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Social Relationships and Mortality among Older People in Taiwan*

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I. Introduction

Social relationships are generally conceptualized as consisting of two major components: Social networks and social support. As the

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structural aspect of social relationships, social networks are often defined as the existence or quantity of relationships. Social support is commonly used to refer to the quality or functional contents of the relationships (Berkman, 1985; Cohen and Wills, 1985). Since the early 1970s, the quantity and quality of social relationships have been increasingly recognized as risk factors of mortality and morbidity (Berkman, 1985; Cassel, 1976; Cobb, 1976; House and Kahn, 1985). According to a recent review, prospective studies consistently show increased risk of death among persons with a low quantity, and sometimes low quality, of social relationships (House, Landis, and Umberson, 1988). However, this conclusion is primarily based on studies conducted in the United States (Berkman and Syme, 1979; Blazer, 1982; Hessler et al., 1990; House, Robbins, and Metzner, 1982; Schoenbach et al., 1986; Seeman, 1987; Steinbach, 1992) and Europe (Grand et al., 1990; Hanson et al., 1989; Jylha, 1989; Kaplan et al., 1988; Orth-Gomer and Johnson, 1987; Welin et al., 1985).

Findings from Oriental societies are relatively sparse and less consistent. For instance, Fujita and Hatano (1990) did not find any statistically significant linkages between social networks and 3-year mortality in a sample of 3,580 elderly Japanese residing in three socio-economically diverse communities. In another study of 1,889 elderly rural residents in Japan, social networks were found to be significantly associated with 5-year mortality in only two out of the four age and gender subgroups: men between 65 and 74 years of age and women 75 years of age or over (Yasuda and Ohara, 1989). A recent prospective study of 2,200 elderly Japanese people suggested that social participation and social support are directly or indirectly

related to mortality (Sugisawa, Liang, and Liu, 1994). In a study of 1,054 Hong Kong Chinese aged 70 years or over, the risk of mortality during a 2-year follow-up period was significantly related to marital status but not to any other measures of social networks and social support, including living arrangement, social contacts, integration into the community, social participation, and tangible support received (Ho, 1991). On the other hand, there are some indications that social relationships in terms of marital status and family support have a significant impact on mortality, and this effect may interact with age (Hu, 1987; 1988). Given these mixed findings, additional research is required in order to reach a more conclusive assessment of the effects of social relations on mortality in the Japanese and Chinese elders.

Berkman (1984) noted the lack of strong influences of social networks and social support on mortality in highly cohesive and well integrated populations such as women in Tecumseh and Japanese Americans in Hawaii. She speculated that in communities where a high level of social contacts and support exist, very few people are sufficiently isolated to reveal a significant increase in risk of death. Another possibility is that social contacts are so much a part of routine in the lives of the respondents that they go unnoticed or unreported (Berkman, 1984).

However, there are several confounding factors which must be addressed before the hypotheses offered by Berkman (1984) can be entertained seriously. First, almost all studies of Japanese and Chinese elders described earlier were conducted in very limited geographic areas; therefore the generalizability of their findings is somewhat constrained. Data representative of more diverse popula-

tions such as those derived from a national probability sample would be particularly useful in extending the generalizability of the empirical observations. Second, in these studies, the quality of social relationship measures was uneven. Whereas measures of social networks were generally included, measures of social support were often not available as predictors.

Third, with a few exceptions, previous studies in the Western and Oriental nations employed binomial logistic regression in their analyses. This procedure ignores the amount of time that elapsed before an event occurred and does not control for censoring (Petersen, 1991). Even when techniques of dynamic analysis such as Cox proportional hazard model were used, little attention was paid to mortality as a function of time (See Sugisawa et al., 1994 as an exception). With reference to the research question of this study, the risk of dying during a four-year period, the shape or the functional form of the survival curve as a function of time is critical. This information simply cannot be obtained by using logit analysis. As a result, conventional analyses have focused almost exclusively on the relative importance of determinants of mortality, while insufficient attention has been directed to the dynamic aspect of this transition. Furthermore, ignoring censorship may lead to biased parameter estimates. Application of the hazard rate approach helps solve both of these problems.

Finally, like many studies conducted in the Western countries, a single equation approach was employed in the studies of older people in Japan and Hong Kong. Assuming that the model is correctly specified, a single equation approach only yields estimates of direct effects, whereas it is quite possible that social networks and

social support may influence mortality indirectly through other variables. For instance, both social networks and social support have been found to be highly correlated with self-rated health, which in turn is a consistent and significant predictor of mortality (Fujita and Hatano, 1990; Idler and Kasl, 1991). The causal linkages among social networks, social support, and mortality may not be fully revealed, because of the oversimplification inherent in the single equation framework. Explication of the causal mechanisms underlying the relationships among social networks, social support, and mortality will certainly facilitate the comparison and synthesis of research findings across the world and lead to new knowledge. For example, in the Oriental societies, social relationships may affect mortality in a manner which is quite different from that in the Western countries.

The purpose of this research is to further assess the effects of social relations on old age mortality in Taiwan. Examining the linkages between social relations and mortality within diverse socio-cultural settings is critical in testing the robustness of the observed effects of social networks and social support. Consistent replications of certain observations under vastly different conditions will reinforce the validity of these observations. Conversely, if the empirical findings cannot be replicated under certain circumstances, they will provide valuable clues toward the identification of possible interaction or specification effects and the exploration of alternative causal mechanisms. As Taiwan differs greatly from developed countries such as the United States and European nations in socio-cultural conditions, it provides an ideal setting for a further examination of the relationships between social ties and mortality.

In addition, the present research attempts to address the limitations identified above. First, to extend the generalizability of the findings beyond limited geographical areas, this analysis involved data collected from a national probability sample of some 4,000 Chinese elders. Second, a rather comprehensive set of variables was employed in the analysis of mortality risk. These included socio-demographic characteristics, social relationships, physical health, and health behaviors. Specifically, in addition to social networks, measures of social support were included as predictors of mortality. Third, hazard rate models were employed to analyze the direct effects of social relationships while emphasizing the time-function associated with death. Fourth, on the basis of the proposed causal framework, the indirect effects of social networks and social support on the risk of dying were also assessed.

II. Model Specification

A multi-equation causal model explicating the causal linkages among social networks, social support, and mortality is presented in Figure 1. This model consists of three classes of variables: (1) exogenous variables including socio-demographic characteristics and social relationships, (2) mediating variables consisting of physical health and health behavior, and (3) the dependent variable, mortality. In the proposed model, both social networks and social support are assumed to have a direct and negative impact on the risk of dying (Berkman and Syme, 1979; House, Robbins, and Metzner, 1982; Seeman, 1987).

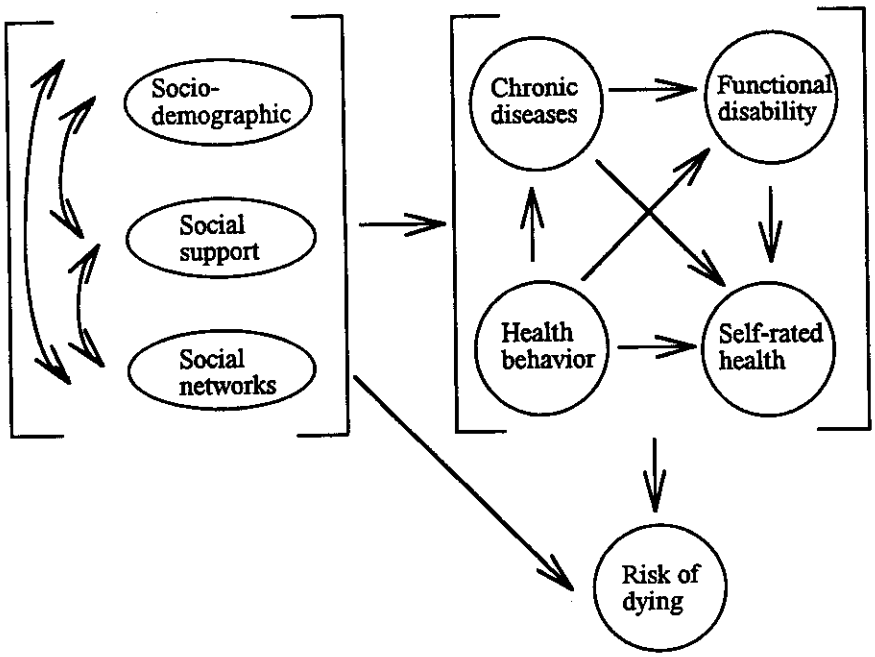

Figure 1: Theoretical Framework of Factors Affecting Mortality for the Chinese Elderly

As shown by Figure 1, both social networks and social support are exogenous variables because their causes are not generated within this framework. Although these two explanatory factors are assumed to be correlated, they may not necessarily be causally linked (Antonucci, 1990; Berkman, 1984; Ell, 1984; O'Reilly, 1988). Furthermore, social networks and support are specified as correlated with socio-demographic variables (Antonucci, 1990).

In addition to social networks and social support, a number of factors are assumed to have direct effects on the mortality in old age. These include socio-demographic characteristics, chronic dis-

eases, functional disability, self-rated health, and health behavior (Breslow, 1983; Coale and Demeny, 1966; Ho, 1991; House, Kessler, and Herzog, 1990; Idler and Kasl, 1991; Kaplan and Camacho, 1983). In analyzing the direct effects of social networks and social support on mortality, these factors are considered to be control variables because they may confound the direct linkage between social relationships and death among the elderly population.

Socio-demographic characteristics, social networks, and social support are also hypothesized to influence physical health status (i.e., chronic diseases, functional status, and self-rated health) and health behavior directly. Finally, given the substantial correlations among chronic diseases, functional status, self-rated health, and health behavior, it is critical to specify their interrelationships. Specifically, self-rated health is assumed to be directly affected by chronic diseases and functional status, whereas functional status is directly influenced by chronic diseases (Liang et al., 1991). Moreover, health behavior is postulated to exert a direct impact on all three dimensions of physical health (Breslow, 1983). It is, therefore, conceivable that some of these variables may not have a direct impact on mortality. For instance, effects of chronic diseases and health behaviors may be mediated through functional status and self-rated health (Blazer, 1982; Fujita and Hatano, 1990; Ho, 1991; Idler and Kasl, 1991).

III. Methods

1. Sample and data

The baseline data were collected from April to October in 1989, through a national survey of adults aged 60 and over in Taiwan. The survey involved a stratified three-stage probability sampling design. In the first stage, 30 townships in mountainous areas with largely aboriginal populations were eliminated from 361 townships in Taiwan, and the remaining 331 townships were stratified into 27 strata by urbanity, educational levels, and total fertility rate. A stratified sample of 56 primary sampling units (PSU) was selected with probability proportional to the size of total population (PPS). In the second stage, blocks or secondary sampling units (SSU), were selected with PPS so that 2 respondents were selected at random within each block. Names of potential respondents were obtained from the Household Registries.

A total of 4,049 interviews, including 180 proxy cases, were completed successfully from the list of 4,412 names, constituting a response rate of 91.8 percent. Excluding proxy interviews, the response rate was 87.7 percent. Major reasons for nonresponse were "no such person at the address and unable to trace" (42%), refusal (13%), death (10%), "no such address" (8%), poor health (3%), and other (e.g., ineligible or went abroad; 25%). A comparison was made between the completed sample and the total population aged 60 and above in Taiwan from the Household Registration data as of the end of 1988. The sample was found quite similar to the elderly population in Taiwan with a very slight over-representation of males and younger-old.

2. Measurement

The survival status for each respondent was followed during a four-year period, from 1989 to 1993. For those who had died during this period, the time of death was recorded. Of the 4,049 respondents contacted in 1989, 569 died during the subsequent four years, and 54 individuals were lost to our follow-up survey in 1993. For each respondent who died, the duration in months that elapsed before death since the date of interview in 1989 was recorded with the exception of 19 deceased respondents whose dates of death were unknown. All survivors are regarded as the right-censored cases and their duration of survival in this period is 48 months, because the current research concentrates on the mortality within four years. That is, the survival status after 1993 was not considered in the present analysis. Due to missing values on one or

Table 1: Age Distribution of Respondents Who Died between 1989 and 1993

Age Group	Frequency	Percentage
60-64	46	10%
65-69	100	22
70-74	95	21
75-79	96	21
80-84	70	15
85+	43	10
Total*	454	100%

* A total of 569 respondents died between 1989 and 1993. Some 20 percent or 115 deceased respondents were excluded due to missing information on one or more variables. Percentages may not add up to 100 due to rounding.

more variables, 454 cases or 80 percent of death were included in the analysis. Table 1 presents the age distribution of these deaths.

Four socio-demographic variables were constructed. Gender was defined as a dummy variable, with male coded as 0 and female as 1. Age was measured in terms of the actual years of age at the time of wave I survey in 1989 on the basis of dates of birth or self-reported age. Educational attainment was indexed by the total number of years in school. Ethnicity was measured as a dummy variable, with the Mainlanders coded 1 and others 0.

Four measures of social networks were included: Marital status, size of household, social contact, and social participation. Marital status was a dummy variable, with "not currently married" coded as 0 and "currently married" as 1. Size of household was defined as the number of persons living in the household, including the respondent. Social contact was assessed by the number of neighbors and friends in contact, whereas social participation was operationalized in terms of the attendance in seven types of organizations including religious group, business association, volunteer group, political group, community center, clan association, and retirement organization. As we did before, they are treated as dummy variables, with "no participation at all" coded as 0, and all else as 1. Since there were nearly 900 persons who did not respond to the question regarding social contact, two dummy variables instead of one, were created. In one dummy variable, "no contact at all" was coded as 1 and all else was coded as 0. In the other variable, "at least one contact" was coded as 1 and all else was coded as 0. The effect of social contact on mortality should be examined through comparing the

regression coefficients of these two dummies. When both are zero, nonresponse is indicated.

Measures of social support included emotional and instrumental support. Emotional support consisted of two five-point scales assessing (1) the amount of love and caring the respondent can expect from her significant others and (2) the willingness of significant others to listen to the personal problems and inner feelings of the respondent. As each respondent was asked these two questions with reference to each of the three types of significant others (i.e., spouse, children, other relatives, and friends), there were six indicators all together. Given that not all respondents had all three types of significant others and that the level of social support varied across the type of significant others, a scheme was necessary to combine these indicators. Having experimented with several approaches, we found the most robust and satisfactory one to be the following. That is, with a given type of emotional support, the strongest level of support provided by the three types of significant others was used. For instance, if a respondent could expect "a great deal of" (score 5) loving and caring from the spouse, "quite a bit" (score 4) from her children, and "a little" (score 2) from other relatives and friend; then she was given a score of 5 on the expected support in terms of loving and caring. This is because in the present research, we are concerned with whether a respondent can expect a certain level of support regardless the source of such support. Similarly, instrumental support was measured by two 5-point scales indicating the amount of sick care and financial assistance from the significant others.

The respondent's sense of loneliness was ascertained by a three-point scale: (1) little, (2) some, and (3) strong. Loneliness is the unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively (Peplau, 1985). Therefore, loneliness is a function of both social networks and social support. Although in the current research literature loneliness is viewed to be distinct from social networks and social support (Rook, et. al.,1985; de Jong-Gierveld, 1987), it can be treated as an cognitive assessment of the adequacy of one's social networks and social support.

We also created five variables indicating status of health and health behavior. Self-rated health was measured by a five-point scale: (1) poor, (2) fair, (3) good, (4) very good, and (5) excellent. Objective health was indicated by the number of chronic diseases reported by the respondents. Functional disability was measured by a composite consisting of three indicators of the degree of difficulty in bathing oneself, climbing 2 or 3 flights of stairs, and walking about 200-300 meters or a few blocks. A higher score indicates a higher degree of functional disability. Health behavior was indicated by two variables: drinking and smoking. Both were measured by dummy variables, with current drinking and smoking coded as 1 and all else as 0.

Table 2 presents the distributions of the respondents on these explanatory and control variables for the effective sample by excluding the cases with missing data from the total sample. Although there were 379 missing cases, the pattern of the distributions for the effective sample appears very close to that for the total sample.

3. Data analysis

A hazard rate model was employed to ascertain the direct effects of social networks and social support on mortality. Here,

Table 2: Life Table Indicators of Survivorship Since First Interview: Taiwanese Elderly Persons, 1989-93

Month since 1st interview m	Number of survivors at beginning l (m)	Number of deaths D (m)	Number exposed to risk L (m)	Probability density function p (m)	Hazard function μ (m)	Cumulative proportion surviving S (m)
0	3995	8	3991	0.0020	0.0020	0.9980
1	3987	10	3982	0.0025	0.0025	0.9955
2	3977	9	3973	0.0023	0.0023	0.9932
3	3968	8	3964	0.0020	0.0020	0.9912
4	3960	10	3955	0.0025	0.0025	0.9887
5	3950	15	3943	0.0038	0.0038	0.9849
6	3935	11	3930	0.0028	0.0028	0.9821
7	3924	11	3919	0.0028	0.0028	0.9794
8	3913	11	3908	0.0028	0.0028	0.9767
9	3902	7	3899	0.0018	0.0018	0.9749
10	3895	16	3887	0.0041	0.0041	0.9709
11	3879	18	3870	0.0046	0.0047	0.9664
12	3861	11	3856	0.0028	0.0029	0.9637
13	3850	12	3844	0.0031	0.0031	0.9607
14	3838	14	3831	0.0036	0.0037	0.9572
15	3824	12	3818	0.0031	0.0031	0.9542
16	3812	14	3805	0.0037	0.0037	0.9507
17	3798	15	3791	0.0039	0.0040	0.9470
18	3783	11	3778	0.0029	0.0029	0.9443
19	3772	19	3763	0.0050	0.0050	0.9396
20	3753	12	3747	0.0032	0.0032	0.9366
21	3741	12	3735	0.0032	0.0032	0.9336
22	3729	10	3724	0.0027	0.0027	0.9311
23	3719	12	3713	0.0032	0.0032	0.9218
24	3707	17	3o99	0.0046	0.0046	0.9238
25	3690	10	3685	0.0027	0.0027	0.9213

Table 2: continued:

Month since 1st interview m	Number of survivors at beginning l (m)	Number of deaths D (m)	Number exposed to risk L (m)	Probability density function p (m)	Hazard function μ (m)	Cumulative proportion surviving S (m)
26	3680	8	3676	0.0022	0.0022	0.9193
27	3672	4	3670	0.0011	0.0011	0.9183
28	3668	8	3664	0.0022	0.0022	0.9163
29	3660	10	3655	0.0027	0.0027	0.9138
30	3650	12	3644	0.0033	0.0033	0.9108
31	3638	13	3632	0.0036	0.0036	0.9075
32	3625	11	3620	0.0030	0.0030	0.9048
33	3614	15	3607	0.0042	0.0042	0.9010
34	3599	17	3591	0.0047	0.0047	0.8968
35	3582	11	3577	0.0031	0.0031	0.8940
36	3571	10	2566	0.0028	0.0028	0.8915
37	3561	7	3558	0.0020	0.0020	0.8897
38	3554	14	3547	0.0039	0.0039	0.8862
39	3540	8	3536	0.0023	0.0023	0.8842
40	3532	13	3526	0.0037	0.0037	0.8809
41	3519	6	3516	0.0017	0.0017	0.8794
42	3513	15	3506	0.0043	0.0043	0.8756
43	3498	14	3491	0.0040	0.0040	0.8721
44	3484	17	3476	0.0049	0.0049	0.8678
45	3467	16	3459	0.0046	0.0046	0.8638
46	3451	10	3446	0.0029	0.0029	0.8613
47	3441	11	3436	0.0032	0.0032	0.8585
48	3430	4	3428	0.0012	0.0012	0.8575
49	3426					

each respondent is assumed to be subject to an instantaneous risk, $h(t)$, of dying, where $t = 0, 1, 2, ..., n$. The function, $h(t)$, is referred to as the hazard function and is analogous to the force of mortality. The hazard is closely related to the more familiar survival function, $S(t)$, such that $S(t) = \exp(-\int h(u)\, du)$, a well-known equation in life table analysis.

A Weibull distribution of the hazard function was used to model the time function of mortality among the elders. This was based on the observation that among the elderly population, mortality usually goes up with increases in age (Coale and Demeny, 1966). The hazard function for this distribution is given by

$$h(t) = \lambda p(\lambda t)^{p-1} \exp(X'B) \qquad (1)$$

where λ is the underlying hazard rate, and p is a parameter specifying the shape of the survival curve. X is a vector of explanatory variables and B is a vector of coefficients. The value of p is expected to be greater than 1, which implies a monotonically increasing hazard function. The parameters of this model are estimated by maximum likelihood (Tuma and Hannan, 1984). A parametric method such as the Weibull distribution, which provides an explicit specification of the shape of the time function, was particularly appropriate, because a major objective of this research was to describe survival as a specific function of time.

Ordinary least squares regression was used to assess the interrelationships among socio-demographic characteristics, social relationships, physical health, and health behavior. The results provided the basis for assessing the indirect effects of social relationships on mortality.

IV. Results

1. Time function of death

A life table of discrete hazard rates and survival function was first constructed in order to identify the time function of death between 1987 and 1990 (Table 3). In Table 3, Column 1 indicates the particular month after the survey. Column 2 gives the number of

Table 3: Percentage Distribution of Taiwanese Elderly Persons by Selected Variables: 1989 National Sample

Selected variable	Percentage distribution	
	effective sample	total sample
Gender		
male	57.5%	57.1%
female	42.5	42.9
sample size	3670	4049
Age		
< 65	36.3%	35.1%
65-69	28.9	28.3
70-74	17.8	18.1
75-79	10.9	11.2
80-84	4.1	4.7
85 and over	2.0	2.6
sample size	3670	4011
Education		
0	49.2%	50.4%
1-6 years	31.4	30.8
7-9	8.5	8.1
10-12	5.8	5.7
13 and over	5.1	5.1
sample size	3670	4031

Table 3: continued:

Selected variable	Percentage distribution	
	effective sample	total sample
Ethnicity		
native Taiwanese	77.7%	77.8%
mainlander of foreign-born	22.3	22.2
sample size	3670	4049
Marital status		
not currently married	34.0%	35.7%
currently married	66.0	64.3
sample size	3670	4049
Size of household		
1 person	9.8%	9.8%
2	16.6	16.5
3	10.4	10.8
4	9.9	9.7
5	12.0	11.8
6	13.4	13.4
7	10.4	10.5
8	6.4	6.4
9	3.3	3.2
10 and over	7.9	7.9
sample size	3670	4049
Social contact		
no contact	4.7%	4.7%
at least one contact	74.8	73.2
unknown	20.5	22.1
sample size	3670	4049
Social participation		
no participation	60.4%	61.5%
at least one participation	39.6	38.5
sample size	3670	4049

Table 3: continued:

Selected variable	Percentage distribution	
	effective sample	total sample
Emotional social support		
0-2 unit	2.1%	2.2%
3-4	21.7	22.0
5-6	35.7	35.4
7-8	40.5	40.4
sample size	3670	3877
Instrumental social support		
0-2 unit	9.2%	13.1%
3-4	22.3	21.6
5-6	32.4	30.6
7-8	36.2	34.7
sample size	3670	4048
Number of chronic diseases		
no disease	23.3%	23.1%
1 disease	20.1	19.6
2 diseases	16.3	16.5
3 diseases	12.3	12.3
4 and over	28.0	28.5
sample size	3670	4048
Self-rated health		
excellent	17.2%	16.7%
very good	22.0	21.1
good	38.4	36.9
fair	18.6	17.9
poor	3.8	7.4
sample size	3670	4049

Table 3: continued:

Selected variable	Percentage distribution	
	effective sample	total sample
Functional disability		
no disability	72.4%	70.9%
1-3 limitations	20.5	20.2
4-6	5.2	5.6
7-9	1.9	3.3
sample size	3670	3958
Smoking		
no	64.6%	65.4%
yes	35.4	34.6
sample size	3670	4048
Drinking		
no	78.3%	78.8%
yes	21.7	21.2
sample size	3670	4049
Feeling of loneliness		
never	78.4%	77.8%
rarely	6.6	6.8
sometimes	9.8	10.0
most of the time	5.1	5.4
sample size	3670	3896

respondents who were at risk of dying at the beginning of each month. Since there were no censored cases before the 36th month, the average of two adjacent rows of Column 2 provides the estimate of the number of older adults exposed to the risk of dying within each month, which is often referred to as person-years of exposure. Column 3 shows the actual number of deaths that occurred at each month after the survey. The three survival functions, q_j, $h(t)$, and

$S(t)$, are displayed in Columns 4, 5, and 6. The hazard rates are shown to be identical to corresponding probabilities because the width of interval is 1 and the fraction of death within each month is small.

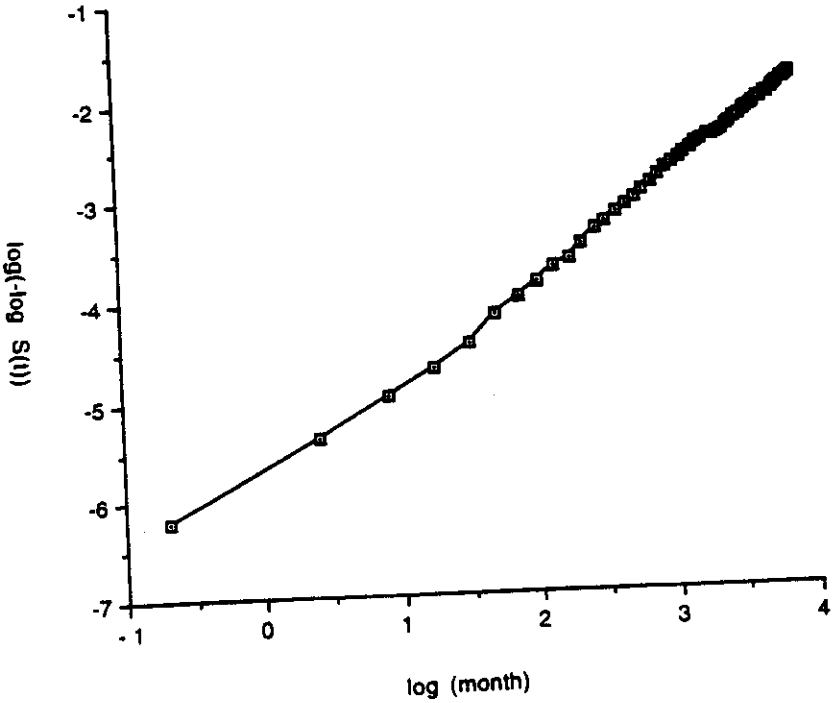

Figure 2: Testing of Weibull Function

While the sequence of hazard rates does not directly indicate a clear distribution of timing at death, the plot of ln(-ln $S(t)$) versus ln (duration) does. Given that a Weibull distribution defines a plot of ln(-ln $S(t)$) versus ln time to be approximately linear (Lawless, 1982), such a plot was used to test whether the time function of death in this research serves the Weibull distribution. The plot

shows an approximately straight curve and, therefore, using a Weibull distribution in this context is reasonable. As indicated earlier, a monotonically increasing hazard rate of mortality over the 4-year duration was expected.

2. Direct effects of social networks and social support

Table 4 presents the results from survival analysis using Weibull model. Interpreting the parameter estimates is much like interpreting unstandardized linear regression coefficients. For instance, the coefficient of .0676 for age means that each additional year of life increases the log of the hazard by .0676, controlling for other variables. The antilogarithm of each regression coefficient (e^b), often referred to as the hazard ratio, is also displayed in order to show the multiplicative effects of the explanatory variables. When the explanatory variable is a dummy variable, the exponentiated coefficient has an intuitive meaning of relative risk. For example, the e^b for gender (i.e., 1 = female, 0 = male) is .540 which means the risk of a woman dying is only 54 percent of the hazard of mortality for a man, other factors being equal. In the case of a continuous variable, the hazard ratio depends on the product of the regression coefficient and the value of the explanatory variable. Computing $100(e^b-1)$ gives the percentage change in the hazard with each one unit change in the explanatory variable (Tuma and Hannan, 1984).

Among the four measures of social networks, only marital status (i.e., 0 = not married, 1 = married) shows a statistically significant direct effect on mortality. With a regression coefficient of -.279, those currently married had a risk of dying which was only 76 percent of that for unmarried respondents. Household size, social contacts, and social participation do not have any statistically

significant direct effects on mortality in the 4-year reference period. On the other hand, emotional support has a direct but negative impact on the hazard rate, whereas instrumental support does not have a statistical significant effect on mortality. A one-point increase in emotional support reduces the risk of mortality during the 4-year period by 7.5 percent. Feelings of loneliness were not found to be significantly related to mortality.

Table 4: Results of Hazard Rate Regression on the Mortality of Taiwanese Elderly Persons Between 1989 and 1993: Waybull Model

Explanatory variables	Coefficient	e^{b}
Gender	-0.6168**	0.5396
Age	0.0676**	1.0699
Education	0.0044	1.0043
Ethnicity	-0.1111	0.8949
Marital Status	-0.2787**	0.7568
Size of household	0.0043	1.0042
No social contact	-0.2001	0.8187
At least one contact	0.0712	1.0738
Social participation	-0.1056	0.8997
Emotional social support	-0.0771*	0.9258
Instrumental support	0.0375	1.0382
Chronic diseases	0.0043	1.0043
Self-rated health	-0.3143**	0.7303
Functional disability	0.1676**	1.1825
Smoking	0.2525**	1.2872
Drinking	-0.4851	0.6156
Feeling of loneliness	0.0424	1.0433
Intercept	-8.2598	0.0003
Shape [a]	1.2273**	
Log-likelihood	-1556.6866	
Sample size	3666	

[a] This parameter is tested by (p - 1.0)/S.E.

* $0.01 < p \leq 0.05$, one-tail; ** $p \leq 0.01$

With reference to socio-demographic characteristics, gender and age have rather substantial and statistically significant direct effects on the hazard rate of death. In particular, the probability of women dying during the 4-year period was only 54 percent of that for men. For each additional year of age, the relative risk of dying increases by 7 percent.

Among the variables of physical health and health behavior, self-rated health, disability, and current smoking have significant and direct effects on the hazard rate of death. With a five-point scale (i.e., 5 = excellent health, ... 1 = poor health), an improvement of each additional point reduced the log of the risk of dying by .314 or decreased the relative risk of death by 27 percent. With each additional point on the disability scale, the risk of dying increases by 18 percent. Current smokers also have a risk of dying which is 29 percent higher than that of nonsmokers'. In contrast, chronic diseases and current drinking do not have statistically significant direct effects on mortality.

The statistically significant estimate of the shape factor with respect to the Weibull model suggests a monotonically increasing pattern of hazard rate, as expected. That is, the chance of experiencing a death rises as this population ages.

3. Survival functions

The results of the hazard rate model was explicated by presenting the survival curves of relevant risk groups. The reason was that hazard rates are unobservable and lack intuitive meaning. Moreover, whether statistically significant differences in hazard rates

can translate into strong differences in timing depends on the magnitude of the baseline hazard rate (Teachman, 1983).

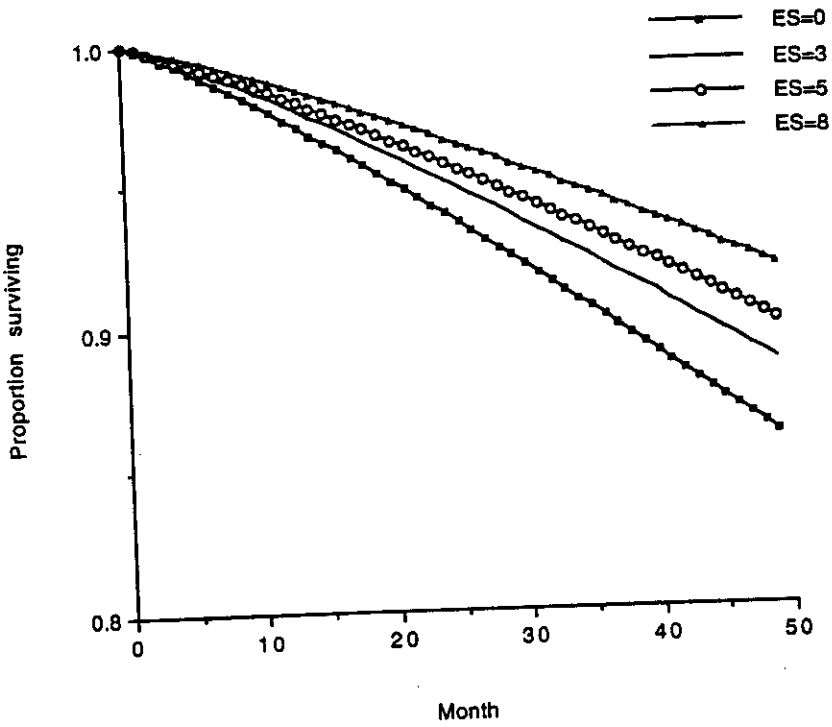

Figure 3: Survival Curves of Four Groups of Emotional Support: Taiwanese Elders

As an illustration, in the following we present the survival curves for the four levels of emotional support that was shown to have a strong direct impact on mortality in the event history analysis. In estimating these survival curves, the values of all the other explanatory variables were fixed at their sample means. Figure 2 depicts the results of fitting the four survival curves for emotional support by Weibull model. The separation of these four curves is

striking and clearly illustrates the magnitude of the differentials in timing of death by these four groups. At each time point, an individual who had more emotional support was expected to have a considerably higher chance of survival than those who never did so, other things equal.

4. Relationships among explanatory variables of mortality

The hazard rate models executed above only reveal the direction and magnitude of the direct effects of social relationships on death. In order to obtain some insights concerning the indirect influences of these factors, a linear regression analysis was employed to predict each of the other endogenous variables considered in the theoretical framework (Table 5). We concentrate on the models predicting self-rated health, disability, and smoking because they are related to both social relationships and mortality. Among the measures of social networks, marital status and social contact are shown to have a statistically significant effect on self-rated health. That is, older adults who are married and have at least one social contact are much more likely to report better health, other things being equal. Given the direct linkage between self-rated health and chance of dying as shown in Table 4, it may be inferred that social networks influence mortality indirectly through self-rated health.

Emotional support has a significant positive impact on self-rated health, as indicated by Table 5. This implies that emotional support may improve self-rated health, which in turn would lead to a reduction in the hazard of death for the Japanese elderly people. Therefore, emotional support may affect mortality both directly and indirectly via self-rated health. Similarly, as the sense of loneliness has a statistically significant effect on self-rated health, loneliness

may have an indirect effect on mortality also. In addition, chronic diseases and functional disability are also shown to have indirect influences on mortality via self-rated health.

Table 5: Structural Regression Coefficients for Direct Relationships among Explanatory Variables: Taiwanese Elderly Persons, 1989 (N= 3666)

Explanatory variables	Dependent variables				
	Self-rated health	Number of diseases	Functional disability	Smoking [a]	Drinking [b]
Intercept	3.2868	1.0304	-2.8856	-3.9243	-1.4857
Gender	-0.1015**	0.5644**	0.0019	3.0481**	2.0658**
Age	0.0020	0.0271**	0.0517**	0.0419**	0.0352**
Education	0.0132**	-0.0668**	-0.0102	0.0480**	-0.0111
Ethnicity	0.1816**	0.0480	-0.0037	0.4080**	-0.2390**
Marital status	-0.0792**	0.4182**	-0.0041	0.1377	0.0012
Size of household	0.0022	-0.0116	0.0191**	0.0266**	-0.0059
No Social contact	0.0783	0.3473	-0.1791	0.3162	-0.4407**
At least one contact	0.1104**	-0.0246	-0.3184**	0.0775	-0.3365**
Social participation	-0.0026	0.1883**	-0.2929**	-0.1041	-0.2237**
Emotional social support	0.0436**	0.0185	-0.0308	0.0082	0.0707**
Instrumental support	0.0116	-0.1360**	0.0278	0.0330	-0.0204
Chronic diseases	-0.1488**		0.1680**		
Functional status	-0.1686**				
Smoking	-0.0066	-0.2630	0.0105		
Drinking	0.0756	-0.4269	-0.2270		
Feeling of loneliness	-0.1059**	0.6294**	0.1733**	-0.0312	0.0763
R^2	0.3622	0.1123	0.2039		
Likelihood ratio				1148.5730	560.3600

[a, b] The results for "Smoking" and "Drinking" are derived from the binomial logistic regression models.

* $0.01 < p \leq 0.05$, one-tail; ** $p \leq 0.01$

We also found evidence that a variable may have an indirect effect on mortality not only via self-rated health but also through one or more other intermediate variables including functional status

and smoking (See Table 5). For instance, social relationships may also influence the hazard of death via disability and smoking. In particular, household size and feelings of loneliness have a positive effect on disability, whereas social contact and social participation have a negative impact. Household size is also positively related to smoking. Finally, in addition to the direct effects of age and gender on mortality, socio-demographic factors including age, gender, education, and ethnicity may have indirect effects on mortality through self-rated health, functional health, and smoking.

Although these findings are in general consistent with the hypothesis that poor social relationships lead to poor health, caution should be exercised in suggesting that household size causes disability. Given that measures of social relationships and health status were all obtained at wave I in 1989, endogeneity may be a concern in that the causal link between household size and disability may be misspecified. As disabled elderly individuals are more likely to need family support, they are more likely to live with their families. Therefore, instead of a cause, household size may be a consequence of disability.

There are at least two possible approaches to deal with the endogeneity problem. One rather conventional practice calls for the exclusion of the given variable from the equation. However, this may lead to misspecification, given that household size is correlated with other predictors such as age, gender, education, and other indicators of social relationships in the equation. Within this context, the inclusion of the household size variable here was meant to control for the association between disability and household size so that the partial regression coefficients associated with other

variables will not be biased. The other approach involves the specification of simultaneous linkages between disability and household size. In this regard, either an instrumental variable needs to be identified or longitudinal data are required. Given that disability and household size were assessed at the same time, these were not viable options for this analysis. Moreover, regression analysis was also undertaken by excluding household size as a covariate, and the results remained largely the same with the exception that education and emotional support became significant at the .10 level.

It should be noted that our assessment of the above indirect effects is based on the implicit assumption that an indirect effect is statistically significant because the component paths are all significant. However, this is a necessary condition but not a sufficient condition. As a result, the statistical significance associated with the indirect effects remain to be determined. In the present research, many indirect effects involve a composite of linear as well as non-linear effects. As such, the indirect effect is no longer a constant but depends on the value of the independent variable which has a non-linear effect on the dependent variable. More importantly, there is no known procedure for deriving the standard error associated with such an indirect effect. Consequently, statistical significance tests cannot be performed.

V. Discussion

This research represents a step toward the explication of mechanisms underlying the observed association between social

networks, social support and mortality. In the proposed model, physical health and health behavior are hypothesized as mediating the effects of social networks and social support on mortality. That is, social relationships influence the risk of dying both directly and indirectly through physical health and health behavior. In particular, among the four measures of social networks considered in the present research, marital status is shown to have a strong impact on mortality, and this effect remains statistically significant when other factors are controlled. Moreover, marital status is found to have indirect effects on the mortality of Chinese elders, through its linkages with self-rated health. On the other hand, household size, social contacts, and social participation influence the risk of mortality indirectly via measures of health and health behavior such as self-rated health, disability, and smoking.

Consideration must also be given to the association between social support and mortality. A statistically significant direct effect of emotional support on mortality is found in this study. In addition, the findings suggest an indirect impact of social support on death through its close linkage with self-rated health. That is, more emotional support leads to improved self-rated health which in turn reduces the chance of dying. As a cognitive assessment of one's social networks and social support, sense of loneliness also influences the risk of dying through its effects on chronic diseases, functional status, and self-rated health. The above observations underscore the importance of undertaking empirical analyses within a causal framework. Hence, conclusions derived from the single equation approach, as employed in most previous studies, might be

misleading because the interrelationships among the various factors are overlooked.

Although the time lag between social relationships and mortality is well defined in this research, this is not the case with reference to the linkages between social relationships and physical health. As a result, a hypothesis of reciprocal linkages between social relationships and health status cannot be ruled out. To empirically examine this hypothesis, at least two waves of observations on social relationships and physical health are needed in addition to the follow-up of survival.

The lack of direct effects of drinking, number of diseases, and functional status on morality needs to be discussed. This may be largely due to the nature of relationships between self-rated health and variables such as diseases, functional status, and drinking. Given that some 60 percent of the variance in self-rated health is accounted for by diseases and functional status (Liang, et. al., 1986), it is conceivable that one's assessment of physical health is based on illness and disability. As a result, the effects of diseases and functional status on mortality are mediated through self-rated health. Although drinking and smoking were considered to be significant predictors of survival, empirical results are not always conclusive. Furthermore, many studies did not include self-rated health as a control variable. It is plausible that the effects of health behavior are manifested through self-rated health, as one rates one's physical health by taking his or her health behavior into account. Finally, cultural differences in the causal mechanism underlying the relationships between health behavior and mortality is a distinct possibility.

Empirical observations concerning the effects of social relationships on mortality in the elderly population in non-western societies have been relatively few and rather limited. Based on prospective data derived from a national probability sample of elderly people in Taiwan, this research has provided additional and significant information concerning the impact of social relationships on the risk of dying in old age. In contrast to the relatively inconclusive findings from previous studies of older people in the Orient (Fujita and Hatano, 1990; Ho, 1991; Yasuda and Ohara, 1989), this research has replicated the empirical results obtained in the western developed nations and Japan.

Although the present research has addressed the issues discussed above, several directions for future research need to be noted. First, as suggested by many investigators, inadequate conceptualization and measurement remain a major problem with studies concerning the impact of social relationships (Antonucci, 1990; Berkman, 1984; House and Kahn, 1985). Although it has long been recognized that social networks and social support are multi-dimensional entities with multiple causes and consequences, there has been little consensus concerning their structures and properties. Unless much more is known about the dimensions of social relationships and the structural linkages among them, relatively little progress can be expected in our understanding of why only certain aspects of social relationships influence mortality and other aspects do not.

Second, whereas the primary concern of this research is the main effects of social relationships on mortality, the possibility of interaction effects due to ascribed social status such as gender need

to be considered. For instance, to what extent can the same causal mechanism underlying the association between social relationships and mortality be applied to men and women alike? As suggested by Nathanson (1977), sex differences entail several important dimensions including biological makeup, exposure of stress, life style, and institutional role. Consequently, gender not only may exert a main effect but also can interact with the effect of social relationships in influencing mortality. Moreover, with reference to adult development across life course women are much more likely to be family and kin centered while men tend to invest more into occupational endeavors (Hagsted, 1990). Given the greater importance of social relationships to women's role definition and self image, one may hypothesize that social relationships will have a greater impact on mortality among women than men. An empirical evaluation of this hypothesis seems to be a reasonable next step of this research.

Third, only mortality during a period of four years has been examined. Conceivably, a longer period of follow-up in mortality and other health outcomes may reveal additional information concerning the time function, particularly beyond the four-year period of observation. As more information regarding the hazard functions associated with old age mortality becomes available, comparisons across different studies will be greatly facilitated and our knowledge concerning health changes in old age will be advanced.

Fourth, ordinary least squares regression in conjunction with hazard rates models was used to ascertain direct and indirect effects of social relationships on mortality. The inferences concerning the

indirect effects of social relationships need to be done in a more systematic and explicit manner. The estimate of the magnitude of the indirect effect and its standard error within an integrated framework cannot be derived easily because of the mixture of linear regression analyses and the multiplicative specifications inherent in the hazard rate approach. This is particularly true when multiple intermediate variables are involved as in the proposed model. Currently, this issue is statistically intractable, and a more refined statistical approach is yet to be developed.

Fifth, in this research all explanatory and control variables were measured at the time of the survey in 1989. Explanatory variables such as social networks and social support may change substantially over time, and such changes may have a major impact on the risk of mortality. Thus, the effects of some covariates may be time-varying, and this possibility needs to be considered seriously in the future.

Sixth, as suggested by Berkman (1984), more attention needs to be directed to the impact of social relationships on specific health outcomes. Accordingly, in addition to total mortality, cause-specific mortalities may be subject to similar analysis in terms of their connections with social networks and social support. Furthermore, given the growing interest in active life expectancy, the risk of dying needs to be related to those of diseases and disability in a dynamic perspective. Conceivably, these linkages can be analyzed in a multidimensional framework.

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