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The forgotten griever: A nationwide follow-up study of mortality subsequent to the death of a sibling

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Abstract. Previous findings suggest that the loss of a family member is associated with mortality among bereaved family members. The least studied familial relationship in the bereavement literature is that of siblings although loss of a sibling may also involve health consequences. The authors conducted a follow-up study based on data from the Swedish total population register, covering the period 1981 to 2002. Using Cox regressions, mortality risk ratios of bereaved and non-bereaved persons aged 18-69 years were estimated. All-cause and cause-specific mortality (unnatural causes, natural causes, cardiovascular disease, cancer, suicides, accidents, and all other causes) were examined. In men, the mortality risk of bereaved persons was 1.26 (95% CI: 1.22-1.30) that of non-bereaved persons, and in women it was 1.33 (1.28-1.39). An elevated mortality risk associated with a sibling's death was found in all age groups studied, but the association was generally stronger at younger ages and could be observed predominantly after more than one year of follow-up. There was an increased death risk also if the sibling died from a discordant main cause, which may strengthen the possibility that the association observed is not due to confounding alone.

Medical subject headings: Bereavement, stress, grief, mortality, sibling, register, Sweden

INTRODUCTION

People linked through social ties have interdependent health. Illness or death in one person may consequently influence the health of another person to whom she is connected (1). Studies have found that the loss of a spouse, parent, or child is associated with health and mortality among bereaved family members (2-5). The most conclusive evidence on this matter concerns the so-called widowhood effect (1), which is thought to demonstrate the health consequences by grief and isolation. In general, bereavement is suggested to adversely affect health through both acute psycho-physiological mechanisms, which has been observed to follow episodes of intense psychogenic shock, (2, 6-8) as well as through longer-term mechanisms involving changes in health-related behaviours such as smoking, increased alcohol consumption, and poor diet and exercise habits (2, 3, 8).

The least studied familial relationship in the bereavement literature is that of adult siblings (9-11). Surviving siblings can consequently be considered as 'forgotten grievers', whose loss and pain are insufficiently acknowledged (12, 13). To the extent that siblings are also beloved and provide companionship or behavioral norms, one would expect that loss of an adult sibling, just as loss of a spouse, would be associated with mortality. In fact, the death of a sibling often represents the loss of the longest and most intimate relationships of a person's lifetime (14). The level of grief following sibling loss might therefore be as severe as grief associated with other types of losses such as losing a parent (11, 15).

There is an extensive literature on the impact of sibling loss during childhood on behavioural problems, emotional disturbances, depression and sleeping difficulties (16-17), as well as on somatic symptoms such as abdominal pain, stomach aches, headaches, hysterical pain, asthma, convulsive states and ulcerative colitis (17-19). By contrast, the health consequences of sibling loss during adulthood have been largely overlooked (20), which is surprising when considering that the loss of a sibling is much more frequent among adults. It

could be that losing an adult sibling has less impact compared to the death of other family members (spouse, children) since adult siblings normally do not live together (21). The adult sibling relationship is also characterised by lower frequency of contact when compared to other familial relationships (11). Some evidence although suggests elevated mortality after the loss of an adult twin (22), that bereaved adult siblings report lower overall health and life satisfaction, and that they have higher risk of hospitalization and disablement (23).

The potential health consequences following the death of a sibling are expected to vary across the life course. The significance of the sibling relationship presumably weakens as the siblings grow older and other relationships become relatively more significant (24). The association between the death of a sibling and the mortality risk of the remaining sibling might hence be weaker at older ages than at younger ages. The association may depend on the nature and time since the death, reflecting the intensity of bereavement (5), and maladaptive coping behaviours can take a longer time to develop compared to acute psycho-physiological reactions.

An important threat to causal inference is the possibility that the death or ill health of two or more persons in the same siblings group share a common prior cause, i.e., that there is confounding of the relationship by an unobserved third variable. For example, if a sibling dies of a chronic disease with a strong genetic component (e.g. lung failure caused by cystic fibrosis) and another sibling dies shortly later, this may be a marker of genetic or biological similarity. Another possibility is that the death of both siblings originates from factors related to shared childhood environment and living conditions (e.g. material circumstances, life styles, parental education etc.). One method of getting closer to causal inference is to examine deaths due to specific causes among pairs of siblings. Separating natural and unnatural deaths, and dissecting these further by the main cause of death, may assist in teasing out causation from confounding.

Our aim was to conduct a large-scale study on health consequences following the loss of a sibling at adult age, using intergenerational linked data from nationwide Swedish registers. We postulated that the association between loss of a sibling and mortality among bereaved siblings will depend on the age at which a person experiences a sibling's death, the time interval since the sibling's death, and the nature of death. We also aimed to get closer to causal inference by studying whether sibling's died of the same specific cause or discordant cause.

MATERIALS AND METHODS

The data come from the Swedish Work and Mortality Data Base (HSIA). HSIA is a multiple-linked data of national Swedish routine registers. The data linkage and use of the data for research purposes was approved by the Regional Ethical Review board of Karolinska Institutet in 2002-11-11 (decision no. 02-481). All persons born in Sweden during the period 1932-1962 and alive at end-1980 were linked to the mother, provided that she was born in Sweden and alive at end-1980. Hence sibling groups are identified through the mother. Persons born to mothers with only one child were excluded from analysis. Individuals were stratified into five different groups consisting of people who experienced sibling loss at ages 18-29 years, 30-39 years, 40-49 years, 50-59 years, and 60-69 years. We included individual-level information about basic socio-demographic variables (age, socioeconomic status, marital status, number of children, number of siblings, region of residence, and calendar year), as well as the month and cause of death for all persons who died during the period 1981-2002. We distinguished natural and unnatural deaths. The former category was further divided into deaths from cardiovascular diseases, cancer, and other diseases, whereas the latter category consisted of suicides, accidents, and other external causes. The ICD codes are provided in the footnotes of Table 1 in the next section.

In conformity with the death of a sibling, which is the key variable of interest, age and calendar year are time-varying. The latter two were used as continuous variables, but alternative categorisations did not affect the results reported here. All other variables were measured at the end of 1980, which was before any sibling death had occurred. Socioeconomic status distinguished blue-collar workers, white-collar workers, self-employed, and people outside the labour market. Marital status consisted of the categories married, previously married, and never married. Number of children and number of siblings were treated as categorical variables. Region of residence refers to each person's county of residence and consisted of 26 different categories.

All persons in the mentioned cohorts were observed over time with regard to a sibling's and their own death. At the point in time when a person died, the surviving sibling changed status from being a non-bereaved to being a bereaved person. The death of a sibling refers to the first death of a person in a siblings group. Hence, in a group with three siblings where one died in August 1983, say, the two surviving siblings become bereaved persons from that date, and they were subsequently observed with regard to their own death. All persons who experienced a sibling's death during the study period (1981-2002) were included into analyses, whereas those who did not experience a sibling's death whatsoever comprised a ten per cent random sample. In the data presentation and statistical estimations, people in each of these two groups were weighted according to their sampling proportion, and all confidence intervals were calculated from corrected t-statistics. Using Cox regressions, we estimated mortality risk ratios of bereaved and non-bereaved persons.

RESULTS

A total of 80,888 men and 79,700 women experienced the death of a sibling (Table 1). The total number of sibling deaths was 72,949. The crude mortality rate (the number of deaths in

relation to the number of person years) was notably higher, or more than twice higher, in bereaved than in non-bereaved persons. The relative difference is smaller in older ages than in younger ones. In absolute terms, the difference between bereaved and non-bereaved increases over age groups, because of an overall increase in mortality with age. Bereaved women have lower mortality rates than bereaved men. As related to non-bereaved persons, however, the mortality rate of bereaved women is slightly higher than that of bereaved men, which is confirmed by the estimation results reported below.

--TABLE 1 HERE--

In younger adult men (18-29 years), the relative mortality risk (RR) associated with sibling loss was 1.83 that of non-bereaved persons (95% confidence interval; 1.16-2.88) when control variables were included (Table 2). The association was lower at older ages, i.e., 1.55 at ages 30-39 years (95% CI; 1.31-1.82), 1.45 at ages 40-49 years (1.34-1.56), and 1.19 at ages 50-59 years (1.13-1.25) and 60-69 years (1.12-1.26). Bereaved women were somewhat more vulnerable than bereaved men, especially at younger ages (<40 years). The mortality risk of women aged 18-29 years who had lost a sibling was 2.19 (1.08-4.41). In those aged 30-39, 40-49, 50-59, and 60-69 years, the risk ratios were 1.83 (1.48-2.26), 1.45 (1.32-1.60), 1.36 (1.28-1.45), and 1.17 (1.08-1.26), respectively. Results of analyses where data on both sexes were pooled (not shown) still revealed that the sex difference in the association between death of a sibling and mortality among bereaved siblings cannot be considered statistically significant, except for in the age group 50-59 years. Both natural and unnatural causes of death in siblings raised the mortality risk of the surviving sibling, with the exception of unnatural deaths experienced by people in the oldest age group. In the youngest ages, unnatural sibling deaths had a stronger association with mortality among bereaved siblings than natural sibling deaths, while the strength of associations was relatively similar in other age groups.

--TABLE 2 HERE--

The association between the death of a sibling and mortality among bereaved siblings were substantially stronger in the longer-term than in the short-term (Table 3). At ages 30-39 years, for instance, the mortality risk of bereaved men during the first year after sibling loss was 1.18 (0.84-1.68), whereas it was 1.69 (and statistically significant) for longer follow-ups (2-5 years and >5 years). A similar pattern, which indicates a notable increase in the mortality risk beyond the first year of bereavement, was observed for both sexes and for both main causes of death, and in most age groups. In the oldest, mortality in bereaved persons during the first year after a sibling's death was even lower than that of non-bereaved persons, but the difference was not statistically significant.

--TABLE 3 HERE--

Examining the causes of death among surviving siblings, we found excess death risks for both natural and unnatural causes in all age groups but older males (50+) (Table 4). In general, unnatural sibling deaths had a stronger association with mortality among bereaved siblings than natural sibling deaths, irrespective of whether natural or unnatural deaths in the index persons were studied. Also natural sibling deaths raised the mortality risk from both natural and unnatural causes, however. This association between discordant causes of death between siblings makes confounding by biological similarity and shared social conditions less likely.

--TABLE 4 HERE--

A more detailed categorisation, where we pooled age groups to obtain reasonable levels of statistical power, revealed that there are associations with regard to practically all combinations of main causes of death (Table 5). A strong association is naturally found for concordant causes. Bereaved men whose siblings died from a cardiovascular disease had an own risk of dying from a cardiovascular disease that was 1.64 (1.49-1.81) that of non-

bereaved men. The corresponding estimate for concordant causes for cancer is 1.25 (1.13-1.37), for other diseases 2.08 (1.83-2.36), for suicides 2.42 (1.85-3.17), for accidents 1.30 (0.87-1.95), and for other external causes 2.33 (1.25-4.35). The pattern for women was similar. It should be noted, however, that there are associations also between most discordant causes, which strengthens our claims that the association is unlikely to be due to confounding alone.

--TABLE 5 HERE--

DISCUSSION

This large-scale follow-up study based on the Swedish population register found that the death of a sibling was associated with an overall increased mortality in surviving siblings, but that the strength of the association was dependent on the age of the bereaved persons, the duration of follow-up, and partly the cause of sibling's death.

In adulthood, the death of a sibling may have a significant impact on the individual when it involves the loss of a companion, source of emotional support, and practical aid. It may serve as a vivid and disturbing marker of one's own mortality with implications for health (23). Because the death of a sibling has been considered to have less impact than the death of other family members, the social support system may be unprepared to respond appropriately to the grieving sibling's needs (11, 14).

Our findings suggest increased mortality following the death of a sibling in all adult age groups studied. The associations are comparable and, in some instances, stronger than those of child and parental deaths (5, 25). The present findings are consistent with studies indicating that the level of grief following the loss of a sibling is comparable to, or even exceeds that associated with other types of familial loss (11).

At younger ages in particular (18-39 years), there was a notable elevation in mortality associated with the death of a sibling. Because there is little expectation of the death of a sibling at these ages, it may involve high immediate stress levels, strong feelings of grief, greater difficulty in accepting the death, and fewer available coping strategies (26, 27). The excess mortality risk at younger ages may also reflect grief processes within the family. Parents who lose a child often become preoccupied and absorbed with their own grief and posttraumatic stress. Under such circumstances, they may be unprepared to respond to the needs of the remaining children (14). The fact that the social support system primarily focuses on the bereaved parents may leave remaining siblings unsupported in their grief process. Such circumstances might lead to adverse health consequences for bereaved siblings at younger ages, especially in the longer-term perspective (15).

We generally found stronger associations between the death of a sibling and mortality among bereaved siblings over the longer-term follow-up (>1 year) than in the short term (the first year after a sibling's death). Adult siblings normally live separate lives and have their own families. It is possible that their primary network (spouse and children) can help them cope with the grief in the immediate aftermath and therefore postpone the association for some years. Maladaptive coping behaviours may also emerge over a period of some years, leading to a time-lag in the association between sibling loss and mortality among the bereaved sibling. Accordingly, some previous research finds adverse mortality consequences only after the first year subsequent to the death of a twin (22).

Sibling deaths from natural causes and from unnatural causes had fairly similar consequences on bereaved persons in the older age groups (40-69 years). At younger ages, unnatural causes of siblings' death had a stronger impact than natural causes. This might reflect an increased exposure to posttraumatic stress disorder, which may follow the

unfortunate circumstance of losing a sibling at young age through an accident, homicide or suicide (28, 29).

By and large, we found an increased risk of dying from both natural and unnatural causes regardless of the sibling's type of death. Additional analyses of ours also revealed associations for most sibling-wise combinations of more specific causes of death such as cardiovascular disease, cancer, accidents and suicide. If the association was confounded by an unobserved third variable (such as genetic similarities between siblings or shared childhood environment and family effects), we would have expected a relationship only in cases when siblings died of the same cause. The excess mortality risk was although generally weaker when siblings died of a discordant main cause. However, among men aged 50+ we found no elevated mortality risk when siblings died from disparate causes (natural/unnatural), which might indicate that they are particularly vulnerable to diseases with shared genetic predisposition or to social health determinants that originate from shared childhood conditions and experiences.

Despite the obvious strengths of this study such as the use of total population register data, longitudinal follow-up, reliable information on mortality and other included variables, some limitations should be noted. More detailed individual information is required to uncover the actual causal mechanisms that link siblings' mortality risks, which could minimize the possibility of omitted variable bias. Ideally, one would like to have access to biological and genetic data, detailed information on diseases from medical records and more information on shared childhood social environment and family characteristics which is unfortunately not included in the registers. Another shortcoming is the lack of indicators on the quality of the relationship and frequency of contact between siblings which might relate to the risk for adverse health outcomes. To proxy this issue, we included information on whether siblings were of same sex, close in age, and lived in geographical proximity to each other. These

variables, to some extent, showed associations in the expected directions (associations were somewhat stronger when siblings were of same sex, close in age and lived in a geographical proximity to each other), but were left out of the final results presented, since they did not improve the fit of the models and had practically no impact on the estimates presented here. We also checked that maternal mortality during follow-up was not a plausible cause of two siblings' death. Heterogeneity in the study population was reduced by restricting the analyses to people born in Sweden, with parents born in Sweden. At the same time, this delimitation excludes possibilities to draw conclusions about the immigrant population residing in Sweden. Associations between death of a sibling and mortality among bereaved siblings may differ among foreign-born people due to, for instance, cultural differences in coping behaviour. Another drawback with the data used is that siblings groups could be constructed only if the mother was alive at the beginning of the observation period. Based on official vital statistics, we approximate that roughly 80 per cent of mothers of the relevant birth cohorts were alive at this time. If sibling groups with a deceased mother (i.e., those who could not be observed in our dataset) differ greatly from those analysed here, we have an inference problem. We do not think that this is a major impediment with regard to the association between the death of a sibling and mortality among remaining siblings, but still aim to overcome the problem in future studies by adopting additional data linkage to include information about deceased parents as well.

Although we found associations between the loss of a sibling and mortality among bereaved siblings from discordant main causes of death, there remains a possibility of residual confounding. For example, if a person dies of liver cirrhosis and the surviving sibling dies shortly thereafter in a car accident they are coded as dying from discordant causes. Yet, it could be that the siblings shared a genetic vulnerability to alcoholism and this, rather than bereavement *per se*, contributed to the death of both siblings.

The results indicate that the healthcare system should care about broader collateral health effects when dealing with terminally ill patients and their families (1). Most discussion has been on bereavement after the death of a spouse or a parent while siblings could be considered as "forgotten grievers". Our findings illustrate that a siblings death can have adverse health consequences also on adult siblings. A caring and emotional attitude displayed by health care professionals have positive effects on recovery from grief (30) and should be of significance also for bereaved siblings. It seems important that psychological support is provided not merely for parents, but also for siblings during end-of-life care as well as after the death. Considering that their loss and pain are often insufficiently acknowledged by the parents and the informal social support system (11, 14), it is important that physicians and healthcare professionals acknowledge bereaved siblings. Our findings conform also to the view that it is important for health care workers to follow and support bereaved siblings over time and in a longer-term perspective (31). The assessment of medical interventions and medical care might alter substantially if benefits and costs incorporate collateral health effects (1). Yet, more research is required on the specific types of efforts that are needed in order to support bereaved siblings. An especially important task for future research is also to furnish the relative importance of underlying mechanisms linking sibling deaths and mortality in bereaved siblings, such as deterioration of health behaviours, and onset of acute psycho-physiological stress mechanisms. Such information could give health care professionals guidance in how to effectively mitigate adverse health by bereavement. Testing such mechanisms requires data with much more detailed longitudinal information than was available here.

To our knowledge, this study provided the first large-scale evidence for mortality associated with the death of a sibling at adult age. Considering the substantial adverse impact

of sibling loss we have found here, more research on the health consequences and underlying mechanisms are suggested.

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Table 1. Number of deaths and person years by sex and age group of the index persons in the Swedish Work and Mortality Database (HSIA), 1981-2002

	All ages	Ages 18-29	Ages 30-39	Ages 40-49	Ages 50-59	Ages 60-69
Men						
# bereaved persons	80,888	2,796	12,589	27,637	29,128	9,008
# non-bereaved persons	810,756	322,011	710,085	841,368	560,953	176,035
# deaths in bereaved persons	3,839	19	150	740	1,679	1,251
# deaths in non-bereaved persons	45,646	1,496	5,547	13,078	17,581	7,944
# person years in bereaved persons	671,820	11,132	82,933	225,993	263,506	88,257
# person years in non-bereaved persons	18,559,670	1,783,397	5,392,925	6,874,318	3,790,235	718,795
mortality rate (×1,000) in bereaved persons	5,7	1,7	1,8	3,3	6,4	14,2
mortality rate (×1,000) in non-bereaved persons	2,5	0,8	1,0	1,9	4,6	11,1
Women						
# bereaved persons	79,700	2,656	11,932	26,565	29,061	9,486
# non-bereaved persons	777,328	305,644	679,375	811,994	545,396	177,780
# deaths in bereaved persons	2,466	8	90	458	1159	751
# deaths in non-bereaved persons	27,348	586	2,851	8,176	10,941	4,794
# person years in bereaved persons	663,934	10,518	80,285	219,369	261,508	92,255
# person years in non-bereaved persons	17,984,212	1,717,522	5,148,960	6,627,697	3,740,853	737,441
mortality rate (×1,000) in bereaved persons	3,7	0,8	1,1	2,1	4,4	8,1
mortality rate (×1,000) in non-bereaved persons	1,5	0,3	0,6	1,2	2,9	6,5

'# bereaved persons' refers to those who experienced the death of a sibling some time during the observation period.
Total number of sibling deaths is 72,949, whereof 23.7% are from cardiovascular diseases, 37.5% from cancer, 19.4% from other diseases, 8.7% from suicides, 7.3% from accidents, and 3.4% from other external causes.
Of all deaths in the index persons, 28.7% (15.9%) in men (women) are from cardiovascular diseases, 28.2% (52.9%) from cancer, 20.6% (18.2%) from other diseases, 9.6% (6.5%) from suicides, 9.0% (4.0%) from accidents, and 3.8% (2.5%) from other external causes.
Cardiovascular diseases refer to ICD8/ICD9/ICD10 codes 390-458/390-459/I00-I99, cancer to codes 140-239/140-239/C00-D48, other diseases to all other codes than those explicitly mentioned here, suicides to codes E950-E959/E950-E959/X60-X84, accidents to codes E807-E949/E800-E949/V01-X59, and other external causes to codes E960-E999/E960-E999/X85-Y98.

Table 2. Association between sibling's death and index persons' all-cause mortality risk by age group, sex and type of sibling's death in the Swedish Work and Mortality Database (HSIA), 1981-2002

	All ages		18-29 years		30-39 years		40-49 years		50-59 years		60-69 years	
	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p
Association, men												
All sibling deaths	1.26 (1.22, 1.30)	0.00	1.83 (1.16, 2.88)	0.00	1.55 (1.31, 1.82)	0.00	1.45 (1.34, 1.56)	0.00	1.19 (1.13, 1.25)	0.00	1.19 (1.12, 1.26)	0.00
Natural sibling deaths	1.26 (1.22, 1.31)	0.00	1.49 (0.71, 3.13)	0.00	1.37 (1.09, 1.72)	0.00	1.40 (1.28, 1.53)	0.00	1.20 (1.13, 1.27)	0.00	1.22 (1.14, 1.30)	0.00
Unnatural sibling deaths	1.25 (1.17, 1.34)	..	2.11 (1.19, 3.73)	..	1.79 (1.42, 2.26)	..	1.55 (1.36, 1.76)	..	1.14 (1.02, 1.27)	..	1.03 (0.88, 1.20)	..
Association, women												
All sibling deaths	1.33 (1.28, 1.39)	0.00	2.19 (1.08, 4.41)	0.00	1.83 (1.48, 2.26)	0.00	1.45 (1.32, 1.60)	0.00	1.36 (1.28, 1.45)	0.00	1.17 (1.08, 1.26)	0.00
Natural sibling deaths	1.32 (1.26, 1.39)	0.00	1.76 (0.56, 5.49)	0.00	1.93 (1.47, 2.53)	0.00	1.44 (1.28, 1.61)	0.00	1.36 (1.27, 1.46)	0.00	1.16 (1.07, 1.27)	0.00
Unnatural sibling deaths	1.37 (1.26, 1.49)	..	2.56 (1.06, 6.18)	..	1.68 (1.20, 2.35)	..	1.48 (1.25, 1.75)	..	1.36 (1.19, 1.55)	..	1.18 (0.98, 1.42)	..

RR, mortality risk ratio (with 95% confidence interval) between bereaved and non-bereaved persons, adjusted for effects of all control variables.

In cases where the parameters tested are two, the p value is for the Wald statistic of their joint significance. '..' consequently represents a deliberate blank.

All p values <0.005 are denoted by 0.00.

Control variables included are age, calendar year, socioeconomic status, marital status, number of children, number of siblings, and region of residence.

Table 3. Association between sibling's death and index persons' all-cause mortality risk by age group, sex, type of sibling's death and time since sibling's death in the Swedish Work and Mortality Database (HSIA), 1981-2002

	All ages		18-29 years		30-39 years		40-49 years		50-59 years		60-69 years	
	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p
Association, men												
All sibling deaths												
1 year's follow-up	1.01 (0.93, 1.09)	0.00	1.71 (0.85, 3.43)	0.00	1.18 (0.84, 1.68)	0.00	1.13 (0.95, 1.34)	0.00	0.96 (0.86, 1.08)	0.00	0.93 (0.81, 1.08)	0.00
2-5 years' follow-up	1.34 (1.27, 1.41)	..	2.02 (1.05, 3.91)	..	1.69 (1.32, 2.18)	..	1.64 (1.46, 1.85)	..	1.21 (1.11, 1.32)	..	1.26 (1.15, 1.39)	..
>5 years' follow-up	1.32 (1.26-1.39)	..	1.58 (0.39, 6.34)	..	1.69 (1.29, 2.20)	..	1.46 (1.30, 1.63)	..	1.28 (1.19, 1.37)	..	1.24 (1.14, 1.34)	..
Natural sibling deaths												
1 year's follow-up	0.98 (0.90, 1.07)	0.00	1.80 (0.67, 4.79)	0.00	1.03 (0.65, 1.64)	0.00	1.06 (0.87, 1.30)	0.00	0.94 (0.83, 1.07)	0.00	0.94 (0.81, 1.09)	0.00
2-5 years' follow-up	1.34 (1.26, 1.42)	..	1.52 (0.49, 4.72)	..	1.87 (1.37, 2.54)	..	1.60 (1.39, 1.83)	..	1.22 (1.11, 1.34)	..	1.28 (1.16, 1.42)	..
>5 years' follow-up	1.35 (1.28-1.43)	..	not applicable	..	1.08 (0.68, 1.72)	..	1.45 (1.26, 1.67)	..	1.33 (1.23, 1.44)	..	1.29 (1.18, 1.42)	..
Unnatural sibling deaths												
1 year's follow-up	1.17 (0.97, 1.41)	..	1.63 (0.61, 4.36)	..	1.46 (0.87, 2.47)	..	1.38 (0.99, 1.93)	..	1.09 (0.80, 1.47)	..	0.82 (0.48, 1.38)	..
2-5 years' follow-up	1.34 (1.18, 1.52)	..	2.43 (1.09, 5.43)	..	1.43 (0.93, 2.20)	..	1.78 (1.43, 2.22)	..	1.16 (0.94, 1.43)	..	1.11 (0.83, 1.49)	..
>5 years' follow-up	1.23 (1.13, 1.35)	..	2.62 (0.65, 10.51)	..	2.30 (1.67, 3.17)	..	1.47 (1.23, 1.76)	..	1.14 (1.00, 1.31)	..	1.03 (0.85, 1.24)	..
Association, women												
All sibling deaths												
1 year's follow-up	1.05 (0.95, 1.16)	0.00	1.21 (0.30, 4.85)	0.04	1.24 (0.77, 2.01)	0.00	1.08 (0.86, 1.35)	0.00	1.07 (0.93, 1.24)	0.00	0.96 (0.80, 1.15)	0.00
2-5 years' follow-up	1.42 (1.32, 1.52)	..	3.14 (1.30, 7.61)	..	2.04 (1.48, 2.81)	..	1.76 (1.52, 2.03)	..	1.34 (1.21, 1.49)	..	1.25 (1.10, 1.41)	..
>5 years' follow-up	1.40 (1.32, 1.49)	..	2.45 (0.34, 17.51)	..	2.06 (1.47, 2.89)	..	1.41 (1.22, 1.63)	..	1.50 (1.38, 1.64)	..	1.20 (1.08, 1.34)	..
Natural sibling deaths												
1 year's follow-up	1.06 (0.96, 1.18)	0.00	1.25 (0.18, 8.90)	0.29	1.02 (0.53, 1.95)	0.00	1.11 (0.86, 1.42)	0.00	1.09 (0.94, 1.27)	0.00	0.99 (0.82, 1.19)	0.00
2-5 years' follow-up	1.41 (1.31, 1.52)	..	2.74 (0.68, 11.00)	..	2.35 (1.59, 3.46)	..	1.72 (1.45, 2.04)	..	1.35 (1.21, 1.51)	..	1.26 (1.10, 1.43)	..
>5 years' follow-up	1.39 (1.30, 1.49)	..	not applicable	..	2.34 (1.50, 3.64)	..	1.39 (1.16, 1.67)	..	1.51 (1.37, 1.67)	..	1.18 (1.04, 1.33)	..
Unnatural sibling deaths												
1 year's follow-up	0.96 (0.73, 1.26)	..	1.17 (0.16, 8.31)	..	1.67 (0.83, 3.34)	..	0.96 (0.57, 1.63)	..	0.94 (0.62, 1.45)	..	0.68 (0.34, 1.35)	..
2-5 years' follow-up	1.44 (1.23, 1.70)	..	3.49 (1.12, 10.88)	..	1.59 (0.90, 2.80)	..	1.86 (1.41, 2.47)	..	1.28 (0.98, 1.66)	..	1.18 (0.81, 1.71)	..
>5 years' follow-up	1.43 (1.28, 1.60)	..	4.21 (0.59, 30.15)	..	1.78 (1.07, 2.96)	..	1.43 (1.14, 1.80)	..	1.48 (1.26, 1.73)	..	1.27 (1.02, 1.59)	..

RR is mortality risk ratio (with 95% confidence interval) between bereaved and non-bereaved persons, adjusted for effects of all control variables.

The p value is for the Wald statistic of joint significance of all three parameters tested. '..' consequently represents a deliberate blank.

All p values <0.005 are denoted by 0.00.

Control variables included are age, calendar year, socioeconomic status, marital status, number of children, number of siblings, and region of residence.

Table 4. Association between sibling's death and index persons' mortality risk by age group, sex, type of sibling's death and type of index person's death in the Swedish Work and Mortality Database (HSIA), 1981-2002

	All ages			18-29 years			30-39 years			40-49 years			50-59 years			60-69 years		
	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p
Men - natural deaths																		
Natural sibling deaths	1.24	(1.19, 1.29)	0.00	1.33	(0.33, 5.34)	0.03	1.57	(1.17, 2.12)	0.00	1.38	(1.24, 1.54)	0.00	1.21	(1.14, 1.29)	0.00	1.23	(1.15, 1.32)	0.00
Unnatural sibling deaths	1.15	(1.06, 1.25)	..	2.79	(1.15, 6.76)	..	1.71	(1.23, 2.40)	..	1.47	(1.25, 1.72)	..	1.06	(0.94, 1.19)	..	1.00	(0.85, 1.17)	..
Men - unnatural deaths																		
Natural sibling deaths	1.22	(1.11, 1.35)	0.00	1.57	(0.65, 3.79)	0.00	1.17	(0.82, 1.66)	0.00	1.46	(1.23, 1.73)	0.00	1.14	(0.97, 1.33)	0.00	1.00	(0.76, 1.32)	0.00
Unnatural sibling deaths	1.69	(1.47, 1.95)	..	1.81	(0.86, 3.80)	..	1.87	(1.35, 2.57)	..	1.75	(1.39, 2.20)	..	1.64	(1.29, 2.09)	..	1.43	(0.87, 2.36)	..
Women - natural deaths																		
Natural sibling deaths	1.30	(1.24, 1.37)	0.00	2.19	(0.54, 8.85)	0.18	1.88	(1.36, 2.60)	0.00	1.46	(1.29, 1.65)	0.00	1.35	(1.26, 1.45)	0.00	1.16	(1.06, 1.27)	0.00
Unnatural sibling deaths	1.24	(1.13, 1.37)	..	2.95	(0.94, 9.22)	..	1.11	(0.68, 1.81)	..	1.32	(1.08, 1.60)	..	1.28	(1.11, 1.47)	..	1.13	(0.93, 1.37)	..
Women - unnatural deaths																		
Natural sibling deaths	1.41	(1.20, 1.65)	0.00	1.27	(0.18, 9.06)	0.10	2.04	(1.26, 3.32)	0.00	1.35	(1.01, 1.81)	0.00	1.48	(1.17, 1.87)	0.00	1.27	(0.81, 1.98)	0.00
Unnatural sibling deaths	2.41	(1.96, 2.95)	..	2.15	(0.53, 8.65)	..	3.01	(1.90, 4.76)	..	2.29	(1.64, 3.20)	..	2.28	(1.60, 3.25)	..	2.62	(1.33, 5.17)	..

RR is mortality risk ratio (with 95% confidence interval) between bereaved and non-bereaved persons, adjusted for effects of all control variables.

The p value is for the Wald statistic of joint significance of both parameters tested. '..' consequently represents a deliberate blank.

All p values <0.005 are denoted by 0.00.

Control variables included are age, calendar year, socioeconomic status, marital status, number of children, number of siblings, and region of residence.

Table 5. Association between sibling's death and index persons' mortality risk by main cause of sibling's death (rows) and main cause of index person's death (columns), all ages, the Swedish Work and Mortality Database (HSIA), 1981-2002

	Cardiovascular			Cancer			Other diseases			Suicides			Accidents			Other external			All causes		
	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p	RR (95% CI)		p
Association, men																					
Cardiovascular	1.64	(1.49, 1.81)	0.00	1.00	(0.88, 1.14)	0.00	1.41	(1.23, 1.63)	0.00	1.14	(0.85, 1.52)	0.00	1.15	(0.86, 1.53)	0.00	1.46	(0.97, 2.19)	0.00	1.36	(1.28, 1.45)	0.00
Cancer	0.91	(0.82, 1.02)	..	1.25	(1.13, 1.37)	..	1.15	(1.01, 1.30)	..	1.08	(0.85, 1.38)	..	1.06	(0.83, 1.36)	..	1.03	(0.69, 1.53)	..	1.11	(1.05, 1.18)	..
Other diseases	1.20	(1.06, 1.37)	..	1.10	(0.96, 1.27)	..	2.08	(1.83, 2.36)	..	1.01	(0.73, 1.40)	..	1.85	(1.46, 2.36)	..	1.85	(1.27, 2.67)	..	1.42	(1.32, 1.52)	..
Suicides	1.03	(0.84, 1.26)	..	1.01	(0.82, 1.25)	..	1.50	(1.22, 1.85)	..	2.42	(1.85, 3.17)	..	1.60	(1.14, 2.23)	..	2.15	(1.38, 3.35)	..	1.31	(1.18, 1.45)	..
Accidents	0.74	(0.57, 0.96)	..	1.10	(0.88, 1.38)	..	1.51	(1.21, 1.90)	..	1.19	(0.78, 1.81)	..	1.30	(0.87, 1.95)	..	1.22	(0.63, 2.36)	..	1.10	(0.97, 1.24)	..
Other external	1.32	(1.01, 1.73)	..	1.01	(0.73, 1.40)	..	1.81	(1.37, 2.39)	..	1.83	(1.13, 2.94)	..	1.51	(0.89, 2.55)	..	2.33	(1.25, 4.35)	..	1.42	(1.22, 1.64)	..
All causes	1.16	(1.09, 1.23)	0.00	1.12	(1.05, 1.19)	0.00	1.49	(1.39, 1.60)	0.00	1.29	(1.13, 1.47)	0.00	1.34	(1.18, 1.53)	0.00	1.51	(1.25, 1.84)	0.00	1.26	(1.22, 1.30)	0.00
Association, women																					
Cardiovascular	1.71	(1.44, 2.02)	0.00	1.16	(1.03, 1.31)	0.00	1.39	(1.15, 1.68)	0.00	1.29	(0.83, 1.98)	0.00	2.20	(1.48, 3.26)	0.00	1.36	(0.70, 2.64)	0.00	1.36	(1.25, 1.47)	0.00
Cancer	0.99	(0.83, 1.19)	..	1.21	(1.11, 1.33)	..	1.35	(1.15, 1.58)	..	1.00	(0.67, 1.49)	..	0.84	(0.50, 1.40)	..	1.40	(0.82, 2.40)	..	1.20	(1.11, 1.28)	..
Other diseases	1.34	(1.08, 1.66)	..	1.27	(1.11, 1.44)	..	2.24	(1.89, 2.64)	..	1.81	(1.23, 2.65)	..	0.95	(0.51, 1.78)	..	3.33	(2.12, 5.22)	..	1.52	(1.39, 1.65)	..
Suicides	1.30	(0.95, 1.78)	..	1.01	(0.83, 1.24)	..	1.48	(1.11, 1.97)	..	3.72	(2.63, 5.27)	..	1.17	(0.55, 2.46)	..	1.75	(0.78, 3.92)	..	1.30	(1.15, 1.49)	..
Accidents	1.82	(1.35, 2.44)	..	1.15	(0.93, 1.41)	..	1.50	(1.09, 2.06)	..	1.54	(0.85, 2.78)	..	2.21	(1.22, 4.01)	..	3.20	(1.65, 6.20)	..	1.43	(1.24, 1.64)	..
Other external	1.67	(1.07, 2.59)	..	0.86	(0.61, 1.21)	..	2.02	(1.37, 2.97)	..	2.49	(1.29, 4.80)	..	2.55	(1.14, 5.69)	..	4.09	(1.83, 9.17)	..	1.42	(1.17, 1.73)	..
All causes	1.35	(1.22,1.49)	0.00	1.17	(1.11, 1.25)	0.00	1.58	(1.44, 1.74)	0.00	1.66	(1.38, 2.01)	0.00	1.40	(1.10, 1.78)	0.00	2.12	(1.62, 2.77)	0.00	1.33	(1.28, 1.39)	0.00

RR is mortality risk ratio (with 95% confidence interval) between bereaved and non-bereaved persons, adjusted for effects of all control variables.

In cases where the parameters tested are six, the p value is for the Wald statistic of their joint significance. '..' consequently represents a deliberate blank.

All p values <0.005 are denoted by 0.00.

Control variables included are age, calendar year, socioeconomic status, marital status, number of children, number of siblings, and region of residence.