American Journal of Epidemiology
Vol. 109, No. 2

Printed in U.S.A.

SOCIAL NETWORKS, HOST RESISTANCE, AND MORTALITY: A NINE-YEAR FOLLOW-UP STUDY OF ALAMEDA COUNTY RESIDENTS

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Berkman, L. F. (Dept. of Epidemiology and Public Health, Yale U., New Haven, CT 06520), and S. L. Syme. Social networks, host resistance, and mortality: A nine-year follow-up study of Alameda County residents. *Am J Epidemiol* 109:186–204, 1979.

The relationship between social and community ties and mortality was assessed using the 1965 Human Population Laboratory survey of a random sample of 6928 adults in Alameda County, California and a subsequent nine-year mortality follow-up. The findings show that people who lacked social and community ties were more likely to die in the follow-up period than those with more extensive contacts. The age-adjusted relative risks for those most isolated when compared to those with the most social contacts were 2.3 for men and 2.8 for women. The association between social ties and mortality was found to be independent of self-reported physical health status at the time of the 1965 survey, year of death, socioeconomic status, and health practices such as smoking, alcoholic beverage consumption, obesity, physical activity, and utilization of preventive health services as well as a cumulative index of health practices.

health surveys; marriage; mortality; smoking; social class; social isolation

Previous research has suggested that social ties and relationships may play a critical role in the determination of health status. Individuals undergoing rapid social and cultural changes (1–5) as well as those living in situations characterized by social disorganization (6–8), and poverty (9–12) appear to be at increased risk of acquiring many diseases. These situations have frequently been described in terms of the absence of stable social ties and resources available to individuals living in such circumstances. Other studies of army wives (13) and men undergoing job loss (14) suggest that social supports may be protective against the harmful health consequences associated with stressful life events.

Furthermore, it repeatedly has been observed that people who are married have lower mortality rates than those who are single, widowed, or divorced (15–17). The relationship between widowhood and increased morbidity and mortality is particularly striking. The results of several investigations (18–21) indicate that widows, especially in the first year following bereavement, have many more complaints about their health, have more mental and physical symptoms, believe they have sustained a

Received for publication April 3, 1978, and in final form July 25, 1978.

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Supported by a National Institute of Mental Health Grant No. T01 MH 13561 and a National Center for Health Services Research Grant No. HS 00368.

The authors gratefully acknowledge the staff of the Human Population Laboratory, California State Department of Health Services (where Dr. Berkman was employed from 1977–1978) for their assistance and support in the preparation of this manuscript. They also thank Dr. Richard Brand, School of Public Health, University of California, Berkeley, for his help with parts of the statistical analyses.

lasting deterioration to their health, and have increased mortality rates. Recent evidence reveals that these differences do not appear to be totally attributable to some primary selection process in marriage (22), homogamy (23), or differences in such risk factors as serum cholesterol, blood pressure, or obesity (24).

The literature cited above provides some preliminary evidence that social and community ties may play some role in the etiology of disease. However, in most of these studies, investigators have not directly measured social contacts. Further, most of these findings have been derived from observations of special population groups such as widowers, army wives, or particular occupational groups. In this paper, results are reported of a study in which the impact of a range of social ties and networks was directly examined in relation to mortality from all causes in a large sample of a general population.

Methods

Study population. The data utilized in this report are based on information collected by the Human Population Laboratory (HPL), part of the California State Department of Health. In 1965, a survey was conducted based on a stratified systematic sample of Alameda County housing units. Institutionalized populations were not included. The sampling procedure, explained in greater detail elsewhere (25), resulted in the selection of 4452 occupied housing units. Each of these units was visited by an enumerator who gathered demographic data on all household members of all ages and left a questionnaire for all persons aged 20 or over, or for younger people who were married. Of the households, 8023 adults were identified as eligible for the study. Of these, 6928, or 86 per cent, finally returned questionnaires. When compared to respondents, the small group of non-respondents included proportionately more older people, males, whites, and single or widowed persons (26). However, the differences between respondents and non-respondents have a negligible effect on population estimates, and respondents have been judged to be a representative sample of adults in the county. The present analysis is restricted to 2229 men and 2496 women between the ages of 30–69.

Mortality follow-up. Mortality data were collected for the nine-year period from 1965 to 1974, when a follow-up survey was conducted. A computer matching file was created with the California Death Registry to obtain the records of those people who died within the state. The exact description of the matching process is given elsewhere (27). Additional out-of-state death clearance information was obtained for those respondents believed to have moved out of state between the two survey periods. Through these methods, death certificates were located for 682 people. Through extensive follow-up in 1974, all but 302 respondents, or 4 per cent, of the original sample were located. Those lost to follow-up were not found to differ markedly on the health measures in the 1965 survey. The collection of mortality data therefore seems to be fairly complete and unbiased.

Statistical analysis. The chi square statistics presented in this paper are based on a modification of the Mantel-Haenszel chi square (28) developed by Brand and Sholtz (29). The Mantel-Haenszel statistic has been modified to include more than two comparison groups. In this paper, the statistic is adjusted for both age and a second covariable of interest, e.g., health practices or socioeconomic status. All age-adjusted mortality rates presented were adjusted by the indirect method (30, 31).

Results

Age-specific mortality rates from all causes for men and women between the

TABLE 1

Age-specific mortality rates per 100 (all causes) men and women, ages 30–69, Human Population Laboratory Study of Alameda County, 1965–1974

Age	No. of respondents	No. of deaths	% died
		Men	
30–39	673	16	2.4
40–49	729	36	4.9
50–59	501	68	13.6
60–69	326	91	27.9
Total	2229	211	9.5 (crude rate)
		Women	
30–39	728	16	2.2
40–49	807	32	4.0
50–59	574	45	7.8
60–69	387	67	17.3
Total	2496	160	6.4 (crude rate)

ages of 30 and 69 are shown in table 1. As expected, women have lower mortality rates than men, and mortality rates increase sharply with age. The age- and sex-specific mortality rates in the Human Population Laboratory sample are similar to mortality rates for Alameda County.

Four sources of social contact. Table 2 shows the age- and sex-specific mortality rates for each of four sources of social contact examined: 1) marriage; 2) contacts with close friends and relatives; 3) church membership; and 4) informal and formal group associations. With few exceptions, respondents with each type of social tie had lower mortality rates than respondents lacking such connections.

In each age and sex group, people who are married have lower mortality rates than the non-married, i.e., separated, widowed, single, and divorced. The relative risks for non-married women compared to married women are approximately 1.4 for each age group. For men, the relative risks in the two younger groups are much larger: 2.9 and 2.1, respectively, for 30–49-year-old men and 50–59-year-old men. The age-adjusted chi square value for the differences in mortality rates among men of different marital status is highly significant; for women, the same chi square value fails to reach statistical significance.

Three questions on the Human Population Laboratory survey comprise an Index of contacts with friends and relatives: 1) "How many close friends do you have?"; 2) "How many relatives do you have that you feel close to?"; 3) "How often do you see these people each month?" Considered individually, none of these questions were important predictors of mortality; however, when combined, they are associated with significant increases in risk. As seen in table 2, in every age and sex category, people who report having few friends and relatives and/or who see them infrequently have higher mortality rates than those people who have many friends and relatives and see them frequently. The age-adjusted chi square values for both men and women are highly significant ($p \leqslant .001$).

It is interesting to note that these differences in mortality rates between people who score high and low on the combined measure of contacts are greater for women than for men. The relative risks for men are 1.8 for men between 30–49 years of age; 1.3 for 50–59-year-old men; and 1.8 for men 60–69 years old. For women in these age groups, the rela-

TABLE 2

Age and sex-specific mortality rates per 100 (all causes) by source of social contact, Human Population Laboratory Study of Alameda County, 1965–1974

	30–49		50–59		60–69		p*
	No.	% died	No.	% died	No.	% died	
			Men				
Marital status							
Married	1227	3.0	446	12.1	268	26.9	$p \leqslant .001$
Non-married	175	8.6	55	25.5	98	33.7	
Contacts with friends and relatives							
High	276	2.9	127	11.0	81	22.2	
Medium	865	3.4	303	14.2	173	24.9	$p \leqslant .001$
Low	236	5.1	62	14.5	59	40.7	
Church member							
Member	391	2.8	168	11.3	88	21.6	$p \leqslant .05$
Non-member	1011	4.1	333	14.7	238	30.3	
Group member							
Member	1066	3.6	394	11.9	223	28.2	ns†
Non-member	336	3.9	107	19.6	103	27.2	
			Women				
Marital status							
Married	1249	3.0	407	7.1	208	14.4	ns
Non-married	286	3.8	167	9.6	179	20.7	
Contacts with friends and relatives							
High	266	1.9	166	6.6	105	11.4	
Medium	1007	2.9	340	7.6	223	17.0	$p \leqslant .001$
Low	239	5.4	57	12.3	42	31.0	
Church member							
Member	484	1.4	217	6.9	152	15.8	$p \leqslant .05$
Non-member	1051	3.9	357	8.4	235	18.3	
Group member							
Member	1005	2.4	347	7.2	173	15.0	$p \leqslant .05$
Non-member	535	4.5	227	8.8	214	19.2	

* Chi square values were calculated for differences in age-adjusted mortality rates among categories.
† Not significant.

tive risks are 2.8, 1.9 and 2.7, respectively.

As shown in table 2, individuals who belong to a church or temple have lower mortality rates than those who do not. These differences are not as large as those observed for other kinds of contacts, i.e., marital status, friends and relatives, although they are consistent. The age-adjusted chi square values are significant for differences in mortality rates among church members and non-members for both men and women ($p \leqslant .05$).

Analysis of mortality by membership in all other groups yields similar findings, as shown in table 2. With the exception of older men, both men and women who belong to one or more formal and informal groups have lower mortality rates than individuals who do not belong to any groups. The differences for men are not significant, although they are significant for women.

In a separate multivariate analysis not shown here, each of the four sources of social contact shown in table 2 was found to predict mortality independently of the other three. However, the more intimate ties of marriage and contacts with friends and relatives were stronger predictors than were ties of church and group membership.

The Social Network Index. To summarize the effects on mortality of increasing social isolation, a Social Network Index was constructed. Briefly, the Social Network Index considers not only the number of social ties but also their relative importance. Thus, intimate contacts are weighted more heavily than church affiliations and group memberships. Four network categories were developed to reflect differences in type and extent of social contact. The procedure by which this Index was developed and the precise description of methods used to score it are available elsewhere (22).

The age- and sex-specific mortality rates from all causes for the Social Network Index are shown in figure 1. The figure reveals a consistent pattern of increased mortality rates associated with each decrease in social connection. The only exception to this pattern is found among women aged 50–59 where those moderately connected had lower rates than those who had the most social ties. The relative risks of those most isolated compared to those with most connections are shown at the base of the figure. For men in the 30–49-year age group, the relative risk is 2.5; for men 50–59 it is 3.2; and for those aged 60–69 it is 1.8. For women, the relative risks are 4.6, 2.1 and 3.0, from the youngest to the oldest age groups, respectively. Age-adjusted relative risks are 2.3 for men and 2.8 for women. The chi square value for the age-adjusted differences in mortality among the four network categories is highly significant ($p \leq .001$).

The relative risks associated with low rank on the Social Network Index are greater than those of any single network

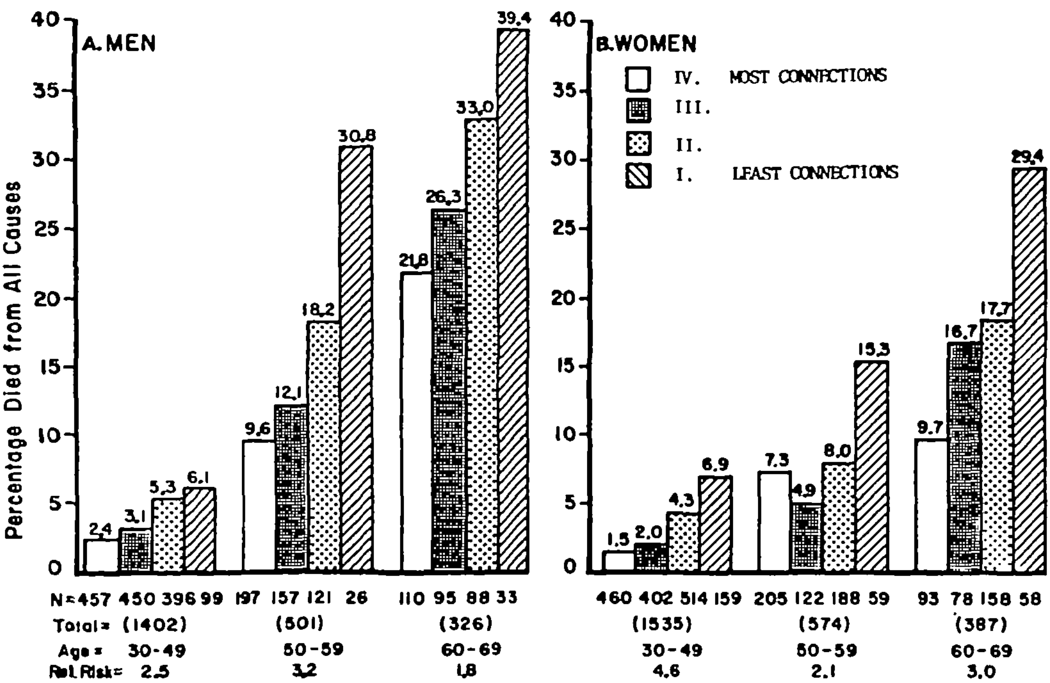

FIGURE 1. Age and sex-specific mortality rates from all causes per 100 for Social Network Index, Human Population Laboratory Study of Alameda County, 1965–1974.

measure or of a combined measure of marital status and contacts with friends and relatives.

The impact of sickness on social networks. While it is apparent that social networks are associated with mortality rates, the reasons for this association are unclear. A commonly expressed hypothesis is that people with few connections are probably sick and physically unable to maintain many ties. This is a difficult problem to assess, but two separate attempts were made to describe the direction of causality.

In the first attempt, the relationship between social networks and mortality was examined while controlling for physical health status at the time of the survey in 1965. Baseline physical health status was assessed by an index developed as a global measure of general physical health (32). This index measures physical health along a spectrum ranging from disability to chronic conditions to symptoms to no health problems.

Age-adjusted mortality rates from all causes, calculated by the indirect method, are shown in table 3 for each category of the Social Network Index and physical health status. From the table it can be seen that the Social Network Index is associated with mortality rates independently of baseline health status. In every category of health status for both men and women, those with the most social contacts have lower mortality rates than those most isolated. The gradient from high to low in the four network categories is consistent with only an occasional deviation and is statistically significant ($p \leq .001$). The gradient is least clear, however, for women who reported having no health problem or few symptoms.

A second approach to this problem was to examine the distribution of network responses by year of death. If physical illness at the time of the survey were responsible for the amount of social disconnection reported during the baseline survey, it would be expected that those ill people would be likely to die in the first years following the survey. Table 4 shows the distribution of the social network responses by year of death. As seen in the table, only a small proportion of the isolates died in the first two years following the survey. Furthermore, among both men and women the percentage of people with few connections who died in the first two years following the survey is similar to the percentage of people with many social contacts who died in that same time period. The figures in this table are not age-adjusted; however it has previously been shown that the Social Network Index is associated with mortality independently of age (see table 3 and figure 1). Though not conclusive, these findings suggest that physical illness alone does not appear capable of accounting for the association between social disconnection and increased mortality rates.

Socioeconomic status. A second potentially confounding factor which might be responsible for the observed association between social connections and mortality is socioeconomic status. In order to explore this issue, the Social Network Index was reduced from four categories to two because of the small number of deaths in some cells. By combining the "connected" and "moderately connected" categories into one category, and the two more isolated categories into another, five categories of socioeconomic status could be maintained.

Measures of income and educational level were used to develop an index of socioeconomic status. Occupation was not used because this resulted in inappropriate coding for women in some instances. Each of the measures, i.e., income and education level, were divided into five categories approximating a normal curve so that the middle category contained approximately a third of the sample, the two surrounding groups included about 20 per cent of the sample in each group, and the two extreme categories included the re-

TABLE 3

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, for Social Network Index and Physical Health Spectrum, Human Population Laboratory Study of Alameda County, 1965–1974

Social Network Index	Physical Health Spectrum									
	Disability	(*n*)	Chronic condition	(*n*)	Symptoms	(*n*)	No health problems	(*n*)	Total	(*n*)
					Men					
I (fewest connections)		(23)*	13.9	(62)		(29)*	8.1	(44)	15.6	(158)
II	28.2	(54)	9.7	(189)	14.3	(152)	8.6	(210)	12.2	(605)
III	18.0	(40)	8.8	(270)	6.0	(181)	5.6	(211)	8.6	(702)
IV (most connections)	18.5	(45)	6.3	(258)	4.8	(183)	5.4	(278)	6.4	(764)
Total (*n*)	22.7	(162)	8.6	(779)	8.1	(545)	6.5	(743)	9.5	(2229)
					Women					
I (fewest connections)	23.0	(53)	8.3	(81)	7.0	(74)	7.7	(68)	12.1	(276)
II	12.2	(112)	8.3	(312)	2.7	(247)	4.5	(189)	7.2	(860)
III	12.8	(55)	4.2	(209)	3.1	(201)	2.8	(137)	4.9	(602)
IV (most connections)	6.6	(72)	2.7	(263)	4.3	(226)	5.1	(197)	4.3	(758)
Total (*n*)	14.1	(292)	5.8	(865)	3.8	(748)	4.5	(591)	6.4	(2496)

* Rates not calculated for cells with 30 or fewer individuals.

TABLE 4

Distribution of Social Network Index responses by year of death for men and women, ages 30–69, Human Population Laboratory Study of Alameda County 1965–1974

Social Network Index	Year of death											
	1965–66		1967–68		1969–70		1971–72		1973–74		Total deaths	
	%	(*n*)	%	(*n*)	%	(*n*)	%	(*n*)	%	(*n*)	%	(*n*)
					Men							
I (fewest connections)	15	(4)	26	(7)	26	(7)	18	(5)	15	(4)	100	(27)
II	19	(14)	18	(13)	21	(15)	21	(15)	21	(15)	100	(72)
III	16	(9)	19	(11)	17	(10)	32	(19)	16	(9)	100	(58)
IV (most connections)	15	(8)	19	(10)	19	(10)	27	(15)	20	(11)	100	(54)
					Women							
I (fewest connections	16	(6)	14	(5)	32	(12)	22	(8)	16	(6)	100	(37)
II	9	(6)	22	(14)	14	(9)	26	(17)	29	(19)	100	(65)
III	4	(1)	22	(6)	19	(5)	22	(6)	33	(9)	100	(27)
IV (most connections)	16	(5)	16	(5)	39	(12)	16	(5)	13	(4)	100	(31)

TABLE 5

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and socioeconomic status, Alameda County, 1965–1974

Social Network Index	Socioeconomic status											
	Lower	(*n*)	Lower-Middle	(*n*)	Middle	(*n*)	Upper-Middle	(*n*)	Upper	(*n*)	Total	(*n*)
						Men						
I and II (fewest connections)	11.8	(86)	12.7	(110)	16.6	(243)	11.7	(242)	7.3	(67)	13.1	(748)
III and IV (most connections	8.0	(89)	11.1	(168)	6.3	(501)	8.1	(498)	4.2	(192)	7.5	(1448)
Total (*n*)	9.9	(175)	11.7	(278)	9.5	(744)	9.1	(740)	5.2	(259)	9.4	(2196)
						Women						
I and II (fewest connections)	9.9	(121)	7.3	(209)	8.2	(431)	6.8	(302)	5.7	(40)	8.0	(1103)
III and IV (most connections)	7.3	(69)	1.1	(151)	4.9	(487)	4.1	(514)	5.2	(123)	4.4	(1344)
Total (*n*)	8.8	(190)	4.6	(360)	6.6	(918)	5.2	(816)	5.4	(163)	6.1	(2447)

maining 15 per cent of the sample in each of those categories. Five new groups were then constructed from the combination of the measures of income and education.

Table 5 shows age-adjusted mortality rates in relation to the Social Network and Socioeconomic Indices. In all five social class categories for both men and women, without exception, those with few social contacts had higher mortality rates than those with many contacts. The chi square values for the differences in mortality rates between the two network risk groups (after adjusting for age and socioeconomic status) were highly significant for both men and women ($p \leq .001$). These data support the conclusion that the Social Network Index predicts mortality independently of socioeconomic status.

Health practices. A third set of factors which might account for the observed association between networks and mortality are health practices. Thus, people who are socially isolated might have engaged in health practices known to be associated with poor health outcomes:

Smoking: Smoking was assessed by smoking status in 1965, i.e., current smoker, past smoker, and never smoked. Table 6 shows the age-adjusted mortality rates within social network and cigarette smoking categories. While there is an association between smoking and the Social Network Index, it can be seen that the mortality gradient among different network groupings persists and is statistically significant ($p \leq .001$) while controlling for smoking status and age.

Obesity: Obesity was measured by the Quetelet Index. This Index adjusts weight for height so that people of comparable proportions are classified together. This Index is calculated as: weight in pounds/(height in inches)^2. Three categories were devised for this index (33): 1) those 10 per cent or more underweight; 2) those between 9.99 per cent underweight and 29.9 per cent overweight; and 3) those 30.00 per cent or more overweight. Age-

TABLE 6

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and smoking history, Alameda County, 1965–1974

Social Network Index	Smoking history							
	Present	(*n*)	Past	(*n*)	Never	(*n*)	Total	(*n*)
				Men				
I (fewest connections	17.2	(91)		(29)*	14.7	(36)	15.8	(156)
II	16.8	(315)	10.1	(139)	5.7	(149)	12.1	(603)
III	10.5	(371)	5.9	(162)	7.2	(165)	8.5	(698)
IV (most connections)	10.2	(348)	6.6	(196)	2.5	(214)	6.8	(758)
Total (*n*)	12.8	(1125)	7.5	(526)	5.5	(564)	9.4	(2215)
				Women				
I (fewest connections)	14.9	(136)	19.8	(31)	7.2	(107)	12.2	(274)
II	7.4	(379)	12.1	(102)	5.8	(365)	7.2	(846)
III	5.1	(276)	2.4	(54)	5.2	(256)	4.9	(586)
IV (most connections)	5.4	(254)	6.5	(83)	3.1	(412)	4.2	(749)
Total (*n*)	7.5	(1045)	9.9	(270)	4.9	(1140)	6.4	(2455)

* Rates not calculated for cells with 30 or fewer individuals.

TABLE 7

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and obesity (Quetelet Index), Alameda County, 1965–1974

Social Network Index	Quetelet Index							
	≥10% underweight	(n)	9.9% underweight–29.9% overweight	(n)	≥30% overweight	(n)	Total	(n)
Men								
I (fewest connections)		(12)*	15.5	(117)		(28)*	15.5	(157)
II		(23)*	11.5	(516)	15.1	(60)	12.5	(599)
III		(18)*	7.8	(609)	11.3	(71)	8.5	(698)
IV (most connections)		(10)*	6.9	(670)	5.9	(79)	6.9	(759)
Total (n)	19.1	(63)	9.2	(1912)	10.0	(238)	9.5	(2213)
Women								
I (fewest connections)		(16)*	10.4	(193)	15.9	(67)	12.1	(276)
II	10.7	(57)	6.6	(629)	8.1	(174)	7.3	(860)
III	9.5	(39)	4.0	(464)	5.9	(99)	4.9	(602)
IV (most connections)		(24)*	4.0	(589)	4.6	(145)	4.3	(758)
Total (n)	10.8	(136)	5.7	(1875)	7.7	(485)	6.4	(2496)

* Rates not calculated for cells with 30 or fewer individuals.

adjusted mortality rates for the Social Network and Quetelet Indices are shown in table 7. Although there were too few numbers in most cells to calculate adjusted mortality rates among those respondents 10 per cent or more underweight, a clear gradient among network categories is observable in the other two weight/height groups. Thus, the Social Network Index predicts mortality independently of obesity ($p \leq .001$).

Alcohol consumption: In table 8 age-adjusted mortality rates are shown for the Social Network Index in relation to alcoholic beverage ingestion. Alcohol ingestion was divided into three categories: 1) those drinking 46 or more drinks a month; 2) those drinking between 17 and 45 drinks a month; and 3) those abstaining or drinking up to 16 drinks a month. Drinks of wine, beer, or liquor were counted equally in this analysis. Among both men and women, the social network-mortality association exists independently of alcoholic beverage consumption. The chi square value for differences in mortality rates among network categories while adjusting for both age and level of alcohol consumption is statistically significant ($p \leq .001$).

Physical activity: Physical activity was assessed by responses to four questions involving how often respondents participated in 1) active sports; 2) swimming or taking long walks; 3) physical exercises; 4) gardening, hunting, or fishing. An index was created based on the degree to which respondents participated in any of these activities. In the Index, the first three activities were given equal weight; and the final item was given half the weight of the first three. Table 9 shows that the differences in mortality risk among network categories do not appear attributable to different levels of physical activity among respondents in network groups. The chi square value for differences in mortality rates among network categories while adjusting for both age and level of physical activity is statistically significant ($p \leq .005$).

A cumulative index of health practices: While these health behaviors, considered one at a time, may not account for the

TABLE 8

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and alcohol consumption, Alameda County, 1965–1974

Social Network Index	Drinks per month							
	46+	(n)	17–45	(n)	0–16	(n)	Total	(n)
				Men				
I (fewest connections)	17.6	(40)	17.9	(38)	13.8	(80)	15.6	(158)
II	20.0	(146)	7.9	(185)	11.5	(274)	12.2	(605)
III	6.4	(164)	5.2	(256)	12.4	(282)	8.6	(702)
IV (most connections)	13.3	(131)	5.1	(242)	6.2	(391)	6.9	(764)
Total (n)	13.2	(481)	6.5	(721)	9.9	(1027)	9.5	(2229)
				Women				
I (fewest connections)	15.9	(31)	9.6	(43)	12.3	(202)	12.1	(276)
II	8.4	(72)	7.0	(176)	7.0	(612)	7.2	(860)
III	6.6	(67)	5.0	(155)	4.6	(380)	4.9	(602)
IV (most connections)	5.8	(49)	4.5	(157)	4.1	(552)	4.3	(758)
Total (n)	8.5	(219)	6.0	(531)	6.4	(1746)	6.4	(2496)

TABLE 9

Age-adjusted mortality rates from all causes per 100 for men and women ages 30–69, by Social Network Index and physical activity, Alameda County, 1965–1974

Social Network Index	Physical activity							
	Least activity	(*n*)	Moderate activity	(*n*)	Most activity	(*n*)	Total	(*n*)
				Men				
I (fewest connections)	18.2	(57)	17.1	(71)		(30)*	15.6	(158)
II	14.4	(150)	12.4	(314)	8.9	(141)	12.2	(605)
III	9.9	(129)	8.8	(377)	6.6	(196)	8.6	(702)
IV (most connections)	9.2	(109)	7.6	(368)	4.4	(287)	6.9	(764)
Total (*n*)	12.4	(445)	9.8	(1130)	5.9	(654)	9.5	(2229)
				Women				
I (fewest connections)	14.8	(137)	8.1	(115)		(24)*	12.1	(276)
II	8.8	(289)	6.3	(444)	5.8	(127)	7.2	(860)
III	7.4	(190)	3.5	(286)	2.3	(126)	4.9	(602)
IV (most connections)	6.0	(173)	4.6	(412)	0.8	(173)	4.3	(758)
Total (*n*)	9.0	(789)	5.2	(1257)	2.9	(450)	6.4	(2496)

* Rates not calculated for cells with 30 or fewer individuals.

association between social networks and mortality, it is possible that a combination of health practices might be responsible for such an association. A cumulative index of seven health practices developed by Belloc and Breslow was used to assess this possibility. A detailed description of the Index and its relationship to physical health has been previously reported (34, 35).

Respondents received a score on this index indicating their number of "good" health practices. One point was received for each of the following practices: 1) does not smoke cigarettes; 2) drinks "moderately" (no more than four drinks per sitting); 3) eats breakfast regularly; 4) does not eat between meals regularly; 5) sleeps seven or eight hours per night; 6) engages in regular physical activity; and 7) is within a certain range of weight for height.

Table 10 shows age-adjusted mortality rates for the Social Network Index and the Index of Health Practices. Examination of the column and row totals shows that both social networks and health practices are strongly associated with mortality. Further, these two variables are associated with one another. At each health practice level, however, the mortality gradient persists among social network level categories although the magnitude of the association is somewhat diminished when health practices are taken into consideration. Differences in mortality rates among the social network groups remain highly significant for both men and women when adjusting simultaneously for age and health practice score ($p \leq .001$).

Health services: Finally, the possibility was explored that the relationship between social networks and mortality, while not due to any health practices, could be due to differential use of medical services by people with few social resources. An index of preventive utilization of health services was developed based on three questions: 1) "Do you have

TABLE 10

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and Health Practices Index, Alameda County, 1965–1974

Social Network Index	Health practices							
	0–4 positive*	(n)	5 positive	(n)	6–7 positive	(n)	Total	(n)
				Men				
I (fewest connections)	21.5	(73)	9.9	(48)	10.5	(37)	15.6	(158)
II	14.6	(251)	11.7	(162)	9.9	(192)	12.2	(605)
III	10.3	(229)	9.9	(215)	6.6	(258)	8.6	(702)
IV (most connections)	7.8	(230)	9.5	(239)	4.2	(295)	6.2	(764)
Total (n)	12.3	(783)	10.2	(664)	6.7	(782)	9.5	(2229)
				Women				
I (fewest connections)	15.2	(123)	8.5	(83)	10.0	(70)	12.1	(276)
II	10.4	(323)	7.5	(272)	4.0	(265)	7.2	(860)
III	5.8	(202)	4.7	(189)	4.3	(211)	4.9	(602)
IV (most connections)	6.5	(191)	2.4	(234)	4.4	(333)	4.3	(758)
Total (n)	9.3	(839)	5.6	(778)	4.7	(879)	6.4	(2496)

* Good health practices.

health insurance?"; 2) "Have you had a dental check-up in the past year, even though you felt well?"; 3) "Have you had a medical check-up in the past year, even though you felt well?" Respondents who had both dental and medical check-ups in the past year were classified as high scorers. Low scorers were respondents who had neither a dental nor a medical check-up although they may have had health insurance; moderate scorers included all other respondents.

Age-adjusted mortality rates for the Social Network Index and an index of preventive utilization of health services are shown for men and women in table 11. This table reveals that people who use preventive health services have slightly lower mortality rates than those who make little or moderate use of such services. People with few social contacts are less likely to use such preventive services. The social network gradient in mortality, however, is still seen in each health care category, with some deviation in pattern. While this measure of health services may not be a sensitive measure of use of preventive health care, variations in mortality observed among people with different kinds of social contacts are not accounted for by the more obvious differences in use of preventive health services ($p \leq .005$).

Discussion

The preceding analyses have shown that social and community ties are associated with risk of mortality. Four sources of social relationships were examined: 1) marriage; 2) contacts with close friends and relatives; 3) church membership and 4) informal and formal group associations. In each instance, people with social ties and relationships had lower mortality rates than people without such ties. Each of the four sources was found to predict mortality independently of the other three; the more intimate ties of marriage and contact with friends and relatives were stronger predictors than were the ties of church and group membership.

TABLE 11

Age-adjusted mortality rates from all causes per 100 for men and women, ages 30–69, by Social Network Index and level of preventive care, Alameda County, 1965–1974

Social Network Index	Level of preventive health care							
	Low	(n)	Medium	(n)	High	(n)	Total	(n)
				Men				
I (fewest connections)	15.4	(49)	9.7	(48)		(29)*	14.2	(126)
II	11.4	(162)	9.8	(203)	9.2	(118)	10.2	(483)
III	7.8	(180)	6.5	(236)	4.5	(170)	6.1	(586)
IV (most connections)	5.8	(181)	5.6	(241)	6.1	(197)	5.8	(619)
Total (n)	8.6	(572)	7.8	(728)	6.9	(514)	7.7	(1814)
				Women				
I (fewest connections)	6.8	(66)	11.4	(78)	8.4	(50)	8.8	(194)
II	8.4	(171)	5.4	(241)	5.4	(236)	6.1	(648)
III	2.7	(115)	6.7	(199)	4.0	(184)	4.7	(498)
IV (most connections)	3.6	(117)	3.5	(238)	3.6	(253)	3.6	(608)
Total (n)	5.6	(469)	5.6	(756)	4.6	(723)	5.2	(1948)

* Rates not calculated for cells with 30 or fewer individuals.

To assess the cumulative effects of these ties and relationships, a Social Network Index was created based on these four sources of contact. When the sample was stratified according to the level of social contact and source of affiliation, the most isolated group of men was found to have an age-adjusted mortality rate 2.3 times higher than men with the most connections; for women who were isolated, the rate was 2.8 times higher than the rate for women with the most social connections. For every age group examined, and for both sexes, people with many social contacts had the lowest mortality rates and people with the fewest contacts had the highest rates. The relative risks between these groups range from just under 2 to over 4.5.

The association between the Social Network Index and mortality was found to be independent of self-reported physical health status at the time of the survey, year of death, socioeconomic status, and such health behaviors as smoking, alcohol ingestion, physical inactivity, obesity, and low utilization of preventive health services, and a cumulative index of health practices.

On the basis of the findings in this study, future research might focus on more sophisticated network models tapping many more dimensions of social and community ties. Of particular interest is the number of possible relationships that place an individual in a particular risk category. For instance, people who were not married but who had many friends and relatives were found to have mortality rates equal to those who were married but who had fewer contacts with friends and relatives. Similarly, it did not seem important whether contacts were among friends or relatives; it was only in the absence of either of these sources of contacts that there was a significant increase in the risk of death during the follow-up period. Trade-offs and substitutions such as this assured that about 60 per cent of the sample, through one kind of contact or another, managed to maintain reasonably low mortality risk. It was only in the presence of mounting social disconnection, when individuals failed to have links in several different spheres of interaction, that mortality rates rose sharply.

Limitation of mortality data. Two limitations involved with the use of mortality data have implications for the conclusions which can be drawn from these results. First, there is the continuing thought that people who died during the nine-year follow-up period were ill at the time of the initial survey. The association between physical health status as determined at the baseline survey and subsequent mortality supports this suspicion. It is therefore possible that the relationship between networks and mortality is due to the fact that isolated people were ill at the time of the survey and were unable physically to maintain extended contacts. This is a serious issue and one which was explored in some depth. The results presented do not support this possible explanation. While controlling for health status at the time of the baseline survey, the Social Network Index continued to predict mortality. In an analysis of year of death, it was shown that the percentage of isolated people who died in the first years following the survey is similar to the percentage of people with many social contacts who died in that same period. If these two analyses involved valid and accurate indicators of illness status at the time of the survey, it does not appear likely that the relationship between networks and mortality is merely a reflection of underlying poor health. On the other hand, if these measures are not valid and accurate indices of health status in 1965, this issue remains unresolved.

The second limitation of mortality data is also related to the association between mortality and morbidity. Throughout this research, the implication has been that social factors influence susceptibility to disease, i.e., disease incidence. In fact, from studies involving mortality data, it is unknown whether the risk factors influence disease incidence or "survival time" between the incidence or diagnosis of disease and death. It should be noted that in either case, host resistance may be the involved mechanism. Previous work on social supports and incidence of pregnancy complications (13) and on cultural and social mobility and coronary heart disease (4) suggests that social factors are capable of influencing disease incidence; however, from the data in this study, it cannot be concluded which end of the disease spectrum is most influenced by social networks.

Mechanisms. Although the hypothesis has been supported that social and community ties may be protective against a wide variety of disease outcomes, the mechanisms by which networks influence health status remain unclear. A critical issue is how social isolation might affect health status. It is interesting to note that the Network Index was found to be associated not only with overall mortality but with four separate causes of death: ischemic heart disease, cancer, cerebrovascular and circulatory diseases, and a category including all other causes of death, e.g., diseases of the digestive and respiratory system, accidents, and suicide. Since social isolation is associated with so many causes of death, it is possible that there are several pathways that might lead from social isolation to illness. One pathway might be through the use of health practices which may lead to poor health consequences. The association between isolation and such practices suggests that this is likely. However, since health practices do not seem capable of explaining more than a small part of the social network/mortality association, other pathways must also be involved.

A second pathway may be through psychological responses to isolation such as depression or changed coping and appraisal processes. Such psychological responses might predispose an individual to suicide or to risk-taking behavior which could result in accidents. It has been suggested that the critical role psychosocial factors play in the causation of disease is not due to stressful objective circumstances, but to the way in which these circumstances are more subjectively perceived and mediated by the individual. In an analysis of psychological factors, social networks, and mortality to be presented in another paper, it was found that none of the psychological factors developed from items from the 1965 Human Population Laboratory survey mediated between social networks and risk of mortality. The correlations between the psychological factors and networks were only moderate, and in all cases the Network Index continued to predict mortality independently of psychological status. It should be noted, however, that the Human Population Laboratory psychological items were not originally created as mediating variables between social circumstances and health outcomes and may therefore not tap the crucial dimensions of such psychological factors.

Another pathway might lead directly from social isolation to physiologic changes in the body which increase general susceptibility to disease. Previous research on the impact of the social environment on a wide range of health outcomes suggests that many social "risk factors," e.g., poverty, migration, may not be etiologically specific for any single disease (36). Kaplan et al. (37), Cobb (38) and Antonovsky (39, 40) recently have proposed that social and community ties may serve as important factors in promoting host resistance to disease. These investigators have proposed that stressful social circumstances such as lack of social ties and resources may alter host susceptibility and consequently would be expected to be associated with a wide range of disease outcomes and with increased morbidity and mortality rates. Nervous, hormonal, and immunologic control systems have frequently been invoked as potential pathways by which stressful circumstances might cause disease. Evidence is clear from animal experiments that stressful social circumstances may modify control systems leading to changes in health status (41–44). Adequate tests of the hypothesis that social circumstances alter general susceptibility to disease in humans will not be possible, however, until data are available on physiologic mechanisms capable of mediating the relationship between social events and disease outcomes.

The role which stressful social circumstances play in the causation of disease may be dependent upon their absolute strength and their strength relative to other causal agents. Thus, when agents are particularly pathogenic and exposure is widespread, the effects of social factors may be small. However, when disease agents are less obviously pathogenic or virulent, social factors may play a significant role in determining variations in health status. The findings from this study suggest that social circumstances such as social isolation may have pervasive health consequences; and they support the hypothesis that social factors may influence host resistance and affect vulnerability to disease in general.

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