# Suicide following the death of a sibling: A nationwide follow-up study from Sweden

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# Suicide following the death of a sibling: A nationwide follow-up study from Sweden

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## ABSTRACT

**Objectives:** The death of a sibling can trigger grief and depression. Sibling deaths from external causes may be particularly detrimental, since they are often sudden. We aimed to examine the association between death of an adult sibling from external causes and the risk of suicide among surviving siblings up to 18 years after bereavement. **Design:** A follow-up study between 1981 and 2002 based on the total population **Setting:** Sweden **Participants:** The total population of Swedes aged 25-64 years (n=1,748,069). **Primary and secondary outcome measures:** Suicide from the Swedish cause of death register **Results:** An increased risk of mortality from suicide was found among persons who had experienced the death of a sibling from an external cause. In women, the suicide risk was 1.65 times that of non-bereaved persons (95% CI: 1.35-2.02), and in men it was 1.37 times higher (95% CI: 1.19-1.58). If one sibling committed suicide, the risk of the remaining sibling also committing suicide was 3.44 (2.40-4.94) among women and 2.46 (1.86-3.24) among men. If one sibling died from external causes other than suicide, the risk of suicide in the surviving sibling was still elevated: 1.77 (1.13-2.77) among women and 1.42 (1.03-1.96) among men. Sibling deaths from chronic diseases, e.g., cardiovascular disease or cancer, displayed much weaker and generally not statistically significant associations with suicide in the surviving sibling. **Conclusions:** Our study provided evidence for suicide risk associated with the death of a sibling at adult age, revealing that bereaved persons' risk of suicide is higher when siblings die from an external cause compared to other causes.


### Article focus

- The loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidality.

- The impact of losing an adult sibling on suicide risk of remaining siblings has been largely overlooked.
- Unexpected causes of deaths may precipitate a more severe reaction compared to deaths following chronic illness in which family members have more time to adjust and cope with the loss

**Key messages**

- This study provided the first large-scale evidence for suicide associated with sibling death at adult age.
- Bereaved persons' risk of suicide is higher when siblings die from an external cause compared to other causes
- The mechanisms linking the death of a sibling and completed suicide among the bereaved person need to be further investigated.

**Strengths and limitations of this study**

- There is a possibility that both the death of a sibling as well as the subsequent ill health of the remaining sibling share a common prior cause such as genetic or environmental confounding.
- The use of total population register data provides a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables.

## INTRODUCTION

Previous studies have established that the loss of a family member leads to an increased risk of death and disease among bereaved family members such as spouses, parents, and children.[1-5] Bereavement also contributes to a higher risk of suicide in bereaved family members.[6-10] However, the impact of grief following the loss of an adult sibling has been largely overlooked. To the extent that siblings are also beloved, provide companionship and support, one would expect that death of an adult sibling -- as much as the death of other family members (e.g. spouse, parents, children) -- would be associated with an increased risk of suicide. In fact, the death of a sibling often represents the loss of the longest and most intimate relationships of a person's lifetime.[11] Some studies even suggest that the death of a sibling is more disruptive and involves a more severe grief process than other familial deaths.[5,12]

Interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide[13-15],both directly as a proximal precipitant for suicide as well as through the onset or exacerbation of psychiatric illness in survivors.[13] Consequently, the loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidality, such as major depression, and anxiety disorders in adults.[13,16,17] However, the grief reaction associated with sibling loss could be expected to vary according to the cause of death. Thus sudden or unexpected causes of deaths (e.g. suicides, accidents and homicides) may precipitate a more severe reaction compared to deaths following chronic illness (e.g. cancer) in which family members have more time to adjust and cope with the loss. It has, for instance, been found that relatives exposed to deaths from external causes are at greater risk of developing complicated grief and post-traumatic stress symptoms[18-22] because such deaths may involve higher immediate stress levels, stronger feelings of grief, greater difficulty in accepting the death, and fewer available coping strategies to deal with the

loss.[23,24] Accordingly, studies suggest that the loss of a spouse or a parent due to external causes increase the risk of suicide among bereaved family members.[2] Furthermore, the time since the death of a family member could be crucial for the risk of suicide after bereavement. For instance, the risk of suicide increases during the first year after the loss of a spouse and decreases thereafter until it is similar to the overall rate.[8] Men appear to be most at risk during the first few months after bereavement, and for women the risk is distributed more evenly over a longer period.[25] Whether a similar pattern can be discerned on the suicide risk of bereaved siblings is unknown

Our aim was to conduct a large-scale longitudinal study on mortality from suicide following the loss of an adult sibling, using intergenerational linked data from nationwide Swedish registers. We postulated that the association between sibling's death and suicide will depend on the nature of sibling's death (external versus non-external causes), time since the sibling's death, and the gender of the remaining sibling.

## METHOD

This study is based on multiple-linked data of national Swedish routine registers including the total population register (TPR), National Population and Housing Censuses, the Longitudinal Data Base on Education, Income and Employment (LOUISE) and the Cause of Death registers. The data is maintained at the Centre for Health Equity Studies (CHESS) in Stockholm and was approved by the Regional Ethical Review board of Karolinska Institutet in 2002-11-11 (decision no. 02-481) and the Central Ethical Review Board 2012-09-13 (application no. 2012/1260-31). These decisions approve that the data can be used for several purposes. All data used for this study was also anonymous and researchers did not have access to any personal information that could identify study participants (e.g. personal identity

number, home address etc.). Consequently, it was not possible to trace specific individuals included in the data material.

In the study, all persons born in Sweden during the period 1932-1962 and alive at the end of 1980 were linked to the mother, provided that she was born in Sweden and alive at the same time. Hence sibling groups were identified through the mother, and singletons were excluded from analysis. To get a reasonable age balance and in order to use adequate control variables, we restricted the sample to people aged 25-64 years. These study persons were observed from 1981 until 2002.

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) to proxy social and regional differences in suicide, and the month and specific cause of death for all persons who died during the study period. 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 covariates except age and calendar year were measured at the end of 1980, which antedated any sibling death. We distinguished sibling deaths from suicide (ICD8 and ICD9 codes E950-E959, and ICD10 codes X60-X84), external causes other than suicide (ICD8 codes E807-E949 and E960-E999, ICD9 codes E800-E949 and E960-E999, and ICD10 codes V01-X59 and X85-Y98), cardiovascular diseases (ICD8 codes 410-438 and 795, ICD9 codes 410-438 and 798, and ICD10 codes I21-I52 and I60-I69), cancer (ICD8 and ICD 9 codes 140-239, and ICD10 codes C00-D48), and all other causes (all other codes).

All people who experienced a sibling's death during the study period were included, whereas those who did not experience a sibling's death comprised a ten per cent random sample. In the statistical analyses, people from each group were weighted according to their sampling proportion. The death of sibling was a time-varying feature, which means that when a sibling died, the surviving sibling changed status from being a non-bereaved to being a bereaved person. Using Cox regressions, we estimated suicide risks of bereaved persons to non-bereaved persons.

## RESULTS

In total, 79,017 men and 77,614 women experienced a sibling's death, and 242 and 125 of them subsequently died from suicide (Table 1). The corresponding numbers in non-bereaved persons were: 4,376 suicide deaths among 812,186 women and 1,761 suicide deaths among 779,252 men. About 9% of all sibling deaths were from suicide.

(Table 1 here)

Suicide was more than twice as common in men (4,618 deaths in total) as in women (1,886 in total), but the association between sibling loss and suicide was greater for women than in men. In bereaved women, the suicide risk was 1.65 times that of non-bereaved women (95% CI: 1.35-2.02). In bereaved men, the suicide risk was 1.37 times that of non-bereaved men (1.19-1.58) (Table 2). People who had experienced a sibling's death from suicide had particularly elevated risks of own suicide mortality: 3.44 times higher among women (2.40-4.94), and 2.46 higher among men (1.86-3.24). However, even if the sibling died of causes other than suicide, we still found elevated suicide risks for the surviving sibling: 1.40 times higher among women (1.11-1.76) and 1.21 times among men (1.04-1.42). Detailed analyses revealed a particularly strong link to sibling deaths from external causes (other than suicide). Men who had experienced a sibling's death from any external cause (besides suicide) had a

suicide risk that was 1.42 times that of non-bereaved men (1.03-1.96). The corresponding relative risk in women was even higher, or 1.77 (1.13-2.77). Sibling deaths from physical disease, such as cardiovascular disease or cancer, displayed much weaker and generally not statistically significant associations.

(Table 2 here)

The variation across age groups in the bereavement effect on suicide mortality was found to be smaller for women than for men (data not shown), which reflects that younger women were more vulnerable to the death of a sibling than young men were.

Women also appeared to exhibit stronger associations in the long term than men (Figure 1). In men, the suicide risk after a sibling's death remained fairly stable according to time since bereavement (around 1.5 times that of non-bereaved men). In women, the suicide risk was 1.8 times that of non-bereaved women during the first year after a sibling's death. Thereafter it slightly declined, but subsequent to the forth year, there appeared to be a rising trend.

(Figure 1 here)

## DISCUSSION

According to the World Health Organization, almost one million people die from suicide each year, and suicide is among the three leading causes of death for people aged less than 25 years.[26] To prevent and identify risk factors for suicide is therefore of utmost importance.

This large-scale follow-up study based on the Swedish population register examined suicide following the death of a sibling. We found an increased risk of mortality from suicide among women and men who had experienced the death of a sibling. External (unnatural) causes of death had the strongest associations with suicide among bereaved persons. Particularly sibling deaths from suicide increased the suicide risk of bereaved individuals and

associations were stronger among women than among men. We also found strong associations with respect to sibling deaths from external causes (other than suicide), whereas associations were significantly weaker with respect to sibling deaths from natural causes (e.g. cardiovascular disease, cancer, and all other causes than external ones). An elevated suicide risk in the longer-term was primarily found among women (>4 years after the death of a sibling) although we also found a short-term elevation of the risk (during the first year after sibling loss). In men, the excess suicide risk was fairly stable over time.

Although interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide,[13-15] the findings of this study suggest that deaths from external and unnatural causes are most detrimental. Relatives exposed to suicide, accidents or violent deaths -- which are often sudden and unanticipated -- might be at greater risk of developing complicated grief and post-traumatic stress symptoms which could explain their higher suicide risk.[13,21,22] In line with this, deaths from cancer and cardiovascular disease showed no significant associations with suicide risk of bereaved siblings. These chronic diseases tend to run a longer course and therefore allow relatives to adjust and adapt to the circumstances.

We also found particularly strong associations between sibling's suicide and suicide among bereaved siblings. Accordingly, it has been argued that the pain of dealing with the loss of a loved one by suicide is especially severe when compared to other types of external deaths such as accidents and homicides. There are qualitative aspects of the mourning process that are intensified and frequently more problematic for survivors of suicide than for other types of bereavement.[13,27] Survivors of suicide seem to struggle more with questions of meaning around the death.[28,29] Survivors often show higher levels of guilt, blame, and responsibility for the death than other mourners.[30,31] Studies also find that survivors experience feelings of rejection and abandonment by the loved one, along with anger toward the deceased.[32] However, death by suicide is also stigmatizing to surviving family members

and initiates a chain reaction of negative consequences[30] that may lead to an unsatisfactory resolution of bereavement. It has been found that suicide survivors received less emotional support than natural death survivors for their feelings of depression and grief and confided less in members of their social networks.[33]

Women's risk of suicide was found to be higher after the death of a sibling from suicide when compared to men. They showed a higher excess risk of suicide following sibling deaths from all causes, suicide, and external causes (other than suicide) when compared to men. This finding might reflect the fact that women place more emphasis on social relationships than men do, particularly when it comes to parents and the family.[34] The loss of a sibling could hence have stronger emotional consequences for women which, in turn, could account for a higher risk of suicide. The strong longer-term association found among women may also suggest that longer-term mechanisms such as an extended and complicated grief process and/or severe depression underlie the association. In a previous study, we found that women's health is more influenced by bereavement following sibling loss than men's health.[5]

The stronger associations between concordant causes of death (both siblings died of suicide) could, to some extent, indicate genetic resemblance or shared risk factors during childhood. Genetic factors can predispose people towards the development of psychiatric disorders that are associated with suicide, particularly depression and bipolar disorders.[14] Siblings also share many environmental exposures during childhood and adolescence. Suicide has been associated with family risk factors for suicide such as disorganization and breakup, parental loss, substance abuse, intrafamily violence, and sexual abuse.[13] Deaths from external causes other than suicide, such as accidents and homicides, could, however, also reflect risk taking behaviours due to depression, psychiatric disorders and shared environmental exposures. Consequently, genetic confounding might account for a higher risk of suicide following sibling deaths from external causes. Hence we cannot exclude the possibility that

the associations we found reflect dome degree of confounding, e.g. that the association might be explained by an unobserved third variable (such as genetic similarities between siblings or shared childhood environment and family effects). Given the strong genetic similarities between siblings there could be a higher risk of confounding when compared to research on other types of bereavement. Considering that the association between bereavement by suicide and suicide in bereaved siblings is the strongest observed in this study it could also reflect the "copycat phenomenon" i.e. suicides in bereaved siblings could be caused by imitation of suicidal behaviour.[35] Nonetheless, it could still be that many deaths from the same cause (both siblings died of suicide) reflect the effects of bereavement. Since suicide and poor mental health is highly responsive to bereavement, deaths from the same cause might therefore truly reflect bereavement rather than genetic confounding; i.e., one sibling dies of suicide and the remaining sibling takes his/her own life due to bereavement rather than genetic vulnerability or shared environmental exposures.

**Limitations**

Despite the obvious strengths of this study such as the use of total population register data, a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables, some limitations should be noted. More detailed individual information is required to uncover the actual causal mechanisms that link sibling suicide and mortality. Such information could also 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, more information on shared childhood social environment and family characteristics, and detailed data on personal and relational characteristics, which are unfortunately not included in the registers. In particular, the inability of registry-based studies to attend for family-level risk factors such as the quality of sibling relationship is a limitation

of the study. The quality of the relationship with the deceased sibling could decide the severity of bereavement and thereby contribute to suicide risk among remaining siblings. The study also involves the lack of information on surviving sibling's medical and psychiatric status, both of which convey important information about suicide risk, and temporal relationship of medical illnesses and mental health disorder episodes to both bereavement and suicide. On the other hand, our results likely underestimate the true bereavement effect following sibling death from suicide, since we could study only completed suicide, and not parasuicides which are much more common.[36] Examining attempted suicide is likely to provide more precision and even greater statistical power.

Our findings suggest that the health-care system should consider collateral health effects when dealing people exposed to sibling deaths from external causes. Most discussion has focused on bereavement after the death of a spouse or a parent, while siblings have tended to be the 'forgotten grievers'. Our findings illustrate that a sibling's death due to external (unnatural) causes can increase the risk of suicide among bereaved siblings. Considering that their loss and pain are often insufficiently acknowledged by the parents and the informal social support system[11,12], it is important that physicians and health-care professionals acknowledge bereaved siblings from causes of death such as suicide, accidents, and violent deaths. Accordingly, targeted support towards bereaved siblings who experienced sibling deaths from external causes may be beneficial and reduce their risk of suicide. Our findings also suggest the need for further research to determine whether long-term follow-up and support provided by health care workers to surviving siblings can reduce suicide risk.

In summary, our study provided evidence for suicide associated with the death of a sibling at adult age and illustrated that bereaved siblings' risk of suicide is primarily influenced by deaths from external causes. The mechanisms linking the death of a sibling and completed suicide among the bereaved person need to be further investigated.

*Contributors*

MR and JS planned the study and the research design. They also analysed data, interpreted the results, and wrote the draft version of the paper. IK contributed to writing, interpretation of data, and critical reviews. All authors corrected and approved the final version of the manuscript.

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*Competing interests*

None

*Data sharing*

No additional data available.

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Table 1. Descriptive statistics by sex of the index persons

| | Men | Women |
|---|---|---|
| Number of sibling deaths | 78,297 | 76,910 |
| % from suicide | 8.7 | 8.9 |
| % from external other than suicide | 10.8 | 10.8 |
| % from cardiovascular diseases | 22.0 | 22.1 |
| % from cancer | 37.3 | 37.2 |
| Number of deaths from suicide | | |
| In bereaved persons | 242 | 125 |
| In non-bereaved persons | 4,376 | 1,761 |
| Number of person years in | | |
| Bereaved persons | 620,584 | 611,382 |
| Non-bereaved persons | 17,893,475 | 17,308,392 |
| Number of (ever) bereaved persons | 79,017 | 77,614 |
| Number of non-bereaved persons | 812,186 | 779,252 |

Table 2. Association between sibling's death from different main causes and suicide in index persons

| | Men | Women |
|---|---|---|
| Cause of sibling's death | | |
| All causes | 1.37 (1.19-1.58) | 1.65 (1.35-2.02) |
| Suicide | 2.46 (1.86-3.24) | 3.44 (2.40-4.94) |
| Not suicide | 1.21 (1.04-1.42) | 1.40 (1.11-1.76) |
| External other than suicide | 1.42 (1.03-1.96) | 1.77 (1.13-2.77) |
| Cardiovascular diseases | 1.26 (0.93-1.71) | 1.36 (0.87-2.14) |
| Cancer | 1.18 (0.92-1.52) | 1.03 (0.68-1.54) |
| All other causes | 1.08 (0.78-1.48) | 1.72 (1.17-2.53) |

Numbers are mortality risk ratios (with 95% confidence intervals), i.e., the ratio of the death risk of bereaved persons and non-bereaved persons, adjusted for effects of all control variables.

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

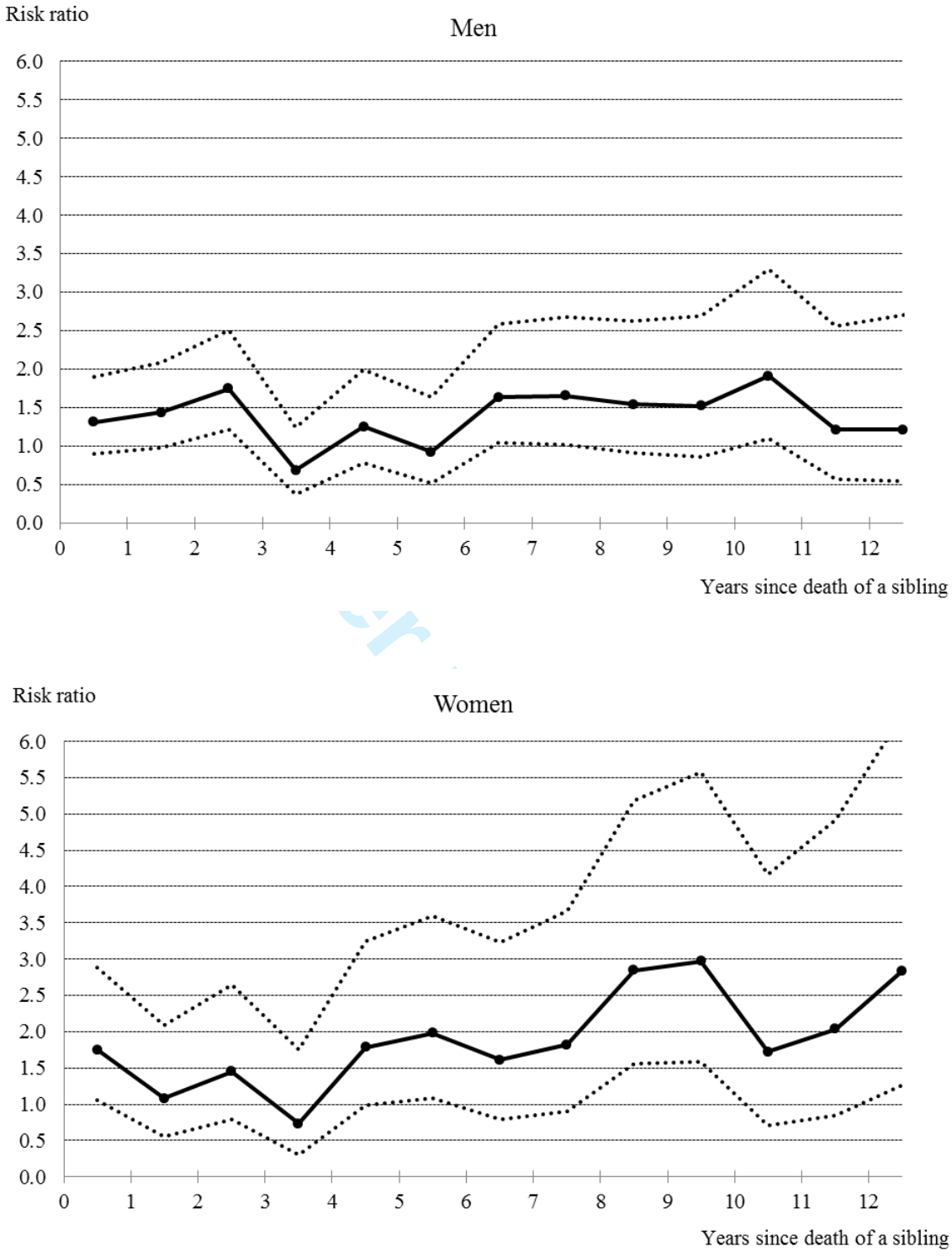


Figure 1. Suicide risk after siblings death as compared with non-bereaved persons (with 95% confidence intervals)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Comment |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | The study design is indicated in the abstract (Design: We conducted a follow-up study between 1981 and 2002). |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | It has been our ambition to provide a summary that is both informative and balanced (see abstract). |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | The rationale is described in the introduction. "the loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidality, such as major depression, and anxiety disorders in adults." |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | Objective: To conduct a large-scale analysis of suicide following the death of a sibling at adult ages. Hypotheses: We postulated that the association between sibling's death and suicide will vary according to time since the sibling's suicide, gender of the bereaved sibling and specific cause of the bereaved sibling's death. |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | The study design is to identify sibling groups on basis of the mother by using the Swedish multigeneration register and link this information to mortality statistics. See the first paragraph of the 'Methods' section. |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | The information used comes from a database that links several routine administrative registers in Sweden. Our information cover the entire native-born Swedish population alive at end-1980, with a mother alive at end-1980. Persons who had experienced the death of a sibling became under exposure at the month the sibling had died. These persons were observed with regard to own mortality at a monthly basis until the end of 2002. The control group consisted of a ten per cent random sample of all people who had not experienced the death of sibling during the observation period. See the 'Methods' section. |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. | The data cover all deaths, and hence all individuals who had experienced the death of a sibling during the period 1981-2002. In the |

| | | | |
|---|---|---|---|
| | | Describe methods of follow-up | administrative registers, all persons living in Sweden can be observed with regard to the month and cause of death. See the 'Methods' section. |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | n/a |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | We distinguished deaths from suicide (ICD8 and ICD9 codes E950-E959, and ICD10 codes X60-X84), external causes other than suicide (ICD8 codes E807-E949 and E960-E999, ICD9 codes E800-E949 and E960-E999, and ICD10 codes V01-X59 and X85-Y98), cardiovascular diseases (ICD8 codes 410-438 and 795, ICD9 codes 410-438 and 798, and ICD10 codes I21-I52 and I60-I69), cancer (ICD8 and ICD 9 codes 140-239, and ICD10 codes C00-D48), and all other causes (all other codes).<br>Covariates included are basic socio-demographic variables – age, socioeconomic status, marital status, number of children, number of siblings – and region of residence and calendar year. All covariates except age and calendar year were measured at the end of 1980, which was before any sibling death had occurred. See the 'Methods' section. |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | Socioeconomic status consists of the categories 'Blue-collar worker', 'White-collar worker', 'Self-employed', and 'Outside labour market'. Marital status consists of the categories 'Married', 'Previously married', and 'Never married'. Region of residence refers to each county ('län') in Sweden (21 counties in total). Further details are available upon request. Each covariate used is measured in exactly the same way for bereaved and non-bereaved persons. The only difference in measurement is in the key variable of interest; the event (and time since) a sibling's death. |
| Bias | 9 | Describe any efforts to address potential sources of bias | Separating specific causes of death is a way to get closer to causal inference and, hence, addressing the question of potential residual confounding. See page 5 of the 'Introduction' section, and paragraph 11 of the 'Discussion' section. |
| Study size | 10 | Explain how the study size was arrived at | All Swedes aged aged 25-64 years (n=1,748,069) during the period 1981-2002, who had experienced a sibling's death are |

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| | | | studied, and compared with a ten per cent random sample from the total population of persons who had not experienced a sibling's death. See 'Methods' section. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | See item no. 8. |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | Cox proportional hazards regressions were used to estimate one-year mortality risk ratios of persons who had experienced the death of sibling relative to persons who had not experienced the death of a sibling. See 'Methods' section. |
| | | (*b*) Describe any methods used to examine subgroups and interactions | n/a |
| | | (*c*) Explain how missing data were addressed | n/a (no missing data, since the information come from administrative registers) |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | n/a (not a problem in this study). |
| | | (*e*) Describe any sensitivity analyses | n/a |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | Details are given in Table 1. |
| | | (b) Give reasons for non-participation at each stage | n/a (non-participation is not an option, since all information comes from administrative registers) |
| | | (c) Consider use of a flow diagram | A lexis diagram showing cohorts/ages/years under study is available upon request. Since the setup of the study is comprehensive without this diagram, it is not, for the sake of brevity, included in the article. |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Details are given in Table 1, and further information available upon request. |
| | | (b) Indicate number of participants with missing data for each variable of interest | n/a |

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| | | (c) Summarise follow-up time (eg, average and total amount) | Details are given in Table 1. |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | Details are given in Table 1. |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | We report only confounder-adjusted estimates and their precision, since it is highly necessary to control for any observable differences that might affect mortality variation across bereaved and non-bereaved persons. See Tables 2 and Figure 1. Unadjusted estimates and their precision are available upon request. |
| | | (*b*) Report category boundaries when continuous variables were categorized | n/a |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | n/a |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | We tested interactions between socioeconomic position, marital status, family type and bereavement related suicide on mortality. We also tested whether increasing the randomized sample of non-bereaved individuals influence our estimates. These numbers are available upon request. |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | An increased risk of mortality from suicide was found among persons who had experienced the death of a sibling from an external cause. In women, the suicide risk was 1.65 times that of non-bereaved persons (95% CI: 1.35-2.02), and in men it was 1.37 times higher (95% CI: 1.19-1.58). If one sibling committed suicide, the risk of the remaining sibling also committing suicide was 3.44 (2.40-4.94) among women and 2.46 (1.86-3.24) among men. If one sibling died from external causes other than suicide, the risk of suicide in the surviving sibling was still elevated: 1.77 (1.13-2.77) among women and 1.42 (1.03-1.96) among men. Sibling deaths from chronic diseases, e.g., cardiovascular disease or cancer, displayed much weaker and generally not statistically significant associations with suicide in the surviving sibling. |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of | We found that the associations between concordant causes of death (both siblings died |

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| | | potential bias or imprecision. Discuss both direction and magnitude of any potential bias | of suicide) were stronger than associations between discordant causes. This could, to some extent, indicate confounding by genetic resemblance or shared environmental risk factors. Genetic factors can predispose people towards the development of psychiatric disorders that are associated with suicide. Siblings also share many environmental exposures during childhood and adolescence such as disorganization and breakup, parental loss, substance abuse, intrafamily violence, and sexual abuse. On the other hand, we also found associations between sibling's suicide and mortality from discordant causes , which strengthen the possibility that the association may be causal. If we had found associations only when both siblings died of suicide, confounding by genetic similarities or shared environmental conditions would seem more likely. Another limitation was that it was not possible to test the actual causal mechanisms that link siblings' mortality risks. These limitations are discussed in the discussion section. |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | Our study provided large-scale evidence for suicide associated with sibling death at adult age. Although sibling suicides were primarily associated with suicide in bereaved survivors, there was an increased mortality risk from discordant causes, which strengthens the possibility that the observed associations are not entirely due to shared genetic causes or environmental factors. |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | Given that we use data from Swedish total population registers it is possible to generalise our findings to the total Swedish population. |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | See 'funding' section |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

# Suicide following the death of a sibling: A nationwide follow-up study from Sweden

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# Suicide following the death of a sibling: A nationwide follow-up study from Sweden

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## ABSTRACT

**Objectives:** The death of a sibling can trigger grief and depression. Sibling deaths from external causes may be particularly detrimental, since they are often sudden. We aimed to examine the association between death of an adult sibling from external causes and the risk of suicide among surviving siblings up to 18 years after bereavement. We adjusted for intra-family correlation in death risks, which might occur because of shared genetics and shared early life experiences of siblings in the same family.

**Design:** A follow-up study between 1981 and 2002 based on the total population.

**Setting:** Sweden

**Participants:** Swedes aged 25-64 years (n=1,748,069).

**Primary and secondary outcome measures:** Suicide from the Swedish cause of death register.

**Results:** An increased risk of mortality from suicide was found among persons who had experienced the death of a sibling. In women, the suicide risk was 1.55 times that of non-bereaved persons (95% CI: 0.99-2.44), and in men it was 1.28 times higher (95% CI: 0.93-1.77). If one sibling committed suicide, the risk of the remaining sibling also committing suicide was 3.19 (95% CI: 1.23-8.25) among women and 2.44 (95% CI: 1.34-4.45) among men. Associations with other main causes of death - such as external other than suicide, cardiovascular diseases, or cancer - were generally much smaller and statistically not significant in either sex. We found no clear support for a specific time pattern according to time since a sibling's death.

**Conclusions:** Our study provided evidence for suicide risk associated with the death of a sibling at adult age, revealing that bereaved persons' risk of suicide is higher when siblings die from suicide, even when adjusting for intra-family correlation in death risks.

## ARTICLE SUMMARY

### Article focus

- The loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidal behavior.
- The impact of losing an adult sibling on suicide risk of remaining siblings has been largely overlooked.
- Unexpected causes of deaths may precipitate a more severe reaction compared to deaths following chronic illness in which family members have more time to adjust and cope with the loss.

### Key messages

- This study provided the first large-scale evidence for suicide associated with sibling death at adult age.
- Even when adjusting for intra-family correlation in death risks, bereaved persons' suicide risk is raised when their siblings had died from suicide.

### Strengths and limitations of this study

- The use of total population register data on sibling groups provides a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables.
- The mechanisms linking the death of a sibling and completed suicide among the bereaved person could not be investigated. For instance, the quality of the relationship with the deceased sibling could decide the severity of bereavement and thereby contribute to suicide risk among remaining siblings.

## INTRODUCTION

Previous studies have established that the loss of a family member leads to an increased risk of death and disease among bereaved family members such as spouses, parents, and children.[1-5] Bereavement also contributes to a higher risk of suicide in bereaved family members.[6-10] However, the impact of grief following the loss of an adult sibling has been largely overlooked. To the extent that siblings are also beloved, provide companionship and support, one would expect that death of an adult sibling -- as much as the death of other family members (e.g. spouse, parents, children) -- would be associated with an increased risk of suicide. In fact, the death of a sibling often represents the loss of the longest and most intimate relationships of a person's lifetime.[11] Some studies even suggest that the death of a sibling is more disruptive and involves a more severe grief process than other familial deaths.[5,12]

Interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide[13-15],both directly as a proximal precipitant for suicide as well as through the onset or exacerbation of psychiatric illness in survivors.[13] Consequently, the loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidal behavior, such as major depression, and anxiety disorders in adults.[13,16,17] However, the grief reaction associated with sibling loss could be expected to vary according to the cause of death. Thus sudden or unexpected causes of deaths (e.g. suicides, accidents and homicides) may precipitate a more severe reaction compared to deaths following chronic illness (e.g. cancer) in which family members have more time to adjust and

cope with the loss. It has, for instance, been found that relatives exposed to deaths from external causes are at greater risk of developing complicated grief and post-traumatic stress symptoms[18-22] because such deaths may involve higher immediate stress levels, stronger feelings of grief, greater difficulty in accepting the death, and fewer available coping strategies to deal with the loss.[23,24] Accordingly, studies suggest that the loss of a spouse or a parent due to external causes increase the risk of suicide among bereaved family members.[2] Furthermore, the time since the death of a family member could be crucial for the risk of suicide after bereavement. For instance, the risk of suicide increases during the first year after the loss of a spouse and decreases thereafter until it is similar to the overall rate.[8] Men appear to be most at risk during the first few months after bereavement, and for women the risk is distributed more evenly over a longer period.[25] Whether a similar pattern can be discerned on the suicide risk of bereaved siblings is unknown.

Our aim was to conduct a large-scale longitudinal study on mortality from suicide following the loss of an adult sibling, using intergenerational linked data from nationwide Swedish registers. We postulated that the association between sibling's death and suicide will depend on the main cause of sibling's death (suicide or other cause), the gender of the remaining sibling, and potentially also time since the sibling's death. Death risks of siblings and suicide risks in particular, are necessarily interrelated because of shared genetics and shared early life experiences. We therefore adjusted for intra-family correlation in death risks using Cox models with random effects.

## METHOD

This study is based on multiple-linked data of national Swedish routine registers including the total population register (TPR), National Population and Housing Censuses, the Longitudinal Data Base on Education, Income and Employment (LOUISE) and the Cause of Death

registers. The data is maintained at the Centre for Health Equity Studies (CHESS) in Stockholm and was approved by the Regional Ethical Review board of Karolinska Institutet in 2002-11-11 (decision no. 02-481) and the Central Ethical Review Board 2012-09-13 (application no. 2012/1260-31). These decisions approve that the data can be used for several purposes. All data used for this study was also anonymous and researchers did not have access to any personal information that could identify study participants (e.g. personal identity number, home address etc.). Consequently, it was not possible to trace specific individuals included in the data material.

In the study, all persons born in Sweden during the period 1932-1962 and alive at the end of 1980 were linked to the mother, provided that she was born in Sweden and alive at the same time. Hence sibling groups were identified through the mother, and singletons were excluded from analysis. To get a reasonable age balance and in order to use adequate control variables, we restricted the sample to people aged 25-64 years. These study persons were observed from 1981 until 2002.

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) to proxy social and regional differences in suicide, and the month and specific cause of death for all persons who died during the study period. 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. Bereaved persons were slightly older than non-bereaved persons, somewhat more of them had a lower socioeconomic position, and they had more siblings, which is expected considering that the likelihood of observing a sibling's

death must be higher in larger sibling groups (not shown). We accounted for distributional differences between bereaved and non-bereaved persons by using the control variables, which generally provided good statistical fit. All covariates except age and calendar year were measured at the end of 1980, which antedated any sibling death. We distinguished sibling deaths from suicide (ICD8 and ICD9 codes E950-E959, and ICD10 codes X60-X84), external causes other than suicide (ICD8 codes E807-E949 and E960-E999, ICD9 codes E800-E949 and E960-E999, and ICD10 codes V01-X59 and X85-Y98), cardiovascular diseases (ICD8 codes 410-438 and 795, ICD9 codes 410-438 and 798, and ICD10 codes I21-I52 and I60-I69), cancer (ICD8 and ICD 9 codes 140-239, and ICD10 codes C00-D48), and all other causes (all other codes).

All people who experienced a sibling's death during the study period were included, whereas those who did not experience a sibling's death comprised a ten per cent random sample. In the statistical analyses, people from each group were weighted according to their sampling proportion. Normalised weights were used to correct for inflated t-statistics. The death of sibling was a time-varying feature, which means that when a sibling died, the surviving sibling changed status from being a non-bereaved to being a bereaved person. Using Cox regressions with random effects[26], we estimated suicide risks of bereaved persons to non-bereaved persons. These models adjusted for intra-family correlations in suicide risks caused by shared genetics and shared family life experiences of siblings from the same family.

## RESULTS

In total, 79,017 men and 77,614 women experienced a sibling's death, and 242 and 125 of them subsequently died from suicide (Table 1). The corresponding numbers in non-bereaved persons were: 4,376 suicide deaths among 812,186 women and 1,761 suicide deaths among 779,252 men. The death rate in bereaved persons was consequently approximately twice that

of non-bereaved persons (0.39/0.25 for men, and 0.20/0.10 for women). About 9% of all sibling deaths were from suicide.

(Table 1 here)

Suicide was more than twice as common in men (4,618 deaths in total) as in women (1,886 in total), but the association between sibling loss and suicide was greater for women than in men. In bereaved women, the suicide risk was 1.55 times that of non-bereaved women (95% CI: 0.99-2.22). In bereaved men, the suicide risk was 1.28 times that of non-bereaved men (0.93-1.77) (Table 2). In particular those who had experienced a sibling's death from suicide had an own high suicide risk: 3.19 times higher among women (1.23-8.25), and 2.44 higher among men (1.34-4.45). Even if the sibling died of another external cause than suicide, there was an elevated suicide risk for the surviving sibling: 1.38 times higher among women and 1.21 times among men. The estimates were statistically not significant, however. The same caveat applies to more detailed categorisations of the cause of death. There seemed to be a link also to sibling deaths from external causes other than suicide. Men with this experience had an own risk of suicide that was 1.41 times that of non-bereaved men, whereas the corresponding relative risk in women was even higher, or 1.71. Sibling deaths from physical disease, such as cardiovascular disease or cancer, displayed even weaker associations. Confidence intervals were although far too wide to permit any detailed insights.

(Table 2 here)

We also found some tendency towards a pattern where the variation across age groups in the bereavement effect on suicide mortality was found to be smaller for women than for men (results not shown). This might reflect that younger women were more vulnerable to the death of a sibling than young men were. Women also appeared to exhibit somewhat stronger associations in the long term than men (Figure 1). In men, the suicide risk after a sibling's death remained fairly stable, whereas in women there was a slight tendency towards an

increase in the suicide according to time since bereavement. These findings should be interpreted with utmost caution as the confidence intervals are very wide due to the relatively small number of deaths.

(Figure 1 here)

## DISCUSSION

According to the World Health Organization, almost one million people die from suicide each year, and suicide is among the three leading causes of death for people aged less than 25 years.[27] To prevent and identify risk factors for suicide is therefore of utmost importance.

This large-scale follow-up study based on the Swedish population register examined suicide following the death of a sibling. We found an increased suicide risk among women and men who had experienced the suicide of a sibling, whereas associations with other main causes of death were generally much lower and statistically not significant. Women appeared somewhat more vulnerable than men with respect to how their suicide risk relates to a sibling's death, and a sibling's suicide in particular. We found no clear support for a specific time pattern according to time since a sibling's death. In men, the excess suicide risk seemed fairly stable over time, whereas among women there was some indications of an increase according to time since the sibling's death.

Although interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide,[13-15] the findings of this study suggest that deaths from suicide in particular are most detrimental. Relatives exposed to suicide, accidents or violent deaths -- which are often sudden and unanticipated -- might be at greater risk of developing complicated grief and post-traumatic stress symptoms which could explain their higher suicide risk.[13,21,22] In line with this, deaths from cancer and cardiovascular disease showed no significant associations with

suicide risk of bereaved siblings. These chronic diseases tend to run a longer course and therefore allow relatives to adjust and adapt to the circumstances.

It has been argued that the pain of dealing with the loss of a loved one by suicide is especially severe when compared to other types of external deaths such as accidents and homicides. This might explain why we found particularly strong associations between sibling's suicide and suicide among bereaved siblings. There are qualitative aspects of the mourning process that are intensified and frequently more problematic for survivors of suicide than for other types of bereavement.[13,28] Survivors of suicide seem to struggle more with questions of meaning around the death.[29,30] Survivors often show higher levels of guilt, blame, and responsibility for the death than other mourners.[31,32] Studies also find that survivors experience feelings of rejection and abandonment by the loved one, along with anger toward the deceased.[33] However, death by suicide is also stigmatizing to surviving family members and initiates a chain reaction of negative consequences[31] that may lead to an unsatisfactory resolution of bereavement. It has been found that suicide survivors received less emotional support than natural death survivors for their feelings of depression and grief and confided less in members of their social networks.[34]

Women's risk of suicide was found to be somewhat higher after the death of a sibling from suicide when compared to men. This finding might reflect the fact that women place more emphasis on social relationships than men do, particularly when it comes to parents and the family.[35] The loss of a sibling could hence have stronger emotional consequences for women which, in turn, could account for a higher risk of suicide. The longer-term association found among women may also suggest that longer-term mechanisms such as an extended and complicated grief process and/or severe depression underlie the association. In a previous study, we found that women's health is more influenced by bereavement following sibling loss than men's health.[5]

Siblings also share many environmental exposures during childhood and adolescence. Suicide has been associated with family risk factors for suicide such as disorganization and breakup, parental loss, substance abuse, intrafamily violence, and sexual abuse.[13] Deaths from external causes other than suicide, such as accidents and homicides, could, however, also reflect risk taking behaviours due to depression, psychiatric disorders and shared environmental exposures. Consequently, genetic confounding might account for a higher risk of suicide following sibling deaths from external causes. Given the strong genetic similarities between siblings there could be a higher risk of confounding when compared to research on other types of bereavement. Considering that the association between bereavement by suicide and suicide in bereaved siblings is the strongest observed in this study it could also reflect the "copycat phenomenon" i.e. suicides in bereaved siblings could be caused by imitation of suicidal behaviour.[36] Nevertheless, our methodological strategy accounted for intra-family correlation in death risks which is a great strength of the study. This is important, considering that genetic factors and shared early life experiences can predispose people towards the development of psychiatric disorders that are associated with suicide; particularly depression and bipolar disorders.[14]

**Limitations**

Despite the obvious strengths of this study such as the use of total population register data, a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables, some limitations should be noted. More detailed individual information is required to uncover the actual causal mechanisms that link sibling suicide and mortality. Such information could also 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, more information on shared childhood social environment and

family characteristics, and detailed data on personal and relational characteristics, which are unfortunately not included in the registers. In particular, the inability of registry-based studies to attend for family-level risk factors such as the quality of sibling relationship is a limitation of the study. The quality of the relationship with the deceased sibling could decide the severity of bereavement and thereby contribute to suicide risk among remaining siblings. The study also involves the lack of information on surviving sibling's medical and psychiatric status, both of which convey important information about suicide risk, and temporal relationship of medical illnesses and mental health disorder episodes to both bereavement and suicide. On the other hand, our results likely underestimate the true bereavement effect following sibling death from suicide, since we could study only completed suicide, and not suicide attempts which are much more common.[37] Examining attempted suicide is likely to provide more precision and even greater statistical power.

Our findings suggest that the health-care system should consider collateral health effects when dealing with people exposed to sibling deaths from external causes. Most discussion has focused on bereavement after the death of a spouse or a parent, while siblings have tended to be the 'forgotten grievers'. Our findings illustrate that a sibling's death due to suicide can increase the risk of suicide among bereaved siblings. Considering that their loss and pain are often insufficiently acknowledged by the parents and the informal social support system[11,12], it is important that physicians and health-care professionals acknowledge bereaved siblings from causes of death such as suicide, accidents, and violent deaths. Accordingly, targeted support towards bereaved siblings who experienced sibling deaths from suicide may be beneficial and reduce their risk of suicide. Our findings also suggest the need for further research to determine whether long-term follow-up and support provided by health care workers to surviving siblings can reduce suicide risk.

In summary, our study provided evidence for suicide associated with the death of a sibling at adult age and illustrated that bereaved siblings' risk of suicide is primarily influenced by deaths from suicide. The mechanisms linking the death of a sibling and completed suicide among the bereaved person need to be further investigated.

*Contributors*

MR and JS planned the study and the research design. They also analysed data, interpreted the results, and wrote the draft version of the paper. IK contributed to writing, interpretation of data, and critical reviews. All authors corrected and approved the final version of the manuscript.

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*Competing interests*

None

*Data sharing*

No additional data available.

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Table 1. Descriptive statistics by sex of the index persons

| | Men | Women |
|---|---|---|
| Number of sibling deaths | 78,297 | 76,910 |
| % from suicide | 8.7 | 8.9 |
| % from external other than suicide | 10.8 | 10.8 |
| % from cardiovascular diseases | 22.0 | 22.1 |
| % from cancer | 37.3 | 37.2 |
| Number of deaths from suicide | | |
| In bereaved persons | 242 | 125 |
| In non-bereaved persons | 4,376 | 1,761 |
| Number of person years in | | |
| Bereaved persons | 620,584 | 611,382 |
| Non-bereaved persons | 17,893,475 | 17,308,392 |
| Death rate (×1,000) | | |
| In bereaved persons | 0.39 | 0.20 |
| In non-bereaved persons | 0.25 | 0.10 |
| Number of (ever) bereaved persons | 79,017 | 77,614 |
| Number of non-bereaved persons | 812,186 | 779,252 |

Table 2. Association between sibling's death from different main causes and suicide in index persons

| | Men | | Women | |
|---|---|---|---|---|
| Cause of sibling's death | | | | |
| All causes | 1.28 | (0.93-1.77) | 1.55 | (0.99-2.44) |
| Suicide | 2.44 | (1.34-4.45) | 3.19 | (1.23-8.25) |
| Not suicide | 1.21 | (0.88-1.71) | 1.38 | (0.84-2.26) |
| External other than suicide | 1.41 | (0.69-2.86) | 1.71 | (0.63-4.68) |
| Cardiovascular diseases | 1.27 | (0.66-2.44) | 1.34 | (0.49-3.69) |
| Cancer | 1.20 | (0.70-2.05) | 1.02 | (0.41-2.52) |
| All other causes | 1.08 | (0.54-2.16) | 1.68 | (0.72-3.96) |

Numbers are mortality risk ratios (with 95% confidence intervals), i.e., the ratio of the death risk of bereaved persons and non-bereaved persons, adjusted for effects of all control variables.

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

Results are from cox models with random effects.

Figure legend:

Figure 1. Suicide risk after siblings death as compared with non-bereaved persons (with 95% confidence intervals). Results are from Cox models with random effects.

**Suicide following the death of a sibling: A nationwide follow-up study from Sweden**

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## ABSTRACT

**Objectives:** The death of a sibling can trigger grief and depression. Sibling deaths from external causes may be particularly detrimental, since they are often sudden. We aimed to examine the association between death of an adult sibling from external causes and the risk of suicide among surviving siblings up to 18 years after bereavement. We adjusted for intra-family correlation in death risks, which might occur because of shared genetics and shared early life experiences of siblings in the same family. **Design:** A follow-up study between 1981 and 2002 based on the total population. **Setting:** Sweden **Participants:** Swedes aged 25-64 years (n=1,748,069). **Primary and secondary outcome measures:** Suicide from the Swedish cause of death register. **Results:** An increased risk of mortality from suicide was found among persons who had experienced the death of a sibling. In women, the suicide risk was 1.55 times that of non-bereaved persons (95% CI: 0.99-2.44), and in men it was 1.28 times higher (95% CI: 0.93-1.77). If one sibling committed suicide, the risk of the remaining sibling also committing suicide was 3.19 (95% CI: 1.23-8.25) among women and 2.44 (95% CI: 1.34-4.45) among men. Associations with other main causes of death - such as external other than suicide, cardiovascular diseases, or cancer - were generally much smaller and statistically not significant in either sex. We found no clear support for a specific time pattern according to time since a sibling's death. **Conclusions:** Our study provided evidence for suicide risk associated with the death of a sibling at adult age, revealing that bereaved persons' risk of suicide is higher when siblings die from suicide, even when adjusting for intra-family correlation in death risks.


### Article focus

- The loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidal behavior.

- The impact of losing an adult sibling on suicide risk of remaining siblings has been largely overlooked.
- Unexpected causes of deaths may precipitate a more severe reaction compared to deaths following chronic illness in which family members have more time to adjust and cope with the loss.

**Key messages**

- This study provided the first large-scale evidence for suicide associated with sibling death at adult age.
- Even when adjusting for intra-family correlation in death risks, bereaved persons' suicide risk is raised when their siblings had died from suicide.

**Strengths and limitations of this study**

- The use of total population register data on sibling groups provides a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables.
- The mechanisms linking the death of a sibling and completed suicide among the bereaved person could not be investigated. For instance, the quality of the relationship with the deceased sibling could decide the severity of bereavement and thereby contribute to suicide risk among remaining siblings.

## INTRODUCTION

Previous studies have established that the loss of a family member leads to an increased risk of death and disease among bereaved family members such as spouses, parents, and children.[1-5] Bereavement also contributes to a higher risk of suicide in bereaved family members.[6-10] However, the impact of grief following the loss of an adult sibling has been largely overlooked. To the extent that siblings are also beloved, provide companionship and support, one would expect that death of an adult sibling -- as much as the death of other family members (e.g. spouse, parents, children) -- would be associated with an increased risk of suicide. In fact, the death of a sibling often represents the loss of the longest and most intimate relationships of a person's lifetime.[11] Some studies even suggest that the death of a sibling is more disruptive and involves a more severe grief process than other familial deaths.[5,12]

Interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide[13-15],both directly as a proximal precipitant for suicide as well as through the onset or exacerbation of psychiatric illness in survivors.[13] Consequently, the loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidal behavior, such as major depression, and anxiety disorders in adults.[13,16,17] However, the grief reaction associated with sibling loss could be expected to vary according to the cause of death. Thus sudden or unexpected causes of deaths (e.g. suicides, accidents and homicides) may precipitate a more severe reaction compared to deaths following chronic illness (e.g. cancer) in which family members have more time to adjust and cope with the loss. It has, for instance, been found that relatives exposed to deaths from external causes are at greater risk of developing complicated grief and post-traumatic stress symptoms[18-22] because such deaths may involve higher immediate stress levels, stronger feelings of grief, greater difficulty in accepting the death, and fewer available coping

strategies to deal with the loss.[23,24] Accordingly, studies suggest that the loss of a spouse or a parent due to external causes increase the risk of suicide among bereaved family members.[2] Furthermore, the time since the death of a family member could be crucial for the risk of suicide after bereavement. For instance, the risk of suicide increases during the first year after the loss of a spouse and decreases thereafter until it is similar to the overall rate.[8] Men appear to be most at risk during the first few months after bereavement, and for women the risk is distributed more evenly over a longer period.[25] Whether a similar pattern can be discerned on the suicide risk of bereaved siblings is unknown.

Our aim was to conduct a large-scale longitudinal study on mortality from suicide following the loss of an adult sibling, using intergenerational linked data from nationwide Swedish registers. We postulated that the association between sibling's death and suicide will depend on the main cause of sibling's death (suicide or other cause), the gender of the remaining sibling, and potentially also time since the sibling's death. Death risks of siblings and suicide risks in particular, are necessarily interrelated because of shared genetics and shared early life experiences. We therefore adjusted for intra-family correlation in death risks using Cox models with random effects.

## METHOD

This study is based on multiple-linked data of national Swedish routine registers including the total population register (TPR), National Population and Housing Censuses, the Longitudinal Data Base on Education, Income and Employment (LOUISE) and the Cause of Death registers. The data is maintained at the Centre for Health Equity Studies (CHESS) in Stockholm and was approved by the Regional Ethical Review board of Karolinska Institutet in 2002-11-11 (decision no. 02-481) and the Central Ethical Review Board 2012-09-13 (application no. 2012/1260-31). These decisions approve that the data can be used for several

purposes. All data used for this study was also anonymous and researchers did not have access to any personal information that could identify study participants (e.g. personal identity number, home address etc.). Consequently, it was not possible to trace specific individuals included in the data material.

In the study, all persons born in Sweden during the period 1932-1962 and alive at the end of 1980 were linked to the mother, provided that she was born in Sweden and alive at the same time. Hence sibling groups were identified through the mother, and singletons were excluded from analysis. To get a reasonable age balance and in order to use adequate control variables, we restricted the sample to people aged 25-64 years. These study persons were observed from 1981 until 2002.

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) to proxy social and regional differences in suicide, and the month and specific cause of death for all persons who died during the study period. 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. Bereaved persons were slightly older than non-bereaved persons, somewhat more of them had a lower socioeconomic position, and they had more siblings, which is expected considering that the likelihood of observing a sibling's death must be higher in larger sibling groups (not shown). We accounted for distributional differences between bereaved and non-bereaved persons by using the control variables, which generally provided good statistical fit. All covariates except age and calendar year were measured at the end of 1980, which antedated any sibling death. We distinguished sibling

deaths from suicide (ICD8 and ICD9 codes E950-E959, and ICD10 codes X60-X84), external causes other than suicide (ICD8 codes E807-E949 and E960-E999, ICD9 codes E800-E949 and E960-E999, and ICD10 codes V01-X59 and X85-Y98), cardiovascular diseases (ICD8 codes 410-438 and 795, ICD9 codes 410-438 and 798, and ICD10 codes I21-I52 and I60-I69), cancer (ICD8 and ICD 9 codes 140-239, and ICD10 codes C00-D48), and all other causes (all other codes).

All people who experienced a sibling's death during the study period were included, whereas those who did not experience a sibling's death comprised a ten per cent random sample. In the statistical analyses, people from each group were weighted according to their sampling proportion. Normalised weights were used to correct for inflated t-statistics. The death of sibling was a time-varying feature, which means that when a sibling died, the surviving sibling changed status from being a non-bereaved to being a bereaved person. Using Cox regressions with random effects[26], we estimated suicide risks of bereaved persons to non-bereaved persons. These models adjusted for intra-family correlations in suicide risks caused by shared genetics and shared family life experiences of siblings from the same family.

## RESULTS

In total, 79,017 men and 77,614 women experienced a sibling's death, and 242 and 125 of them subsequently died from suicide (Table 1). The corresponding numbers in non-bereaved persons were: 4,376 suicide deaths among 812,186 women and 1,761 suicide deaths among 779,252 men. The death rate in bereaved persons was consequently approximately twice that of non-bereaved persons (0.39/0.25 for men, and 0.20/0.10 for women). About 9% of all sibling deaths were from suicide.

(Table 1 here)

Suicide was more than twice as common in men (4,618 deaths in total) as in women (1,886 in total), but the association between sibling loss and suicide was greater for women than in men. In bereaved women, the suicide risk was 1.55 times that of non-bereaved women (95% CI: 0.99-2.22). In bereaved men, the suicide risk was 1.28 times that of non-bereaved men (0.93-1.77) (Table 2). In particular those who had experienced a sibling's death from suicide had an own high suicide risk: 3.19 times higher among women (1.23-8.25), and 2.44 higher among men (1.34-4.45). Even if the sibling died of another external cause than suicide, there was an elevated suicide risk for the surviving sibling: 1.38 times higher among women and 1.21 times among men. The estimates were statistically not significant, however. The same caveat applies to more detailed categorisations of the cause of death. There seemed to be a link also to sibling deaths from external causes other than suicide. Men with this experience had an own risk of suicide that was 1.41 times that of non-bereaved men, whereas the corresponding relative risk in women was even higher, or 1.71. Sibling deaths from physical disease, such as cardiovascular disease or cancer, displayed even weaker associations. Confidence intervals were although far too wide to permit any detailed insights.

(Table 2 here)

We also found some tendency towards a pattern where the variation across age groups in the bereavement effect on suicide mortality was found to be smaller for women than for men (results not shown). This might reflect that younger women were more vulnerable to the death of a sibling than young men were. Women also appeared to exhibit somewhat stronger associations in the long term than men (Figure 1). In men, the suicide risk after a sibling's death remained fairly stable, whereas in women there was a slight tendency towards an increase in the suicide according to time since bereavement. These findings should be interpreted with utmost caution as the confidence intervals are very wide due to the relatively small number of deaths.

(Figure 1 here)

## DISCUSSION

According to the World Health Organization, almost one million people die from suicide each year, and suicide is among the three leading causes of death for people aged less than 25 years.[27] To prevent and identify risk factors for suicide is therefore of utmost importance.

This large-scale follow-up study based on the Swedish population register examined suicide following the death of a sibling. We found an increased suicide risk among women and men who had experienced the suicide of a sibling, whereas associations with other main causes of death were generally much lower and statistically not significant. Women appeared somewhat more vulnerable than men with respect to how their suicide risk relates to a sibling's death, and a sibling's suicide in particular. We found no clear support for a specific time pattern according to time since a sibling's death. In men, the excess suicide risk seemed fairly stable over time, whereas among women there was some indications of an increase according to time since the sibling's death.

Although interpersonal loss and disruption of attachments from any cause could elevate the risk for suicide,[13-15] the findings of this study suggest that deaths from suicide in particular are most detrimental. Relatives exposed to suicide, accidents or violent deaths -- which are often sudden and unanticipated -- might be at greater risk of developing complicated grief and post-traumatic stress symptoms which could explain their higher suicide risk.[13,21,22] In line with this, deaths from cancer and cardiovascular disease showed no significant associations with suicide risk of bereaved siblings. These chronic diseases tend to run a longer course and therefore allow relatives to adjust and adapt to the circumstances.

It has been argued that the pain of dealing with the loss of a loved one by suicide is especially severe when compared to other types of external deaths such as accidents and

homicides. This might explain why we found particularly strong associations between sibling's suicide and suicide among bereaved siblings. There are qualitative aspects of the mourning process that are intensified and frequently more problematic for survivors of suicide than for other types of bereavement.[13,28] Survivors of suicide seem to struggle more with questions of meaning around the death.[29,30] Survivors often show higher levels of guilt, blame, and responsibility for the death than other mourners.[31,32] Studies also find that survivors experience feelings of rejection and abandonment by the loved one, along with anger toward the deceased.[33] However, death by suicide is also stigmatizing to surviving family members and initiates a chain reaction of negative consequences[31] that may lead to an unsatisfactory resolution of bereavement. It has been found that suicide survivors received less emotional support than natural death survivors for their feelings of depression and grief and confided less in members of their social networks.[34]

Women's risk of suicide was found to be somewhat higher after the death of a sibling from suicide when compared to men. This finding might reflect the fact that women place more emphasis on social relationships than men do, particularly when it comes to parents and the family.[35] The loss of a sibling could hence have stronger emotional consequences for women which, in turn, could account for a higher risk of suicide. The longer-term association found among women may also suggest that longer-term mechanisms such as an extended and complicated grief process and/or severe depression underlie the association. In a previous study, we found that women's health is more influenced by bereavement following sibling loss than men's health.[5]

Siblings also share many environmental exposures during childhood and adolescence. Suicide has been associated with family risk factors for suicide such as disorganization and breakup, parental loss, substance abuse, intrafamily violence, and sexual abuse.[13] Deaths from external causes other than suicide, such as accidents and homicides, could, however, also

reflect risk taking behaviours due to depression, psychiatric disorders and shared environmental exposures. Consequently, genetic confounding might account for a higher risk of suicide following sibling deaths from external causes. Given the strong genetic similarities between siblings there could be a higher risk of confounding when compared to research on other types of bereavement. Considering that the association between bereavement by suicide and suicide in bereaved siblings is the strongest observed in this study it could also reflect the "copycat phenomenon" i.e. suicides in bereaved siblings could be caused by imitation of suicidal behaviour.[36] Nevertheless, our methodological strategy accounted for intra-family correlation in death risks which is a great strength of the study. This is important, considering that genetic factors and shared early life experiences can predispose people towards the development of psychiatric disorders that are associated with suicide; particularly depression and bipolar disorders.[14]

**Limitations**

Despite the obvious strengths of this study such as the use of total population register data, a large sample size, longitudinal follow-up, reliable information on deaths from suicide and other included variables, some limitations should be noted. More detailed individual information is required to uncover the actual causal mechanisms that link sibling suicide and mortality. Such information could also 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, more information on shared childhood social environment and family characteristics, and detailed data on personal and relational characteristics, which are unfortunately not included in the registers. In particular, the inability of registry-based studies to attend for family-level risk factors such as the quality of sibling relationship is a limitation of the study. The quality of the relationship with the deceased sibling could decide the

severity of bereavement and thereby contribute to suicide risk among remaining siblings. The study also involves the lack of information on surviving sibling's medical and psychiatric status, both of which convey important information about suicide risk, and temporal relationship of medical illnesses and mental health disorder episodes to both bereavement and suicide. On the other hand, our results likely underestimate the true bereavement effect following sibling death from suicide, since we could study only completed suicide, and not suicide attempts which are much more common.[37] Examining attempted suicide is likely to provide more precision and even greater statistical power.

Our findings suggest that the health-care system should consider collateral health effects when dealing with people exposed to sibling deaths from external causes. Most discussion has focused on bereavement after the death of a spouse or a parent, while siblings have tended to be the 'forgotten grievers'. Our findings illustrate that a sibling's death due to suicide can increase the risk of suicide among bereaved siblings. Considering that their loss and pain are often insufficiently acknowledged by the parents and the informal social support system[11,12], it is important that physicians and health-care professionals acknowledge bereaved siblings from causes of death such as suicide, accidents, and violent deaths. Accordingly, targeted support towards bereaved siblings who experienced sibling deaths from suicide may be beneficial and reduce their risk of suicide. Our findings also suggest the need for further research to determine whether long-term follow-up and support provided by health care workers to surviving siblings can reduce suicide risk.

In summary, our study provided evidence for suicide associated with the death of a sibling at adult age and illustrated that bereaved siblings' risk of suicide is primarily influenced by deaths from suicide. The mechanisms linking the death of a sibling and completed suicide among the bereaved person need to be further investigated.

*Contributors*

MR and JS planned the study and the research design. They also analysed data, interpreted the results, and wrote the draft version of the paper. IK contributed to writing, interpretation of data, and critical reviews. All authors corrected and approved the final version of the manuscript.

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*Competing interests*

None

*Data sharing*

No additional data available.

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Table 1. Descriptive statistics by sex of the index persons

| | Men | Women |
|---|---|---|
| Number of sibling deaths | 78,297 | 76,910 |
| % from suicide | 8.7 | 8.9 |
| % from external other than suicide | 10.8 | 10.8 |
| % from cardiovascular diseases | 22.0 | 22.1 |
| % from cancer | 37.3 | 37.2 |
| Number of deaths from suicide | | |
| In bereaved persons | 242 | 125 |
| In non-bereaved persons | 4,376 | 1,761 |
| Number of person years in | | |
| Bereaved persons | 620,584 | 611,382 |
| Non-bereaved persons | 17,893,475 | 17,308,392 |
| Death rate (×1,000) | | |
| In bereaved persons | 0.39 | 0.20 |
| In non-bereaved persons | 0.25 | 0.10 |
| Number of (ever) bereaved persons | 79,017 | 77,614 |
| Number of non-bereaved persons | 812,186 | 779,252 |

Table 2. Association between sibling's death from different main causes and suicide in index persons

| | Men | | Women | |
|---|---|---|---|---|
| Cause of sibling's death | | | | |
| All causes | 1.28 | (0.93-1.77) | 1.55 | (0.99-2.44) |
| Suicide | 2.44 | (1.34-4.45) | 3.19 | (1.23-8.25) |
| Not suicide | 1.21 | (0.88-1.71) | 1.38 | (0.84-2.26) |
| External other than suicide | 1.41 | (0.69-2.86) | 1.71 | (0.63-4.68) |
| Cardiovascular diseases | 1.27 | (0.66-2.44) | 1.34 | (0.49-3.69) |
| Cancer | 1.20 | (0.70-2.05) | 1.02 | (0.41-2.52) |
| All other causes | 1.08 | (0.54-2.16) | 1.68 | (0.72-3.96) |

Numbers are mortality risk ratios (with 95% confidence intervals), i.e., the ratio of the death risk of bereaved persons and non-bereaved persons, adjusted for effects of all control variables.
Control variables included in the estimations are age, calendar year, socioeconomic status, marital status, number of children, number of siblings and region of residence.
Results are from cox models with random effects.

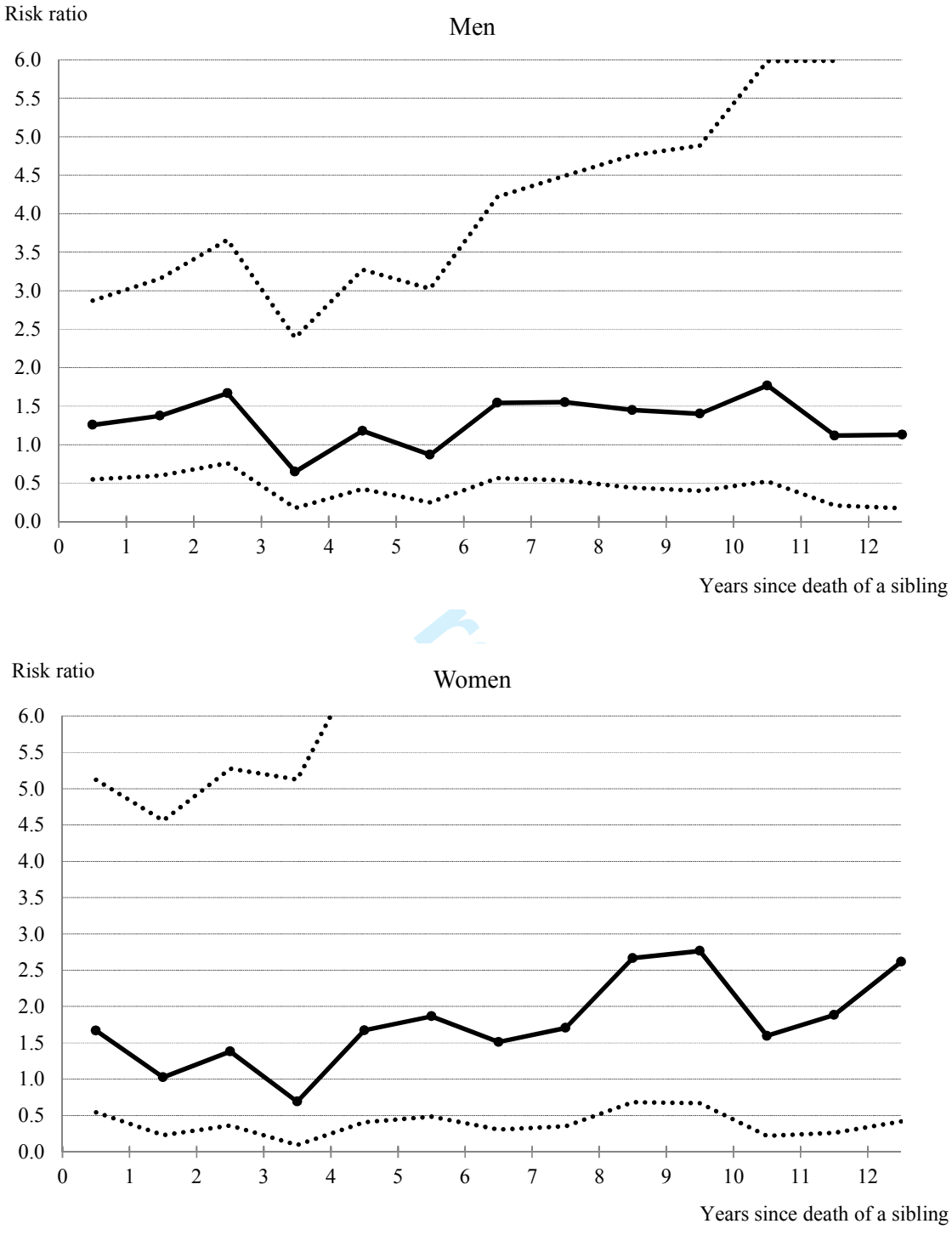


Figure 1. Suicide risk after siblings death as compared with non-bereaved persons (with 95% confidence intervals). Results are from Cox models with random effects.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Comment |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | The study design is indicated in the abstract (Design: We conducted a follow-up study between 1981 and 2002). |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | It has been our ambition to provide a summary that is both informative and balanced (see abstract). |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | The rationale is described in the introduction. "the loss of a family member has been linked to increased vulnerability of psychiatric disorders that may be highly associated with suicidality, such as major depression, and anxiety disorders in adults." |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | Objective: To conduct a large-scale analysis of suicide following the death of a sibling at adult ages. Hypotheses: We postulated that the association between sibling's death and suicide will vary according to time since the sibling's suicide, gender of the bereaved sibling and specific cause of the bereaved sibling's death. |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | The study design is to identify sibling groups on basis of the mother by using the Swedish multigeneration register and link this information to mortality statistics. See the first paragraph of the 'Methods' section. |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | The information used comes from a database that links several routine administrative registers in Sweden. Our information cover the entire native-born Swedish population alive at end-1980, with a mother alive at end-1980. Persons who had experienced the death of a sibling became under exposure at the month the sibling had died. These persons were observed with regard to own mortality at a monthly basis until the end of 2002. The control group consisted of a ten per cent random sample of all people who had not experienced the death of sibling during the observation period. See the 'Methods' section. |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. | The data cover all deaths, and hence all individuals who had experienced the death of a sibling during the period 1981-2002. In the |

| | | | |
|---|---|---|---|
| | | Describe methods of follow-up | administrative registers, all persons living in Sweden can be observed with regard to the month and cause of death. See the 'Methods' section. |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | n/a |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | We distinguished deaths from suicide (ICD8 and ICD9 codes E950-E959, and ICD10 codes X60-X84), external causes other than suicide (ICD8 codes E807-E949 and E960-E999, ICD9 codes E800-E949 and E960-E999, and ICD10 codes V01-X59 and X85-Y98), cardiovascular diseases (ICD8 codes 410-438 and 795, ICD9 codes 410-438 and 798, and ICD10 codes I21-I52 and I60-I69), cancer (ICD8 and ICD 9 codes 140-239, and ICD10 codes C00-D48), and all other causes (all other codes).<br>Covariates included are basic socio-demographic variables – age, socioeconomic status, marital status, number of children, number of siblings – and region of residence and calendar year. All covariates except age and calendar year were measured at the end of 1980, which was before any sibling death had occurred. See the 'Methods' section. |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | Socioeconomic status consists of the categories 'Blue-collar worker', 'White-collar worker', 'Self-employed', and 'Outside labour market'. Marital status consists of the categories 'Married', 'Previously married', and 'Never married'. Region of residence refers to each county ('län') in Sweden (21 counties in total). Further details are available upon request. Each covariate used is measured in exactly the same way for bereaved and non-bereaved persons. The only difference in measurement is in the key variable of interest; the event (and time since) a sibling's death. |
| Bias | 9 | Describe any efforts to address potential sources of bias | Separating specific causes of death is a way to get closer to causal inference and, hence, addressing the question of potential residual confounding. See page 5 of the 'Introduction' section, and paragraph 11 of the 'Discussion' section. |
| Study size | 10 | Explain how the study size was arrived at | All Swedes aged aged 25-64 years (n=1,748,069) during the period 1981-2002, who had experienced a sibling's death are |

| | | | |
|---|---|---|---|
| | | | studied, and compared with a ten per cent random sample from the total population of persons who had not experienced a sibling's death. See 'Methods' section. |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | See item no. 8. |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | Cox proportional hazards regressions were used to estimate one-year mortality risk ratios of persons who had experienced the death of sibling relative to persons who had not experienced the death of a sibling. See 'Methods' section. |
| | | (*b*) Describe any methods used to examine subgroups and interactions | The ten percent random sample of persons not experiencing a sibling death was used as comparison group. |
| | | (*c*) Explain how missing data were addressed | n/a (no missing data, since the information come from administrative registers) |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | n/a (not a problem in this study). |
| | | (*e*) Describe any sensitivity analyses | n/a |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | Details are given in Table 1. |
| | | (b) Give reasons for non-participation at each stage | n/a (non-participation is not an option, since all information comes from administrative registers) |
| | | (c) Consider use of a flow diagram | A lexis diagram showing cohorts/ages/years under study is available upon request. Since the setup of the study is comprehensive without this diagram, it is not, for the sake of brevity, included in the article. |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Details are given in Table 1, and further information available upon request. |
| | | (b) Indicate number of participants with missing data for each variable of interest | n/a |

| | | | |
|---|---|---|---|
| | | (c) Summarise follow-up time (eg, average and total amount) | Details are given in Table 1. |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | Details are given in Table 1. |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | We report only confounder-adjusted estimates and their precision, since it is highly necessary to control for any observable differences that might affect mortality variation across bereaved and non-bereaved persons. See Tables 2 and Figure 1. Unadjusted estimates and their precision are available upon request. |
| | | (*b*) Report category boundaries when continuous variables were categorized | n/a |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | n/a |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | We tested interactions between socioeconomic position, marital status, family type and bereavement related suicide on mortality. We also tested whether increasing the randomized sample of non-bereaved individuals influence our estimates. These numbers are available upon request. |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | An increased risk of mortality from suicide was found among persons who had experienced the death of a sibling from an external cause. In women, the suicide risk was 1.65 times that of non-bereaved persons (95% CI: 1.35-2.02), and in men it was 1.37 times higher (95% CI: 1.19-1.58). If one sibling committed suicide, the risk of the remaining sibling also committing suicide was 3.44 (2.40-4.94) among women and 2.46 (1.86-3.24) among men. If one sibling died from external causes other than suicide, the risk of suicide in the surviving sibling was still elevated: 1.77 (1.13-2.77) among women and 1.42 (1.03-1.96) among men. Sibling deaths from chronic diseases, e.g., cardiovascular disease or cancer, displayed much weaker and generally not statistically significant associations with suicide in the surviving sibling. |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of | We found that the associations between concordant causes of death (both siblings died |

| | | | |
|---|---|---|---|
| | | potential bias or imprecision. Discuss both direction and magnitude of any potential bias | of suicide) were stronger than associations between discordant causes. This could, to some extent, indicate confounding by genetic resemblance or shared environmental risk factors. Genetic factors can predispose people towards the development of psychiatric disorders that are associated with suicide. Siblings also share many environmental exposures during childhood and adolescence such as disorganization and breakup, parental loss, substance abuse, intrafamily violence, and sexual abuse. On the other hand, we also found associations between sibling's suicide and mortality from discordant causes , which strengthen the possibility that the association may be causal. If we had found associations only when both siblings died of suicide, confounding by genetic similarities or shared environmental conditions would seem more likely. Another limitation was that it was not possible to test the actual causal mechanisms that link siblings' mortality risks. These limitations are discussed in the discussion section. |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | Our study provided large-scale evidence for suicide associated with sibling death at adult age. Although sibling suicides were primarily associated with suicide in bereaved survivors, there was an increased mortality risk from discordant causes, which strengthens the possibility that the observed associations are not entirely due to shared genetic causes or environmental factors. |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | Given that we use data from Swedish total population registers it is possible to generalise our findings to the total Swedish population. |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | See 'funding' section |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

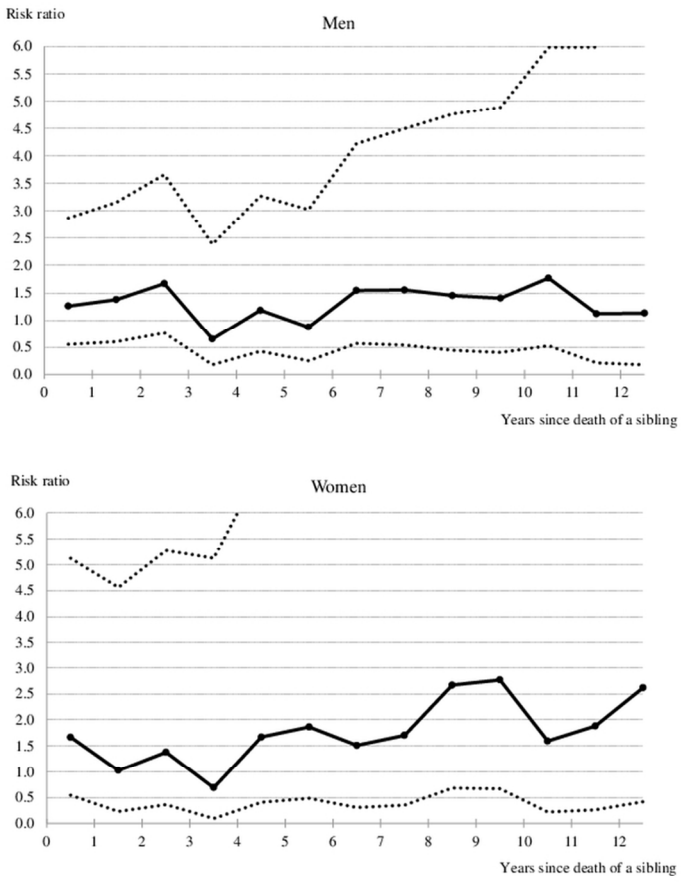


Figure 1. Suicide risk after siblings death as compared with non-bereaved persons (with 95% confidence intervals). Results are from Cox models with random effects.

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