Mortality among the Elderly in the Alameda County Study: Behavioral and Demographic Risk Factors

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Abstract: We studied the association between behavioral and demographic risk factors and 17-year mortality in members of the Alameda County (California) Study who were 60–94 years of age at baseline. In this age group, increased risk of death is associated with being male, smoking, having little leisure-time physical activity, deviating from moderate weight relative to height, and not regularly eating breakfast. These increased risks were independent of age, race, socioeconomic position (SEP), other behavioral risk factors, and baseline physical health status. Further examination of the group aged 70 or more revealed the same patterns of heightened risk. (*Am J Public Health* 1987; 77:307–312.)

Introduction

Changes in the age structure of the populations of most industrialized countries, with an increasing proportion of individuals in older age groups, have been widely noted.[1–3] Attention to these changes cannot help but underscore the limitations of existing epidemiologic knowledge concerning the aged. Most of the larger community-based, prospective studies that have examined associations between risk factors and health outcomes have studied middle-aged individuals, and it is not known to what extent the results of these studies can be generalized to older individuals. Indeed, some have argued that increasingly older groups represent highly selected "survivors" with, perhaps, lowered susceptibility to standard risk factors resulting from the cumulative effect of selective mortality on those with high levels of risk factors.[4–7] On the other hand, the aged, like other groups, evinces wide ranges of health outcomes, and there is no *a priori* reason to believe that these differences in health are not associated with variations in risk factor levels.

Although epidemiologic interest in the elderly is a fairly recent phenomenon, some data are available on risk factor associations in older age groups. Associations between demographic characteristics such as sex, race, socioeconomic status, and mortality at older ages have been most extensively documented. Vital statistics, for example, consistently show higher mortality rates for males at nearly all ages, including older ages.[8–11] The mortality differential between Blacks and Whites declines with age, with the White advantage disappearing by age 75.[2,12,13] Similarly, analyses of mortality differentials associated with socioeconomic position (SEP) also suggest that the association between lower SEP and higher mortality is strongest at younger ages.[14–16]

Data are also available from several prospective studies which have examined changes in risk factor associations with age. Their findings have been mixed, with some reporting few important associations between behavioral or physiologic risk factors and mortality in older persons[17,18] and others finding substantial evidence for their importance.[10,19–23] It is not clear if these different patterns of results stem from differences in populations studied, risk factor measurement, time of study, or other factors that vary between studies.

To examine this issue further, we have used data from the Human Population Laboratory's (HPL) Alameda County Study.[24,25] The availability of information on a wide variety of behavioral and demographic characteristics and 17-year, all-cause mortality in this cohort allows us to examine age-related changes in risk factor associations in some detail. Previous research from this study has focused on the effects of these risk factors among those under 70 years of age at baseline in 1965.[24,26,27] The presence of a large number of older individuals in this cohort provides an opportunity to examine the association between behavioral and demographic risk factors and all-cause mortality for older groups as well as to compare findings with those seen for younger individuals.

Methods

The data used in these analyses come from the HPL's study of adult residents of Alameda County, California. Details of study design and sampling have been reported elsewhere.[24,25] In 1965, a representative sample of some 6,928 adult residents of Alameda County aged 20 or more (16 if ever married) completed an extensive questionnaire about behavioral, social, and psychological aspects of their lives. One goal of the HPL study has been to examine the contribution of these factors to subsequent morbidity and mortality. The current analyses focus on those respondents who were at least age 38 in 1965, limiting the sample to those individuals who would be at least age 55 by 1982 (N = 4,174). This age range enables us to compare findings for those over age 60 with several younger age groups. Of those age 38 or older in 1965, 890 individuals (21 per cent) were 65–70 years old in 1965, and 564 were over 70 years of age. By 1982, 1,219 of these individuals (29 per cent) had died. Data on the behavioral and demographic risk factors examined in these analyses were obtained from the baseline 1965 questionnaire responses.

Seven behavioral risk factors previously shown to be associated with mortality in younger individuals in the Alameda County Study[24–29] were examined in these analyses: not smoking, being within 10 per cent under or 30 per cent over one's "ideal" weight as determined from the Metropolitan Life Insurance Company standards, engaging in some regular physical activity, drinking only moderate amounts of alcohol, getting seven to eight hours of sleep per night, eating breakfast regularly, and not snacking. Information on the coding of these risk factors is presented in the Appendix.

It should be noted that the lack of sufficient numbers of truly heavy drinkers at older ages does not allow us to examine the association between heavy drinking and mor-

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tality at older ages that has been found in analyses of the Alameda County Study cohort and elsewhere.[30]

The association between demographic characteristics (sex, race, and SEP) and mortality was also examined. Because of small numbers in other racial groups, only Whites and Blacks were included in these analyses. Socioeconomic position was measured by total household income adjusted for household size and scored as very adequate, adequate, inadequate, and very inadequate in comparison to federal standards for 1965.[25] Marital status and other psychosocial factors will be the subject of a separate report.

Outcome data on all-cause mortality were available for a 17-year follow-up period (1965–82). Deaths were ascertained via computer-matching procedures in which names of HPL respondents were identified in the California Death Registry.[31,32] Additional deaths were identified via extensive in-state and out-of-state tracing procedures in 1965–74[24] and, for a randomly selected 50 per cent sample of 1974 respondents, in 1975–82. A comparison of the number of deaths ascertained using the matching procedure utilized in 1965–74 with those expected from California vital statistics data indicates an under-ascertainment of approximately 10 per cent.[31] Those not positively identified as dead are considered alive in these analyses.

When the deaths ascertained via tracing are included, the total loss to follow-up is 4.4 per cent for the first nine years of follow-up and 5.7 per cent for the next eight years in the 50 per cent subsample that was traced. To determine if there was bias associated with differential loss to follow-up of those both alive and dead, we examined the association between such losses in the first nine years of follow-up and the risk factors and adjustment variables considered in these analyses. For most variables, there were no important differences in loss to follow-up. For the few variables in which there were substantial differences, they were in the direction of greater loss in the high-risk group. Because those lost are considered alive, this procedure would bias any observed associations towards the null.

In the following analyses, we have used a Cox proportional hazards regression model[33,34] to examine the association of behavioral and demographic risk factors with subsequent 17-year mortality risk, while simultaneously adjusting for age at baseline, sex, race, and baseline health status. Baseline health status was measured from 1965 self-reports of symptoms, conditions, and disabilities. These reports have been shown to be strongly associated with mortality.[24,35] The parameter of interest in these models is the estimated relative hazard, a measure that can be interpreted as the approximate instantaneous relative-risk associated with a particular risk factor. Use of a proportional hazards model for estimating relative hazards as opposed to a logistic regression model, for example, where odds ratios are used to estimate relative risks, is particularly advantageous for analyses such as those presented in this paper. The high 17-year risk of death, 80 per cent for those age 70 or more at baseline and 47 per cent for those ages 60–69, results in an odds ratio calculated in a logistic regression model that no longer provides a good estimate of the ratio of mortality rates.[36] Even direct estimates of relative risks for a 17-year follow-up are affected by these high death rates. As the death rates in the low risk group approach 100 per cent, an artificial ceiling on the relative risk is imposed. Indeed, if follow-up is sufficiently long, everyone will die in both the high and low risk groups, and all relative risks will equal 1.00. The proportional hazards regression model is advantageous in such cases because it utilizes information about time to death to provide an estimate of the average instantaneous relative risk (i.e., the relative hazard or ratio of mortality rates) over short time intervals in which the outcome remains a rare event even for older groups.

The basic focus of this report is the strength of risk factor associations at older ages. Thus age-stratified proportional hazard analyses were used to compare risk factor associations for those ages 60–69 and 70+ at baseline. Risk factor associations were also examined for two younger age groups (38–49 and 50–59) to examine age-related trends in risk factor associations.

Results

Demographic Characteristics

Of the three demographic characteristics considered in these analyses (sex, race, and SEP), only sex is associated with 17-year mortality rates in those over 60 years old at baseline (Table 1). Above age 60, men have a risk of death from all causes almost twice as high as women. Table 1 also shows similar results when all three demographic factors and age are simultaneously included in the analysis. Separate examination of groups aged 60–69 and 70 (Table 4) or more indicates that the increased risk for men is also present in the oldest age groups. Neither of these age groups shows an association between SEP and mortality. On the other hand, there is some indication of a change in the association between race (Black/White) and mortality in the older age group, with Blacks evidencing decreased risk compared to Whites.

In all subsequent analyses, proportional hazard regression models include adjustment for sex, race, age, and baseline self-reported health status.

Behavioral Risk Factors

Examination of the associations between seven behavioral risk factors and all-cause mortality for those over 60 years of age revealed strong associations with 17-year mortality for smoking, physical activity, and regular habit of eating breakfast and a somewhat weaker association for relative weight. For example, those age 60+ at baseline who were current smokers had 1.5 times the mortality risk of those who have never smoked (95 per cent confidence interval = 1.2–1.8). Current smokers were also at higher risk than past smokers (RH = 1.2; 95 per cent CI = 1.0–1.5). Those engaging in little leisure-time physical activity and those not regularly eating breakfast have mortality risk increases of the same magnitude as current smokers (Table 2). Persons who

TABLE 1—Association between Demographic Factors and 17-Year Mortality: Alameda County Study, Males and Females Aged 60 Years or More

Risk Factor	Relative Hazard[a]			
	Individual Model	95% CL	Combined Model[b]	95% CL
Sex	1.82[c]	1.57, 2.10	1.84[d]	1.57, 2.14
Race	0.93	0.72, 1.20	0.92	0.70, 1.22
SEP	0.94[e]	0.88, 1.01	0.96	0.90, 1.04

[a]Relative hazard from Cox proportional hazards regression analysis with adjustment for age and self-reported health status at baseline.
[b]Model includes all three risk factors.
[c]$0.001 < p < 0.01$
[d]$p < 0.001$
[e]$p < 0.10$

TABLE 2—Association between Behavioral Risk Factors and 17-Year Mortality: Alameda County Study, Males and Females Aged 60 Years or More

Risk Factor	Relative Hazard[a]			
	Individual Model	95% CL	Combined Model[b]	95% CL
Smoking				
current/never	1.47[e]	1.21, 1.78	1.40[e]	1.15, 1.71
past/never	1.23[c]	1.01, 1.51	1.22[f]	0.99, 1.50
Physical Activity				
low/high	1.41[e]	1.20, 1.66	1.38[e]	1.17, 1.62
Relative Weight				
moderate/else	1.20[c]	1.01, 1.43	1.18[f]	0.99, 1.41
Alcohol Consumption				
45+/0–45 drinks per month	1.21	0.93, 1.58	1.10	0.84, 1.45
Hours Sleep				
else/7–8	1.02	0.87, 1.21	1.02	0.87, 1.19
Eating Breakfast				
else/regularly	1.46[e]	1.17, 1.83	1.35[d]	1.08, 1.70
Snacking				
else/never	1.10	0.95, 1.27	1.12	0.97, 1.30

[a]Relative hazard from Cox proportional hazards regression analysis with adjustment for age and self-reported health status at baseline.
[b]Model includes all seven risk factors.
[c]$0.01 < p < 0.05$
[d]$0.001 < p < 0.01$
[e]$p < 0.001$
[f]$0.05 < p < 0.0$

maintained moderate relative weight (i.e., not more than 10 per cent underweight or 30 per cent overweight) had 1.2 times the mortality risk of those who did not (95 per cent CI = 1.0–1.43). For the remaining three behavioral risk factors (alcohol consumption, snacking, and eight hours of sleep per night), the association with mortality is weak (relative hazards ranged from 1.0–1.2) at best.

In the above analyses, we examined each of the seven behavioral risk factors individually. To examine the independent contribution of each risk factor, a proportional hazards model including all seven behavioral risk factors was utilized. There was little or no change in the individual relative hazards associated with the various behavioral risk factors. Again, not smoking, engaging in some form of leisure-time physical activity, maintaining moderate relative weight, and eating breakfast regularly were associated with lower mortality rates (Table 2), although the precision of the estimates is, in some cases, decreased due to the large number of covariates.

To examine further these patterns of association, separate analyses were carried out, with simultaneous adjustment for all seven behavioral risk factors, for those 60–69 years old and those who were 70 or more years (Table 3). Physical inactivity and currently being a smoker continue to be associated with mortality risk in both age groups, as does being a past smoker in the 60–69 age group and regularly eating breakfast for those over 70 years old. Deviation from moderate relative weight is no longer associated for the 60–69 age group, although it remains so for those aged 70 or over.

Comparisons with Younger Age Groups.

To examine the consistency of the observed associations over a wide age range, separate proportional hazard regression analyses were also carried out for two additional age groups, 38–49 and 50–59. The results of these analyses for sex, race, and SEP are presented in Table 4. The increased death rate for males compared with females is seen in all four age groups. Although the effect is weakest in the youngest group, it becomes stronger and relatively constant after 50 years of age. For race and income, Table 4 indicates increased risk associated with Black status and low SEP only below age 60. This pattern of results is also seen for sex and income when all demographic factors are included simultaneously in the analysis. As demonstrated previously,[16] the increased death rate for Blacks compared with Whites in the younger age groups disappears when there is adjustment for

TABLE 3—Association between Behavioral Risk Factors and 17-Year Mortality: Alameda County Study, Males and Females, by Age Group

Risk Factor	Relative Hazard (RH)[a]							
	Age 38–49		Age 50–59		Age 60–69		Age 70+	
	RH	95% CL	RH	95% CL	RH	95% CL	RH	95% CL
Smoking								
current/never	1.77[c]	1.21, 2.61	1.81[d]	1.33, 2.47	1.46[c]	1.10, 1.94	1.43[c]	1.08, 1.89
past/never	1.24	0.73, 2.08	1.06	0.69, 1.61	1.57[c]	1.16, 2.13	1.01	0.76, 1.33
Physical Activity								
low/high	1.48[c]	1.08, 2.02	1.27[e]	0.97, 1.66	1.38[c]	1.09, 1.75	1.37[c]	1.09, 1.72
Relative Weight								
moderate/else	1.66[c]	1.17, 2.35	1.32[e]	0.97, 1.79	1.02	0.77, 1.35	1.32[b]	1.05, 1.67
Alcohol Consumption								
45+/0–45 drinks/month	1.33	0.93, 1.90	1.14	0.80, 1.62	0.94	0.64, 1.39	1.39	0.94, 2.05
Hours Sleep								
else/7–8	1.23	0.88, 1.70	1.44[c]	1.08, 1.91	0.95	0.73, 1.24	1.05	0.85, 1.29
Eating Breakfast								
else/regularly	1.30	0.95, 1.79	0.94	0.69, 1.26	1.28	0.93, 1.76	1.45[b]	1.05, 2.02
Snacking								
else/never	0.85	0.61, 1.18	0.87	0.66, 1.15	1.05	0.83, 1.32	1.15	0.95, 1.40

[a]Relative hazard from Cox proportional hazards regression analysis, with all seven risk factors included and with adjustment for age and self-reported health status at baseline.
[b]$0.01 < p < 0.05$
[c]$0.001 < p < 0.01$
[d]$p < 0.001$
[e]$p < 0.10$

TABLE 4—Association between Demographic Factors and 17-Year Mortality: Alameda County Study, Males and Females Aged 38 Years or More

	Relative Hazard (RH)[a]							
	Age 38–49		Age 50–59		Age 60–69		Age 70+	
Risk Factor	RH	95% CL	RH	95% CL	RH	95% CL	RH	95% CL
Sex	1.29[e]	0.96, 1.73	1.82[d]	1.40, 2.36	1.79[d]	1.43, 2.24	1.85[d]	1.52, 2.24
Race	1.35[e]	0.94, 1.94	1.47[c]	1.08, 2.01	1.11	0.78, 1.56	0.76	0.52, 1.12
SEP	1.20[b]	1.01, 1.42	1.26[d]	1.10, 1.45	0.89	0.80, 1.00	0.94	0.86, 1.04

[a]Relative hazard from Cox proportional hazards regression analysis with adjustment for age and self-reported health status at baseline.
[b]$0.01 < p < 0.05$
[c]$0.001 < p < 0.01$
[d]$p < 0.001$
[e]$p < 0.10$

SEP, indicating that low SEP is an important contributor to the poorer health status of younger Blacks.

Table 3 also presents the results of similar analyses for the set of seven behavioral risk factors. Current smoking is a strong predictor of increased mortality risk in all cases, although the strength of the association appears to decline somewhat above age 60. Increased risk for past versus never smokers is seen only in the 60–69 year strata. Little or no leisure-time physical activity is associated with a consistently increased risk at all ages, although only marginally so for the 50–59 year olds. Deviations from moderate values of relative weight are associated with mortality in all age groups except those 60–69. Eating breakfast regularly, however, is most strongly associated with mortality risk in the oldest age group (RH = 1.45). Its association is somewhat weaker among the 60–69 year-olds and those 38–49 (RH = 1.28 and 1.30, respectively). Among the 50–59 year-olds, there was no association (RH = 0.94). Figure 1 (a–e) presents age, sex, and physical health status adjusted survival curves that compare the 17-year mortality experience of 38–49 year-olds with those age 70 or more for the behavioral and demographic risk factors showing the strongest associations.

Discussion

The results presented here offer substantial evidence that many behavioral and demographic risk factors remain predictors of 17-year mortality risk, even at older ages. The absence of large age differences in the associations of many variables with mortality seem striking to us, particularly given some of the statements that risk factors are not as important for older people. Perhaps this view is correct for the very old, but in this study 21 per cent of those in the over 70 age group were actually over 80 years of age at baseline in 1965.

Although they are strongly associated with 17-year mortality outcomes, it is possible that the measures of baseline physical health status used in these analyses are not sensitive enough to adjust properly for the confounding effects of health on the association between risk factors and mortality. To test this possibility, we examined multivariate models in which baseline health status was measured by seven indicator variables corresponding to the seven conditions and symptoms most strongly associated with 17-year mortality (cancer, heart trouble, stroke, diabetes, high blood pressure, chest pain, and trouble breathing). There were only minor changes in coefficients and confidence intervals that do not affect the pattern of results presented earlier.

The notable age trend in the association between SEP and death seems to us likely to be the consequence of demographic shifts associated with aging rather than any real change in the association. Because retirement frequently leads to a decline in income, for many of those over age 65, reported current income may underestimate the income and general economic status which they experienced during most of their adult life. To the extent that their mortality experience is based more on their "long-term" economic situation, current income for those 65+ may represent a case of misclassification. Such misclassification would tend to weaken observed relationships in the older age groups.

Like sex, race is a stable characteristic that is not susceptible to the same problem of misclassification as income. The decrease in the association between race and mortality with increasing age is more problematic. Previous reports based on vital statistics data have shown a similar pattern of change in the relative mortality experience of Blacks and Whites with age.[4,11] Explanations of this cross-over effect range from differential rates of misclassification of age in Blacks and Whites to "differential survivorship."[13] However, lacking a careful explanation of the mechanisms and consequences of differences in survivorship, such an explanation merely restates the empirical finding. Our analyses indicate that Blacks and Whites in the older age groups share similar mortality risks. Other analyses of these data further suggest that the race differential in mortality observed for those under age 60 is largely explained by socioeconomic differences.[16] Once adjusted for income differences, data for Blacks and Whites under age 60 also show essentially no differences in their mortality risks.

With respect to the behavioral risk factors, our findings indicate that even at older ages (e.g., 70+), risk factors such as smoking, lack of regular physical activity, and not regularly eating breakfast are associated with increased risk of death. Thus even among the elderly, mortality is not a uniform or random process; individual behavioral and demographic characteristics are associated with patterned variations in mortality risk.

Although for some risk factors there is a weakening of the association with all-cause mortality with increasing age, it is also true that, for others, there is not a linear decrease with age, possibly reflecting a cohort effect. In the case of "eating breakfast," the association is actually stronger in the oldest group. This latter finding accounts for the lack of an

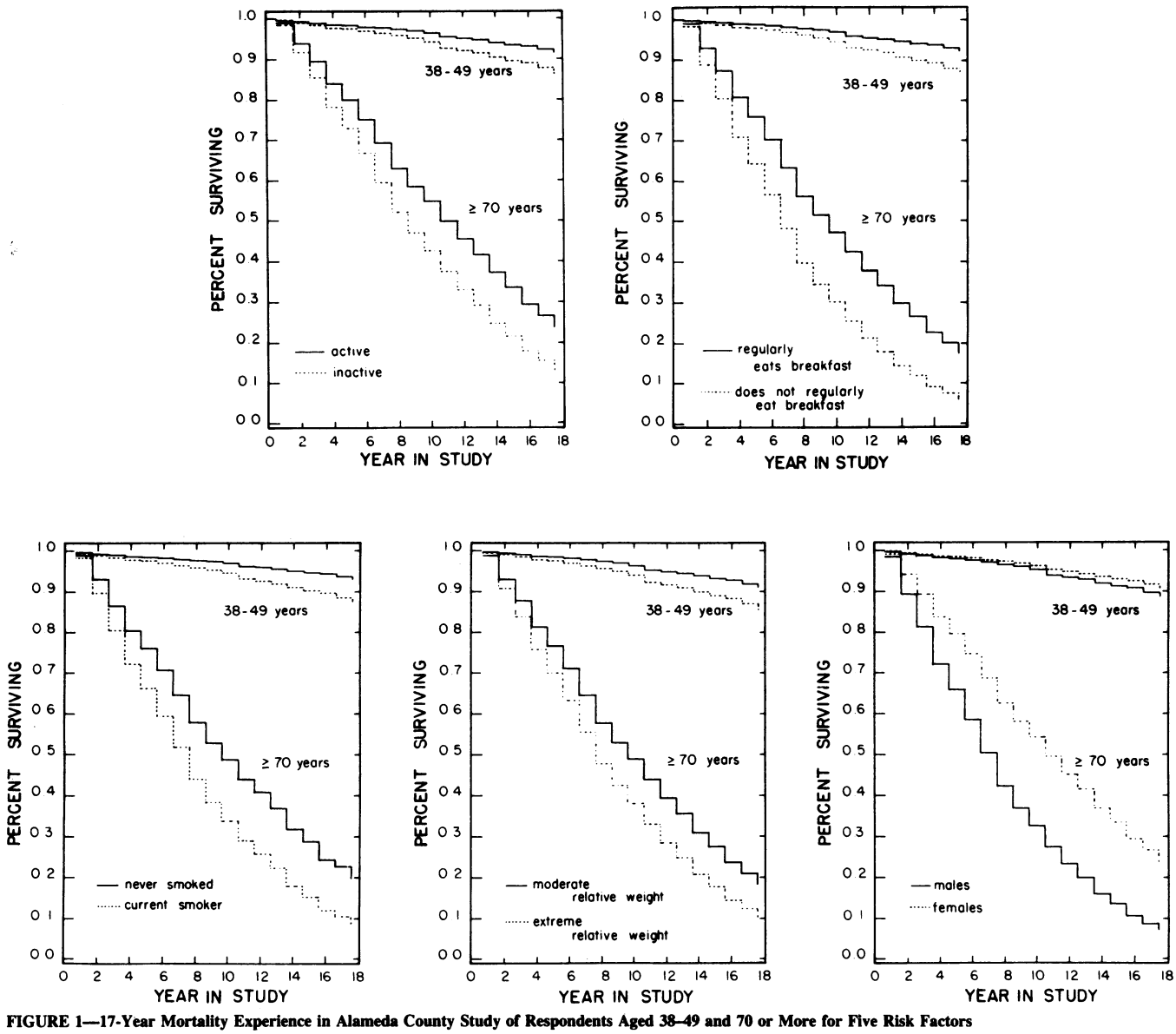

FIGURE 1—17-Year Mortality Experience in Alameda County Study of Respondents Aged 38–49 and 70 or More for Five Risk Factors

association for "eating breakfast" in other analyses of this data, which were confined to those under 70 years of age.[24,29]

We have no information on how long individuals have been exposed to particular risk factors, whether risk factor levels might have changed, or if there were changes in risk factors due to health problems. For example, reduced leisure-time physical activity might be the consequence of the presence of existing health problems. Thus those who were inactive might have changed their level of activity because of health problems and subsequently evidence higher mortality rates. In the present analyses, these problems are avoided, to some extent, by adjustment for measures of baseline health status that are in themselves strong predictors of mortality.[24,29,35] In further reports, we will address the role of physical health status, behavioral, and psychosocial factors in the maintenance or change in risk factor levels, as well as the health consequences of risk factor change at various ages.

The results presented here demonstrate that many of the risk factors that are important determinants of health among the middle-aged are also important for those three decades older and more. The notion that the elderly represent a special, highly selected population evincing substantially different patterns of risk factors is not supported by these analyses. We believe that these findings argue strongly that high mortality rates are not the inexorable consequence of aging. Demonstration of the continuing impact of these risk factors at older ages suggests possible points of intervention to minimize mortality risk at older ages where the burden of mortality is the greatest.

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APPENDIX
Variables in the Analysis

Variable	Categories[a]	Remarks
Demographic Status		
Sex	Female/male	
Age	Years	Age in years at baseline.
Race	White/Black	
Income	Very adequate/adequate/marginal/ inadequate	1965 family income adjusted for family size compared to federal standards.
Physical Health Status		
	0/1+ chronic conditions	Based on self-reports of 34 conditions, symptoms, and disabilities.
	0/1+ symptoms	
	0/1+ disabilities	
Behavioral Risk Factors		
Smoking History	Never/current	
	Never/past	
Weight	Moderate (9.9% underweight to 29.9% overweight/other)	Measured by the Quetlet Index, weight in pounds/height in inches,[2] categories based on Metropolitan Life Insurance Reports of desirable weights.
Physical Activity	Active/inactive	Based on frequency (often, sometimes, never) and presumed strenuousness of reported leisure time participation in active sports, swimming, or taking long walks, physical exercise, gardening, and/or hunting and fishing.
Alcohol Consumption	0–45 drinks per month/46 or more	Based on frequency of drinking (number of times/week) and amount consumed (usual number of drinks/sitting) for beer, wine, and liquor combined.
Sleeping Patterns	7 or 8 hours per night/more or less	
Breakfast	Eats breakfast regularly/never or sometimes	
Snack	Never snacks/sometimes or always	

[a]low risk/high risk.