The results indicated that men could reduce their current probability of dying within 10 years by 25.68 percent, which was significantly greater than the 18.84 percent by which women could reduce theirs ($P<0.001$). Men were more likely to report smoking cigarettes, drinking alcohol, and driving more than 10,000 miles a year. Women were more likely to report feeling depressed often or much of the time, being overweight in terms of the percentage that they were above an ideal weight relative to height, and not exercising—that is, not walking 2 miles or climbing 5 flights of steps weekly (the HHA criterion for minimal exercise). According to the assigned norms for blood pressure and cholesterol, men had significantly higher values of systolic and diastolic blood pressure, but women had nonsignificantly higher values for cholesterol.

Race. Blacks, whites, and other racial groups did not differ significantly in the percentage of reducible risk ($P>0.25$). There were almost no significant differences between responses from black and white interviewees to the questions in the HHA, although this

result may have been a function of the small number of black respondents.

Education. Education was negatively correlated with the percentage of reducible risk ($r = -0.29$, $P < 0.001$). However, since older people had completed fewer years of school, this negative correlation is more correctly attributable to age than to education. After the effects of age were partialed out, education by itself was just significantly correlated with the percentage of reducible risk (partial $r = -0.13$, $P = 0.05$).

Income. Annual income was negatively correlated with the percentage of reducible risk ($r = -0.24$, $P < 0.001$). After age was partialed out, however, income alone was not significantly correlated with the percentage of reducible risk (partial $r = -0.09$, $P > 0.05$). Income tends to increase gradually with age until it levels off at some point and then drops markedly after age 59. Because of this curvilinear component, this partial correlation should be regarded cautiously.

Location of residence. The respondent's address was coded as being in the inner-city north area of Milwaukee (a Housing and Urban Development-defined low income area with a majority of black residents), the inner-city south (a Housing and Urban Development-defined low to middle income area with white and Hispanic residents), or noninner-city areas. The percentage of reducible risk did not differ significantly among respondents living in these three areas ($P > 0.1$).

Risk factor intercorrelations. Pair-wise correlations were computed by use of measures of smoking cigarettes, drinking alcohol, wearing seatbelts, exercising, and being overweight. Of the 10 possible pair-wise correlations, the only significant correlations were between the number of cigarettes smoked daily and the amount of alcohol consumed weekly ($r = 0.29$, $P < 0.001$) and between exercise and wearing seatbelts ($r = 0.15$, $P < 0.05$). Because as in other studies (*16*) measures of various risk behaviors were only weakly correlated, doubts arise about whether these unhealthful behaviors actually represent coherent lifestyles.

Discussion and Conclusions

Accuracy of the survey. One limit on the accuracy of this survey is the small sample size. However, there were relatively few refusals, the sample was representative of the adult population of Milwaukee, and results for specific questions were comparable to larger national surveys. The results of an additional sample of 198 inner-city Milwaukee residents surveyed by the Special Projects Division in May 1979 were similar to those reported here for the inner-city residents and for the city as a whole.

A more important limitation is that average, rather than actual, values of blood pressure and cholesterol were used to calculate the respondent's HHA. Using different assumptions and equations, Kleinman (*17*) estimated the potential reduction in coronary heart disease mortality from stopping smoking and lowering diastolic blood pressure and cholesterol by 15 percent for black and for white men aged 40–54. He reported that 80 percent of the overall potential reduction in mortality was attributable to that half of his population who had high levels for two or three of these risk factors. Since people frequently have multiple cardiovascular risk factors that are highly elevated (*18*), the survey mean of 22 percent reducible risk (based on respondents given average values for blood pressure and cholesterol) most likely underestimates the true percentage of reducible risk.

Accuracy of the HHA. The HHA's apparent precision in estimating current and achievable probabilities is deceiving since the estimates are based on data and assumptions that may be inaccurate (*2*). The HHA's accuracy depends upon three sources of data—death certificate data for establishing the average probability of each cause of death for every combination of age, sex, and race; epidemiologic data and clinical estimates for assigning values to risk factors affecting the causes of death; and respondents' self-reports of risk factors. The biases involved in using death certificate data have been well documented (*19*), and the inability or unwillingness of respondents to report accurately on their risk factors is a problem for health research in general, not just for the HHA. The values assigned by the HHA to certain risk factors may be questioned for individuals and for groups. Applying risk factor values to individual cases may be misleading (*20*), since they are valid predictors of mortality only when averaged across many individuals. Applying risk factor values to groups not involved in the original epidemiologic research may also be misleading, since these values are likely to underestimate risk in poorer, less educated, and more geographically mobile populations that receive fewer medical and social services (*21*).

The estimates of the achievable probability and the percentage of reducible risk are even less precise than estimates of the current probability. The calculation of the achievable probability assumes that

most risk factor modifications will produce the maximum reduction in the current probability of dying within 10 years. However, whether and how risk factor modification actually leads to reduced mortality is unknown for many risk factors (*22*), and the further assumption that modifications generally lead to maximum reduction is reasonable only for some changes, like wearing seatbelts. It may be unreasonable, for example, to assume that people who begin to exercise vigorously after years of sedentary living can achieve the same low risk factor value for exercise as persons who have exercised regularly all their lives. For nonbehavioral risk factors, such as serum cholesterol level, it is necessary to show both that a behavior change, such as changing one's diet, affects cholesterol and that the resulting change in cholesterol level reduces mortality (*23,24*). The HHA does attempt to incorporate the existing data on the impact of the risk factor modification on mortality into its calculation of the achievable probability. For example, ex-smokers who, when they quit, were not at high risk because of existing illnesses, must continue to abstain for 15 years before achieving the same mortality rates as lifelong nonsmokers (*25*). Nonetheless, partial, rather than total, modification is likely for many risk factors, and partial, rather than maximum, reduction in the probability of mortality within 10 years is the likely outcome of any modification. In addition, the calculation of the achievable probability and the percentage of reducible risk does not take account of the possible unfavorable consequences of changing risk factors. Reductions in some risk factors may be accompanied by increases in others (*26*), and reduced frequencies for one cause of death will mean increased frequencies for other causes (*27*), particularly in older populations.

The possible inaccuracy in calculating the achievable probability and the percentage of reducible risk is greatly compounded when multiple risk factors for the same cause of death are present. Risk factors combine synergistically (*18*), and in the HHA one of many possible statistical procedures for estimating the combined impact of multiple risk factors is used (*28,29*). These estimates can be compared with actual mortality data. However, there are no mortality data to assess the impact of modifying high risk factors when others are present. For example, modifying one high risk factor may have little or no impact on coronary heart disease mortality if the person has other high risk factors (*30*). Also, risk factor modifications may be redundant—for a person who has succeeded in lowering blood pressure and cholesterol, weight loss may not contribute as much, or anything at all, to further risk reduction (*31*). The HHA's calculation of the achievable probability assumes that reducing a risk factor always lowers that risk factor's value by the same amount, regardless of whether other high risk factors are present or are also being reduced. From this assumption, the HHA calculates that substantial risk reduction will result from simultaneously lowering several multiple risk factors for the same cause of death. Whether this calculation accurately represents the impact of risk factor modification is untested but crucial, since most of the reducible risk in the HHA results from simultaneously lowering several multiple risk factors for arteriosclerotic heart disease.

Limitations of the HHA. Limitations of the HHA's approach to health promotion have been previously discussed (*21*). However, the results from this survey highlight these limitations in a somewhat new way. In the HHA, the person's health habits are evaluated according to the criterion of risk reduction or death postponement, rather than alternatives like reduced morbidity or enhanced vitality or wellness (*32*). The problem with a death postponement criterion is most strikingly illustrated by the relatively small amount of reducible risk in people under age 40, who are not likely to die within 10 years of chronic diseases precipitated by poor health habits. Most adults under age 40 will be given HHAs which show that their existing poor health habits have relatively little effect on their probability of dying within 10 years. Furthermore, their appraisals might suggest that the effects of not exercising and of other poor habits could be reversed later in life with little or no damage. Thus, the HHA provides little statistical incentive to change poor health habits for most adults under age 40, because death postponement is an inappropriate criterion of health promotion programs for this age group. Some programs seek to counter this nonmotivating message by calculating what the person's HHA is likely to be at age 40, assuming that he or she has the same health habits and history then as now. However, people appear much healthier in this simulation than, in fact, they are likely to be at age 40.

A further consequence of using a death postponement criterion is an overemphasis on the medical aspects of social problems. For example, people smoke tobacco for many social and emotional reasons, as well as for taste, so simply threatening them with the medical risk information generally will not reduce smoking. The threatening information is effective only if persons have specific behavioral skills and

concrete plans for changing their behavior (*33*). Because the HHA identifies only the medical risk, a counselor must be available to provide information on the positive aspects of disease prevention and health promotion, as well as on specific programs and methods for changing their clients' behavior to reduce the risk. To a large extent, people's responses to health threats are based on the sensations and symptoms in their bodies rather than on a rational calculation of health risks and benefits (*34,35*). Being out of breath after climbing steps is likely to be a more potent motivator of smoking cessation in a young adult than is the remote threat of dying in 45 rather than 50 years.

Another limitation of the HHA results from its focus on the individual as the sole or primary cause of poor health and poor health habits. This focus may lead to an inefficient use of health promotion resources. The HHA does not take account of societal and environmental risk factors like pollution, unemployment, or inadequate access to medical and preventive health services. The fact that its focus is only on the individual's risk factors may partially explain the surprising lack of differences in the percentage of reducible risk between black and white respondents or between inner-city and noninner-city residents, despite known differences in mortality rates. One's risk factors may predict mortality only when combined with social or environmental risk factors (*36*). Individual health counseling should, of course, emphasize the changes that a client can make to improve his or her health. However, public health programs may produce greater benefits by focusing on the community's responsibility, rather than the individual's, for making changes that can reduce an individual's high risk factors (*37*).

The criticisms of the HHA's accuracy are applicable to other attempts to measure reducible risk. The limitations discussed for the HHA apply whenever risk reduction measures are used to guide and evaluate health promotion programs and to motivate individual health behavior change (*24*). Counseling with the HHA seems especially suited for programs that screen persons 40–59 years old. Programs based on risk reduction or death postponement are less appropriate for the general population of younger adults, whose poor health habits are not likely to cause death from chronic diseases within 10 years. Programs using the HHA generally have not targeted older populations (*38*). One reason is that risk factor values derived from studies of middle-aged populations are not good predictors of mortality in older populations (*20,39*). Also, the effects of existing disease and of previous poor health habits are likely to be less reversible in older populations (*22*). Nonetheless, older people can benefit from changes in their health behaviors. With supervision, older adults seem able to start and maintain new exercise habits that can lead to increased vigor and, perhaps, longevity (*40,41*). Elderly volunteers have reported modifying their health habits, such as increasing exercise or wearing seatbelts, as the result of their participating in preliminary studies in which the HHA was used as a counseling tool (*42*). Therefore, programs using the HHA may prove effective in postponing mortality in persons 60 and older.

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SYNOPSIS

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The Special Projects Division of the City of Milwaukee Health Department conducted a telephone survey among randomly selected adult residents to determine the population having the greatest potential for benefiting from a health screening and counseling program. A modified version of the Health Hazard Appraisal (HHA) was completed by 268 respondents. From the survey results, it was estimated that by reducing various health risk factors, the respondents could lower their current probability of dying within 10 years by an average of 22 percent. The major predictor of the percentage of reducible risk was age. Persons 18–39 years old could reduce their current probability of dying within 10 years by an average of about 10 percent, whereas persons 40 years and older could reduce theirs by an average of more than 30 percent. Men could lower their probability by slightly more than women, but other sociodemographic factors, such as race, income, education, and residential area, either did not predict significantly the percentage of reducible risk or did so only because of their correlation with age. The results raise questions about the HHA's accuracy in calculating reducible risk, its use of death postponement information to motivate changes in behavior, and its value in health promotion programs, particularly for young adults who are not likely to die of chronic diseases within 10 years. The HHA should only be considered for public health screening programs that target middle-aged and, perhaps, elderly populations rather than the general population of persons under 40 years old.