AMERICAN JOURNAL OF EPIDEMIOLOGY
Vol. 126, No. 4
Printed in U.S.A.

SOCIAL NETWORK TIES AND MORTALITY AMONG THE ELDERLY IN THE ALAMEDA COUNTY STUDY

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Seventeen-year mortality data from the Alameda County Study are used to examine the relative importance of social ties as predictors of survival at different ages, ranging from 38–94 years at baseline. Previous analyses of Alameda County data by Berkman and Syme (*Am J Epidemiol* 1979;109:186–204) have shown that such ties are significant predictors of lower nine-year mortality risk for persons aged less than 70 years at baseline. Proportional hazard analyses indicate that social ties are also significant predictors of lower 17-year mortality risks for those aged 70 and older after adjusting for age, sex, race, baseline health status, perceived health, depression, and health practices (relative hazard = 1.49 for Berkman-Syme Social Network Index; 95% confidence interval (CI) = 1.09–2.05). Comparisons of the relative importance of four types of social ties reveal an interesting shift across the age groups. Marital status assumes primary importance for those aged less than 60 years at baseline (relative hazard = 1.6 and 1.4 for those aged 38–49 and 50–59, respectively; 95% CI = 1.12–2.29 and 1.02–1.91, respectively). However, ties with close friends and/or relatives assume greater importance for those aged 60 and older (relative hazard = 1.17 comparing those reporting five or more contacts per month to the more socially isolated who report less than five such contacts per month; 95% CI = 0.98–1.89).

aged; marriage; mortality; single person; social isolation; social support

Although social network ties have become a topic of increasing epidemiologic interest and research (1, 2), little epidemiologic attention has yet been directed to the association between such ties and mortality in older population groups. Beginning with Berkman and Syme's (3) analyses of nine-year mortality risks among adult residents of Alameda County, many studies have focussed on the middle age groups (3–5). Indeed, the Berkman-Syme analyses which provided the first direct evidence that social ties are related to mortality risk included only those respondents aged 30–69 years at baseline.

There have been numerous subsequent attempts at replicating these findings; attempts which have met with mixed success, perhaps in part because of differences in their measures of social ties (4–10). Nevertheless, their findings do generally sup-

Received for publication July 15, 1986, and in final form December 18, 1986.

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This research was supported by Grant AG 04610 from the National Institute on Aging, NIH. Dr. Seeman was also partially supported by the MacArthur Program on Successful Aging.

port the hypothesis that social ties are related to mortality risk (11). Again, however, many of these studies did not include persons aged 70 years and older (4, 5). Of those with older subjects (6–10), only the Evans County Study (7) made age comparisons of network risk relationships.

Extending the examination of risk factor associations to the older age groups is of particular importance for several reasons. First, these groups are at highest risk for nearly all morbid and mortal events. Second, they represent one of the fastest growing population subgroups, estimated to reach 20 per cent of the total population at the turn of the century (12). Thus, it is of some importance to understand how factors such as social ties influence health risks at older ages. The present study addresses two critical questions: 1) do social network factors which have been shown to be associated with increased risk at younger ages continue to do so in older age groups; and 2) do network characteristics such as marital status, for example, vary in relative importance as a function of age.

The available research on social ties and health risks in older age groups suggests that the answer to the latter question may be "yes" while the answer to the former is less clear, primarily because of the dearth of research in this area. For example, studies which have examined the effects of social ties on mortality risks in older age groups have frequently found that marital status does not show a significant association with mortality risk (7, 8, 10, 13–15). These findings are in direct contrast to the strong associations between marital status and mortality risk generally seen in younger age groups (3, 4, 14). Other social ties, however, do appear to influence mortality risks in older age groups. The study by Blazer (8) of 30-month mortality in a sample of persons aged 65 years or older at baseline found that both a general lack of social ties with children and siblings as well as low perceived support from one's social network were each independently associated with increased mortality risk. Similarly, other studies of mortality risks in older populations (aged 60 years and older at baseline) have also shown that social ties with others (e.g., contacts with children, general social activity) and participation in group activities are associated with reduced mortality risks (10, 13). The Evans County Study (7) also included specific analyses of persons aged 60–80 years at baseline. Analyses of social ties and mortality risk for this age group showed a significant association between 13-year mortality risks and a summary measure of social network ties, even when adjusted for baseline health status (7). As hypothesized, those reporting fewer ties experienced greater mortality. These results suggest that social ties may well continue to affect mortality risks for those aged 60 years and older. They also suggest that certain types of social ties may actually become more important (e.g., ties with friends and relatives), while others may decline in importance (e.g., marital status).

Unfortunately, the available evidence provides no direct intra-study comparisons of the relative importance of different types of social network ties in different age groups. Data from the Human Population Laboratory's Alameda County study allow us to compare the relative importance of four types of social ties to mortality risk across four age groups spanning a wide range of ages (38–94 years). These data provide for direct age comparisons of the patterns of association for these various social ties in a representative community sample. Particular attention is devoted to the patterns of association in those aged 70 years and older at baseline since this latter group has not been studied previously in the Alameda County dataset.

Materials and Methods

The details of the Alameda County study design and sampling have been reported elsewhere (16). Briefly, in 1965 a representative sample of some 7,000 adult residents of Alameda County aged 20 years and older was asked to complete an extensive questionnaire about behavioral, social, and

psychologic aspects of their lives. The goal of the Human Population Laboratory 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 38 years old in 1965, limiting the sample to those persons who, if they survived, were at least 55 years old by the end of follow-up in 1982. Of the 4,174 who were 38 years or older in 1965, 890 persons were 65 years or older in 1965 (21 per cent of the total sample) and 564 were over 70 years of age. By 1982, 1,219 (29 per cent) persons had died. Data on the social characteristics examined in these analyses were obtained from the baseline 1965 questionnaire responses.

The four types of social ties examined here (as in the earlier Berkman and Syme analyses) reflect 1) tie with a spouse (i.e., marital status), 2) contacts with close friends and relatives, 3) membership in a church group, and 4) memberships in other types of groups. Tie with a spouse is represented by a dichotomous measure of marital status at baseline in 1965 (coded as married/not married). The second measure of social ties reflects more general social isolation, measured by few (if any) contacts with friends and relatives. This latter measure was constructed from responses to three questions asking respondents how many close friends and close relatives they had and how many of these people they saw at least once per month. Those who reported less than five total contacts per month with family and close friends were classified as isolated (24 per cent). Membership in a church group (yes/no) is measured from a single questionnaire item. Membership in other types of groups is also coded as a dichotomous measure, reflecting any versus no memberships in labor, community, political, or service groups.

In addition to separate analyses of these different types of social ties, we have also examined a composite Social Network Index which measures overall social connectedness, combining information on the four individual types of ties into a single, interval scale. This latter index was originally developed and tested by Berkman and Syme (3) using data for respondents aged 30–69 years. The analyses presented here represent an a priori test of this index for those respondents who were 70 years or older at baseline in 1965. This contrasts with earlier "a posteriori" analyses for those under 70 years of age in which the index was both developed and tested using the same persons. These analyses also examine an extended follow-up period, now covering some 17 years (1965–1982). Earlier analyses by Berkman and Syme for this sample covered only the first nine years of mortality follow-up.

Outcome data on all-cause mortality were available for 1965 through 1982. A computer-matching procedure was used to identify deceased members of the Alameda County sample from the California Death Registry (17, 18). Additional deaths, both within and outside of California, were discovered via active tracing of sample members in 1974 and 1983. As indicated, 1,219 respondents aged 38 years or older at baseline died between 1965 and 1982; respondents not known to have died are assumed to be alive. Underascertainment of deaths appears to be slight; during the first nine years of follow-up it was found to be approximately 4 per cent (17).

In testing the associations of the various measures of social ties with mortality risk, we have used Cox proportional hazards models to estimate the relative hazards for each type of social tie while simultaneously adjusting for age (within 10-year age group), sex, race, and baseline health status. Baseline health status was measured by three dichotomous measures reflecting the presence or absence of symptoms, conditions, and disabilities. These measures have been shown to be strongly associated with mortality (19). The parameter of in-

terest in these models is the estimated relative hazard—a measure which can be interpreted as the approximate instantaneous relative risk associated with a particular risk factor.

Since the goal of these analyses is to examine possible age-related differences in the associations between social network ties and 17-year mortality risk, with particular attention to the patterns of association at older ages, we have examined these associations in four separate age groups: two groups ≥60 years of age (60–69 and 70+ years) and two groups under 60 years of age (38–49 and 50–59 years). For each of these age groups, we first examined separate models for each of the four different types of social ties, estimating their associations with mortality risk. We then examined proportional hazards models which simultaneously included all four types of social ties, estimating the associations for each type of social tie independent of the other types of ties. In addition, models estimating relative hazards associated with the composite Social Network Index were also examined for each age group. The final models examine these relations while simultaneously adjusting for other behavioral and psychologic risk factors which have shown significant associations with mortality risk (20).

These latter risk factors include smoking history, physical activity, relative weight, eating breakfast regularly, perceived health, and depression. Each of these was measured in accord with previous analyses of the Alameda County data (16). Smoking history was measured by two dummy variables comparing current and past smokers with never smokers. Relative weight was dichotomized into high- and low-risk groups with high risk defined as being more than 9.9 per cent underweight or more than 29.9 per cent overweight. A measure of physical activity based on the frequency (often, sometimes, never) and presumed strenuousness of reported leisure time participation in active sports, swimming, taking long walks, physical exercise, gardening, and/or hunting and fishing was dichotomized into active and inactive classification for these analyses.

The dichotomous measure of depression used here is based on self-reported symptoms and defines a case as those reporting more than five symptoms (i.e., scoring >1 standard deviation above the mean). This measure has been used previously and has been shown to compare favorably to standard measures of depression such as the Center for Epidemiologic Studies Depression Scale (CES-D) (21). Perceived health was scored as excellent, good, fair, and poor.

Results

Table 1 presents the results of proportional hazards models for each of the four types of social ties for those aged 60 years and older, adjusting for age, sex, race, and baseline health status. Since adjustments for these latter factors do not markedly affect the associations between the four types of ties and mortality, only the adjusted results are presented here in the interest of parsimony. In this age range, both contacts with friends and relatives and membership in a church group are significant predictors of lower 17-year mortality

TABLE 1

Four Cox proportional hazards models showing the association between social network measures and all-cause mortality (1965–1982) in Alameda County for those aged 60+ at baseline; relative hazards are adjusted for age, sex, race, and baseline health status

Models	Relative hazards	95% confidence intervals
Marital status (1965): not married/married	1.10	0.94–1.30
Social isolation (contacts with close friends and/or relatives): isolated/not isolated	1.30	1.10–1.53
Membership in church group: no/yes	1.32	1.13–1.54
Memberships in other groups: no/yes	1.08	0.93–1.25

risks. Marital status and membership in non-church-related groups are marginally associated with mortality risks.

Examination of these associations separately for those aged 60–69 and those aged 70 years and older at baseline indicates that lack of contacts with friends and relatives and nonmembership in a church group remain significant predictors of increased mortality risk in both of these older age groups (table 2). Comparison of these results with those for the younger age groups reveals that, in contrast to the two older age groups, marital status is a significant predictor in the two younger age groups (38–49 and 50–59 years). Also, while general social isolation is a significant predictor of mortality risk in the two older age groups, it is not significant for those under 60 years of age. Membership in church groups is associated with decreased mortality risks in all age groups (except those aged 50–59), while membership in other types of groups is generally not significantly related to mortality risk.

Table 3 presents the results of proportional hazards analyses which simultaneously examine the four types of social ties. These models provide estimates of the independent associations of each of these four types of social ties with mortality risk, again adjusted for age (within age group), sex, race, and baseline health status. As shown in table 3, there is little change in the patterns of associations from the previous individual analyses of these different types of social ties. Being unmarried remains a significant predictor of increased mortality risk in the two younger age groups. Similarly, greater social isolation from family and/or friends remains a significant predictor of increased mortality risk for those ≥60 years of age. Membership in a church group remains a significant predictor of lower mortality in all age groups except age group 50–59 years, while membership in other types of groups is not significantly related to mortality risks in any age group.

In addition to these comparative analyses of the different types of social ties, the association between social ties and mortality risk in the older age groups was also examined using the composite Social Network Index previously developed by Berkman and Syme (3). As shown in table 3, similar analyses for a 17-year follow-up period confirm that this association remains significant for those aged 38–69 years at baseline. Indeed, comparisons of these results with similar analyses for a nine-year follow-up reveal few differences (16). Although unadjusted for baseline health, these earlier analyses for ages 30–69 years

TABLE 2

Four Cox proportional hazards models showing the association between social network measures and all-cause mortality (1965–1982) in Alameda County for four age groups; relative hazards are adjusted for age, sex, race, and baseline health status

Models	Age groups (years)			
	38–49	50–59	60–69	70+
Marital status (1965): not married/married	1.83 (1.30–2.57)*	1.41 (1.04–1.93)	1.05 (0.82–1.34)	1.15 (0.93–1.43)
Social isolation (contact with close friends and/or relatives): isolated/not isolated	1.25 (0.92–1.71)	1.06 (0.78–1.45)	1.35 (1.05–1.72)	1.31 (1.05–1.64)
Membership in church group: no/yes	1.82 (1.27–2.59)	1.09 (0.83–1.44)	1.40 (1.08–1.80)	1.32 (1.08–1.62)
Memberships in other groups: no/yes	1.31 (0.96–1.79)	1.08 (0.81–1.44)	0.94 (0.85–1.33)	1.20 (0.99–1.46)

* 95% confidence intervals in parentheses.

TABLE 3

Cox proportional hazards models showing the associations between social ties and all-cause mortality (1965–1982) in Alameda County: models compare associations for the individual types of ties versus the Social Network Index, adjusting for age, sex, race, and baseline health status

	Age groups (years)			
	38–49	50–59	60–69	70+
	Model 1			
Marital status (1965): not married/married	1.70 (1.20–2.40)*	1.40 (1.03–1.91)	0.98 (0.76–1.27)	1.15 (0.92–1.42)
Social isolation (contacts with close friends and/or relatives): isolated/not isolated	1.16 (0.84–1.59)	1.04 (0.76–1.42)	1.32 (1.02–1.70)	1.27 (1.02–1.59)
Membership in church group: no/yes	1.65 (1.15–2.37)	1.06 (0.80–1.40)	1.36 (1.05–1.76)	1.26 (1.03–1.55)
Memberships in other groups: no/yes	1.14 (0.83–1.57)	1.04 (0.77–1.40)	0.89 (0.71–1.12)	1.14 (0.94–1.39)
	Model 2			
Social Network Index (coded 1–4): lowest, 1/highest, 4	2.46 (1.58–3.82)	1.64 (1.11–2.42)	1.52 (1.09–2.10)	1.69 (1.24–2.29)

* 95% confidence intervals in parentheses.

show relative risks of 1.5, 1.4 and 1.2, respectively, for marital status, church membership and other group memberships. (Our measure of social isolation differs from the earlier measure of ties with friends and relatives and, therefore, direct comparisons are not possible.)

Of particular interest, however, are the analyses of those aged 70 years and older for whom the present analysis represents an a priori test of the relation between the Social Network Index and mortality risk. Table 3 shows that for those aged 70 years and older, 17-year mortality risk is quite strongly related to overall social connectedness. The strength of the association is, in fact, comparable to that in the 50–59 and 60–69-year age groups. Persons aged 70 and older scoring in the lowest category of the Social Network Index have a mortality risk that is approximately 1.7 times greater than that of persons in the highest quartile ($p < 0.001$).

The analyses presented thus far have examined the associations between social ties and mortality risk, independent of possible confounders such as age (within age group), sex, race, and baseline health status.

Additional proportional hazards models were developed to examine the possibility of confounding from other known psychologic and behavioral predictors of mortality risk such as perceived health, depression, and various health practices such as smoking and physical activity (20).

As shown in table 4, adjusting for possible confounding by these various psychologic and behavioral factors does lead to some reduction in the size of the relative hazards associated with the various types of social ties. Also, p values increase somewhat, reflecting the decrease in precision associated with these estimates due to the increased number of covariates in these models. The pattern of results, however, remains the same. For those aged 60 years and older, the association between social isolation and greater mortality risk is weaker, though still of borderline significance (relative hazard = 1.17; 95 per cent confidence interval (CI) = 0.98–1.39). If we examine this association separately for those aged 60–69 and those aged 70 years

TABLE 4

*Cox proportional hazards models of the association between all-cause mortality (1965–1982) in Alameda County and individual types of social ties and the Social Network Index; relative hazards are adjusted for age, sex, race, baseline health status, and behavioral and psychologic risk factors**

	Age groups (years)			
	38–49	50–59	60–69	70+
	Model 1			
Marital status (1965); not married/married	1.60 (1.12–2.29)†	1.39 (1.02–1.91)	1.01 (0.78–1.32)	1.12 (0.89–1.40)
Social isolation (contacts with close family and/or friends): isolated/not isolated	1.07 (0.77–1.49)	0.95 (0.69–1.32)	1.15 (0.87–1.51)	1.18 (0.93–1.50)
Membership in church group: no/yes	1.49 (1.02–2.17)	0.93 (0.70–1.24)	1.26 (0.96–1.65)	1.14 (0.92–1.42)
Memberships in other groups: no/yes	1.10 (0.80–1.52)	0.97 (0.72–1.31)	0.80 (0.63–1.02)	1.06 (0.86–1.31)
	Model 2			
Social Network Index (coded 1–4): lowest, 1/highest, 4	2.00 (1.27–3.15)	1.40 (0.93–2.11)	1.28 (0.90–1.81)	1.49 (1.09–2.05)

* Behavioral and psychologic risk factors include smoking, physical activity, relative weight, eating breakfast, depression, and perceived health status.

† 95% confidence intervals in parentheses.

or older, the 95 per cent confidence intervals now include 1.0 (table 4). The relative hazards for social isolation in these two age groups, however, do remain larger than those seen for the two younger age groups. In the two younger age groups, marital status remains a significant predictor.

Similar analyses for the Social Network Index show that this composite measure of social ties remains strongly associated with lower mortality risks for those aged 70 years and older (relative hazard = 1.49; 95 per cent CI = 1.09–2.05). The association is somewhat weaker for those aged 60–69 years (relative hazard = 1.28; 95 per cent CI = 0.90–1.81). For those aged less than 60 years the Social Network Index continues to show an independent association with lower mortality risks when the psychologic and behavioral factors are included in the model (table 4).

DISCUSSION

The analyses presented here provide a direct examination of the association between social ties and mortality risks for those aged 70 years and older, a group which has generally been neglected in previous social network research. Comparisons of the associations between several different types of social ties and mortality for those aged 70 and older with those for younger age groups point to some interesting differences in the relative importance of certain types of ties both within and across age groups. Generally, memberships in groups other than church groups were unrelated to mortality risk in all four age groups, while membership in church groups was associated with significantly lower mortality risks in all age groups except those aged 50–59 years. By contrast, the two measures of more intimate social ties (i.e., those with a spouse and with close friends and/or relatives) showed strikingly different patterns of association with mortality risk in the different age groups: marital status being significantly associated with mortality only in the two younger age groups, 38–49 and 50–59 years, while more

general social isolation from family and friends was a significant predictor of mortality risk in the two older age groups.

We considered whether one reason for these changing patterns of association with age for marital status and contacts with friends and relatives might be misclassification resulting from age-related shifts in social network structure. One major shift is the growing prevalence of widowhood at older ages. As a consequence, in the older age groups, 1965 marital status becomes a less accurate classification over time since many of those who report being married at baseline become widowed during the 17-year follow-up. Follow-up data for this sample, for example, indicate that among those aged 60 years and older who were married in 1965, 15 per cent of the men and 37 per cent of the women were widowed within nine years. Among those aged 70 years and older, 18 per cent of the men and 46 per cent of the women who were listed as married in 1965 were actually widowed by 1974. Use of 1965 marital status in essence leads to misclassification of these individuals. Such misclassification is most common in the older age groups and might tend to obscure any real differences in mortality risks between those who are married and those who are not.

However, examination of the survival curves for the married and unmarried in the older age groups shows that marital status is unrelated to mortality throughout the follow-up period, including the early period when misclassification due to widowhood would not be a major concern. Thus, misclassification would not appear to explain the lack of significant marital status differentials in mortality in the older age groups. An alternative explanation for the observed decline of marital status as a predictor of mortality risk is that widowhood may be a more expected and normative life event for older persons. As a result, there may be fewer negative health consequences associated with widowhood among the elderly (22, 23).

This apparent decline of marital status as a risk factor at older ages is worthy of further study. If marital status does become relatively less important in relation to mortality risks, replaced perhaps by contacts with friends and/or other relatives, this shift could have important implications. Such a shift in the relative importance of marital status and contacts with friends and/or relatives in the older age groups may in fact provide important protection against increased mortality risk. Were marital status to remain a significant predictor of mortality risk at older ages, a majority of older persons would fall into the high-risk group (i.e., the unmarried). However, with respect to contacts with friends and/or relatives, the elderly are less obviously "disadvantaged" since such ties appear to be quite common. Indeed, we find that those in the older age groups are no more likely to report being socially isolated than are those in the younger age groups. Approximately 20 per cent of each age group fall into the "isolated" category (i.e., those reporting less than five contacts with friends and/or relatives per month). The presence of contacts with friends and/or relatives would seem to represent an important protection against increased mortality risk, perhaps even substituting to some extent for the tie with a spouse which is more likely lost at older ages. Interestingly, separate analyses of the married and widowed in the oldest age group indicate similar associations with mortality risks for contacts with friends and relatives. Thus, it would not appear to be the case that such ties assume greater importance for only the widowed; rather ties with friends and relatives seem more significant at older ages for both the married and unmarried.

The differential patterns of association for marital status and contacts with friends and relatives in the different age groups also demonstrate the utility of examining not only the composite network index but also its component items. Had we looked only at the associations between the com-

posite index and mortality risks in the four age groups, we would have concluded that social ties are significant predictors of mortality risk in both younger and older age groups. We would not have seen, however, that this apparent similarity across age groups actually reflects important underlying shifts with age in the relative importance of marital status and contacts with friends and relatives.

A small cautionary note is in order, however. Although these data point to age differences in the relative importance of different social ties to mortality risks, we cannot rule out the possibility that these differences may also reflect cohort effects since our age comparisons are also comparisons of different birth cohorts. Follow-up of a subsequent sample of Alameda County residents taken in 1974 indicates that there may be substantial cohort effects (24).

The final analyses adjusting for behavioral and psychologic risk factors further suggest that part of the association between social ties and mortality risk reflects their joint association with psychologic and behavioral risk factors. An initial tendency might be to see this as an example of confounding. However, available data suggest otherwise. Analyses of the Human Population Laboratory data, for example, indicate that social isolation is prospectively associated with certain psychologic risk factors (21) and that the presence of few social ties is associated with decreases in health practices over a nine-year follow-up (25). This suggests that the joint associations seen in the present analyses may reflect indirect pathways by which social ties affect mortality risks via their effects on psychologic and behavioral risk status. The present analyses, as well as others (26), indicate however that these indirect effects are relatively small; the direct effects of social network ties on mortality risks are substantially larger and significant. Similar analyses of joint associations between social network ties and health status also show significant direct effects of social ties on mortality risks for persons at different health status levels (16).

It would appear that social network ties have a variety of individual pathways of influence, including both direct and indirect pathways. These findings are in line with recent studies of immune and neuroendocrine function which suggest that the social environment may have important indirect effects on disease susceptibility via its effects on various "intermediary" physiologic processes such as immune and neuroendocrine functions (27–31).

In summary, our findings indicate that social ties remain significant predictors of mortality risk even for those aged 70 years and older. Our results also indicate that different types of ties assume greater importance with respect to mortality risks at different ages. For those aged 70 and older, contacts with friends and/or relatives are the strongest predictors, while marital status is more important for those under 60 years of age. At first glance, this pattern of associations might seem counterintuitive (i.e., one might hypothesize that ties with friends and relatives would also be important in younger age groups such as those under 30 years of age where many have yet to marry). This may well be true; our findings for those aged "less than 60" actually cover only ages 38–59. Thus, our younger groups might more accurately be termed middle-aged, a group for whom marriage is quite common and where ties with a spouse are perhaps not surprisingly of central importance. The greater importance of contacts with friends and relatives in the older age groups is of particular interest; friends and/or relatives perhaps providing "protective" social contacts at a time when ties with a spouse are increasingly likely to be severed.

Analyses of the composite measure of social connections, the Social Network Index, do indicate that social ties, in a more global sense, continue to show a significant, direct association with mortality risk independent of other significant psychologic

and behavioral risk factors. The significance of this association for those aged 70 years and older at baseline is noteworthy since the relation between social ties and mortality risk in this oldest age group had not been previously examined for Alameda County residents. These analyses suggest that mortality is not a random process for those aged 70 years and older, any more than it is at younger ages.

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