Parental death by external causes and psychosocial sequelae in bereaved offspring

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Abbreviations

Parental DBEC	Parental death by external causes
ICD	International classification of deceases
DSH	Deliberate self-harm
HRs	Hazard ratios
ORs	Odds ratios
95% CI	95% confidence interval

Thesis summary

Background: Losing a parent to external causes of death such as suicide, accidents and homicide is one of the most significant life events that children and adolescents can experience, probably due to the strong attachment that normally exists between parents and children and the traumatic nature of the loss. Previous research has reported that children and adolescents who have experienced parental death by external causes have increased risks of psychosocial problems compared to peers who have not experienced such loss. No previous studies have, however, investigated the potential association between parental death by external causes and educational attainment at all levels, several specific psychiatric disorders, psychiatric comorbidity or co-occurrence of psychosocial problems. Moreover, findings concerning potential differences between various factors related to the death are generally inconclusive and sparse.

Aims: The present thesis aimed to investigate whether offspring who lost a parent to external causes of death during childhood and adolescence had increased long-term risks of lower education, hospital treated deliberate self-harm (DSH), psychiatric disorders, psychiatric comorbidity or co-occurrence of these adverse outcomes compared to non-bereaved peers. We additionally aimed to study important factors that may influence these associations, specifically the parent’s cause of death, the gender of the deceased parent, the gender of the bereaved offspring, the offspring’s age at bereavement and the time since bereavement.

Materials and Methods: We retrieved individual-level data from four Norwegian national longitudinal registers. Papers I, III and IV used cohort studies, while paper II used a nested case control study. The cohort in papers I, III and IV was based on a 25% random sample of all Norwegian residents who had a link to their father and mother in the Central Population Register and initially included people born from 1970 to 2012. Paper I, however, only included people born until 1994 due to specific analytic needs. The cohort in paper I consisted of 373 104 people, while the cohort in papers III and IV consisted of 655 477 people. In paper II, study cases were people born between 1970 and 2003 who received acute somatic hospital treatment for DSH between 2008 and 2013. DSH was broadly operationalised to detect probable cases, yielding 12 526 cases. Controls comprised 222 362 people matched for date of birth, gender and date of DSH hospitalisation.

Regression analyses were used to compare risks between bereaved offspring and non-bereaved peers; Cox regression investigated the risks of educational attainment and psychiatric disorders in the cohort studies and conditional logistic regression investigated the risk of DSH hospitalisation in the nested case-control study. Co-occurrence of adverse outcomes was examined with chi-square tests of independence, and log likelihood ratio tests were used to examine interactions between variables.

Results: Compared to people who had not experienced parental death by external causes, offspring who experienced such loss had significantly increased risks of lower educational attainment at all levels, hospital treated DSH and several psychiatric disorders, namely depressive disorders, reactions to stress, anxiety disorders, substance use disorders, developmental disorders, childhood behavioural and emotional disorders, psychotic disorders, bipolar disorder, and personality disorders. Bereaved offspring also had a significantly higher likelihood of two or three of these adverse outcomes co-occurring and a significantly increased risk of psychiatric comorbidity. On the contrary, bereaved offspring did not have significantly increased risks of eating disorders.

Concerning educational attainment, no large differences were evident between the various external causes of death. Regarding DSH hospitalisation, however, parental suicide and accidental falls and poisoning were associated with significantly increased risks, while transport accidents and other external causes were not associated with significantly increased risks. As for psychiatric disorders, all external causes of death were associated with a significantly increased risk of any psychiatric disorder, while parental suicide was associated with the largest risks.

Losing a mother and father were both associated with increased risks, and no large differences associated with the gender of the deceased parent were evident. Likewise, loss up to 18 years was associated with increased risks, with minimal differences between age groups. When examining the time since bereavement, we found significantly increased risks of DSH hospitalisation the first 10 years after bereavement, but no significantly increased risk 10 to 15 years after bereavement. No large differences were evident between females and males.

Conclusion: The present thesis indicates that the loss of a parent from all external causes of death during childhood and adolescence is associated with increased long-term risks of

psychosocial sequelae. Consequently, we advocate that all bereaved offspring should be routinely offered supportive follow-up in primary healthcare and educational support services. Given the higher risks associated with parental suicide compared to other external causes of death, suicide bereaved offspring should be offered follow-up in specialised child and adolescent mental health services on a routine basis. The extensive and long-lasting sequelae following parental bereavement emphasise the importance of a multi-faceted, comprehensive and long-term follow-up of this vulnerable group.

Sammendrag (Norwegian)

Bakgrunn: At en forelder dør grunnet ytre dødsårsaker slik som selvmord, ulykker og drap er en av de mest signifikante hendelser et barn eller ungdom kan oppleve, antagelig grunnet den ofte sterke tilknytningen mellom foreldre og barn og den traumatiske typen dødsfall. Tidligere forskning har vist at barn og ungdom som har opplevd at foreldre dør grunnet ytre dødsårsaker har økt risiko for psykososiale problemer sammenlignet med personer som ikke har opplevd slikt tap. Ingen tidligere studier har derimot undersøkt de potensielle assosiasjonene mellom foreldres død grunnet ytre dødsårsaker og fullføring av utdannelse på alle utdanningsnivåer, flere ulike psykiske lidelser, psykiatrisk komorbiditet eller sammenfallende psykososiale problemer. Videre er resultater vedrørende potensielle forskjeller mellom ulike faktorer relatert til dødsfallet sparsommelige og uklare.

Formål: Denne avhandlingens formål er å undersøke hvorvidt personer som har mistet en forelder grunnet ytre dødsårsaker i barndom eller ungdomstid har økt langvarig risiko for lavere utdannelse, sykehusbehandlet villet egenskade, psykiske lidelser, psykiatrisk komorbiditet eller flere av disse problemene samtidig sammenlignet med ikke-etterlatte personer. Vi ønsket også å studere viktige faktorer som kan påvirke disse assosiasjonene, spesielt foreldrenes dødsårsak, kjønnet til den avdøde forelder, kjønnet til det etterlatte barnet, barnets alder ved dødsfallet, og tidsrommet siden dødsfallet.

Metode: Vi ekstraherte data på individnivå fra fire norske longitudinelle registre. Artikkel I, III og IV benyttet kohort studier, mens artikkel II benyttet en «nested case-control» metode. Kohortene i artikkel I, III og IV var basert på et 25% tilfeldig utvalg av den norske befolkning som hadde en registrert kobling til begge foreldre i Folkeregisteret, og inkluderte opprinnelig personer født i 1970-2012. Artikkel I inkluderte derimot kun personer født opp til 1994 grunnet spesifikke analytiske behov. Kohorten i artikkel I bestod av 373 104 personer, mens kohorten i artikkel III og IV bestod av 655 477 personer. I artikkel II undersøkte vi personer født mellom 1970 og 2003 som mottok akutt somatisk sykehusbehandling for villet egenskade mellom 2008 og 2013. For å inkludere sannsynlige tilfeller av villet egenskade hadde vi en bred tilnærming til identifisering av tilfeller, noe som resulterte i 12 526 personer med villet egenskade. Kontroller var 222 362 personer matchet på kjønn, fødselsdato og dato for sykehusbehandlet villet egenskade.

Regresjonsanalyser ble brukt for å sammenligne risiko mellom etterlatte og ikke-etterlatte; Cox-regresjon ble brukt for å undersøke risiko for å ikke fullføre utdannelse og for psykiske lidelser i kohortstudiene og betinget logistisk regresjon ble brukt for å undersøke risikoen for å ha mottatt sykehusbehandling for villet egenskade i «nested case-control» studien. Samvariasjonen av problemer ble undersøkt med chi-kvadrat-tester, mens «log likelihood ratio» tester ble brukt for å undersøke interaksjonen mellom variabler.

Resultater: Sammenlignet med personer som ikke hadde opplevd at foreldre døde grunnet ytre dødsårsaker hadde de som hadde opplevd slikt tap signifikant høyere risiko for å ikke fullføre utdannelse på alle utdanningsnivåer, motta sykehusbehandling for villet egenskade og bli diagnostisert med en psykisk lidelse, spesifikt depressive lidelser, reaksjoner på alvorlig belastning, angstlidelser, rusbrukslidelser, utviklingsforstyrrelser, atferdsforstyrrelser og følelsesmessige forstyrrelser i barne- og ungdomsalder, psykotiske lidelser, bipolar lidelse og personlighetsforstyrrelser. Etterlatte hadde også en signifikant høyere sannsynlighet for å ha flere av disse psykososiale problemene samtidig og en signifikant økt risiko for psykiatrisk komorbiditet. På den andre siden hadde de etterlatte ikke en signifikant høyere risiko for spiseforstyrrelser.

For fullføring av utdannelse var det ingen tydelige forskjeller i risiko mellom ulike typer ytre dødsårsaker. For sykehusbehandlet villet egenskade derimot var selvmord, fallulykker og forgiftningsulykker assosiert med signifikant økt risiko, mens transportulykker og andre ytre dødsårsaker ikke var assosiert med signifikant økt risiko. Når det gjelder psykiske lidelser var alle typer ytre dødsårsaker hos foreldre assosiert med signifikant økt risiko for enhver psykisk lidelse hos etterlatte, mens selvmord var assosiert med størst risiko.

Tap av mor og far var begge assosiert med økt risiko, og ingen store forskjeller avhengig av kjønnet til den avdøde forelderen var tydelige. Likeledes var tap opp til 18 år assosiert med økt risiko, med minimale forskjeller mellom aldersgrupper. Når vi undersøkte tidsrommet siden dødsfallet fant vi signifikant økt risiko for sykehusbehandlet villet egenskade de første 10 år etter dødsfallet, men ikke 10-15 år etter. Ingen store forskjeller mellom kvinner og menn var tydelige.

Konklusjon: Denne avhandlingen indikerer at tap av foreldre i barndom og ungdomstid grunnet alle ytre dødsårsaker er assosiert med en forhøyet og langvarig risiko for psykososiale problemer.

Derfor anbefaler vi at alle etterlatte barn og ungdom bør rutinemessig tilbys oppfølging i primærhelsetjenesten og i skolesystemet. Siden de som har mistet en forelder i selvmord har en høyere risiko sammenlignet med de som har mistet foreldre grunnet andre ytre dødsårsaker, bør barn og ungdommer som etterlates ved selvmord rutinemessig tilbys oppfølging og hjelp innen psykisk helsevern for barn og unge. De omfattende og langvarige psykososiale problemene som etterfølger tap av foreldre grunnet ytre dødsårsaker fremhever viktigheten av en mangefasettert, omfattende og langvarig oppfølging av denne sårbare gruppen.

List of papers

The thesis consists of the following papers:

Paper I

Burrell L.V., Mehlum L., Qin P. (2020). Educational Attainment in Offspring Bereaved by Sudden Parental Death from External Causes: A National Cohort Study from Birth and throughout Adulthood. Social Psychiatry and Psychiatric Epidemiology, 55, 779-788.
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Paper II

Burrell L.V., Mehlum L., Qin P. (2020). Parental death by external causes and risk of hospital treated deliberate self-harm in bereaved offspring. European Child & Adolescent Psychiatry.
doi: https://doi.org/10.1007/s00787-020-01534-3.

Paper III

Burrell L.V., Mehlum L., Qin P. (2021). Parental Death by External Causes during Childhood and Risk of Psychiatric Disorders in Bereaved Offspring. Child and Adolescent Mental Health.
doi: 10.1111/camh.12470.

Paper IV

Burrell L.V., Mehlum L., Qin P. (2021). Co-occurrence of psychosocial sequelae in bereaved offspring. Journal of Affective Disorders, 283, 325–328.
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1. Introduction

> "I believe the person who commits suicide puts his psychological skeleton in the survivor's emotional closet - he sentences the survivor to deal with many negative feelings and, more, to become obsessed with thoughts regarding his own actual or possible role in having precipitated the suicidal act or having failed to abort it. It can be a heavy load".
>
> - Edwin S. Shneidman (1)

It can be a heavy load, indeed, to experience that a close friend or family member takes their own life. The bereaved family and friends are left behind, struggling with the notion that their loved one chose to leave and the uncertainty of whether their words or actions could have made a difference. As Shneidman articulates, the person who takes their own life can transfer their psychological challenges to the loved ones left behind – equipping them with worries, ruminations, psychiatric challenges, peer stigma and potential suicidal thoughts of their own. Likewise, the sudden and violent death of a loved one due to an accident or homicide can be a life-changing and traumatic experience. Despite the lack of the deceased's own choice to die, such deaths are also violent, premature and unnatural, and can leave bereaved family and friends with ruminations, distribution of blame, and feelings of shock and trauma.

Losing a parent to sudden and violent causes of death is one of the most significant and traumatic life events that children and adolescents can face (2, 3). A mother of three children who had lost their father to suicide shared her experiences through conversations with the research fellow in the course of working with this thesis. She said that her oldest daughter took her new boyfriend to the cemetery to introduce him to her father. The daughter felt despair when knowing her father could not follow her down the aisle at her wedding or rock her grandchildren in his arms. Her youngest daughter, on the other hand, experienced feelings of anger towards her father and had isolated herself from him in the period leading up to the suicide due to his mental illness. All her three children responded to the loss very differently, but the loss of what was and what could have been was nevertheless boundless and life-long.

1.1. The scope of the problem

Several mathematical calculations are needed to estimate the number of children and adolescents who have experienced parental death by external causes (parental DBEC) from birth and until age 18, both in Norway and worldwide. However, not all required information is readily available, and we can hence only estimate the scope of the problem. A further complicating factor lies in the varying data quality in registers that are recording external causes of death, especially suicide. We will, however, venture an educated guess as to the scope of the problem, both in Norway and worldwide.

In 2018, the last year with available data, 2 707 people in Norway died from external causes of death, that is mainly suicide, accidents and homicide (International Classification of Deceases, Tenth Revision (ICD-10) codes V01-Y89) (4). Of these deaths, 2 676 were people above 17 years who were, hence, in an eligible age for having children. Even though we are unable to know how many of these people actually have children, and how many children they have, the numbers give a rough impression of the scope of the problem.

The World Health Organization estimates that approximately 5 million people die from external causes of death worldwide each year (5). This data is, however, more uncertain than Norwegian data. First, the worldwide estimate is, to some extent, based on extrapolated data from countries that lack vital registration systems. As an example, national vital registration data were only available for 19% of African countries, and data from the remaining countries were estimates based on proxy information. Furthermore, the data may be outdated and the situation in some countries may have changed significantly since this information was collected (5).

Note, additionally, that the above numbers are only from one year, and that the accumulated numbers are naturally much larger. Even though the scope of the problem is very difficult to estimate both in Norway and worldwide, we may assume that there is a considerable number of children and adolescents who have experienced the death of one or both parents due to external causes of death.

1.2. Attachment and loss

The relationship between parents and children has long been of great importance within developmental psychology, from Freud's initial theories in the early 1900s emphasising the importance of the infant-mother relationship, to attachment theory being the dominant perspective on parent-child relationships today. Throughout this, the importance of early childhood experiences on functioning in later life has been emphasised (6). According to John Bowlby's attachment theory, attachment is the emotional bond with another person, originally the primary caregiver (7). Attachment is an innate core human goal throughout life. This bond between parent and child starts from birth and is enabled by the infants' innate capacity to emit signals and the adults' biological predisposition to respond (7). We are biologically programmed to seek and form close relationships. Mothers tend to be the primary attachment figure for most infants, but infants also become attached to their fathers at approximately the same time (6). Note, however, that the infant may form an insecure attachment with their parents, or fail to form an attachment at all, depending on the sensitivity, warmth, amount of stimuli and appropriateness of response from the parents (7). For securely attached children, the attachment figure acts as a secure base from which the child can explore its surrounding environment. The exploratory system motivates the child to explore the world, while the attachment system motivates the child to return to its secure base at intervals in order to regain energy, feel safe or seek comfort (7). The child hence oscillates or fluctuates between these two motivational systems. Securely attached children often have a close emotional relationship with their parent, while insecurely attached children can either avoid emotional closeness or seek a very high level of closeness in their relationships (7).

Attachment theory provides a framework for understanding parental bereavement – the loss of the child's primary attachment figure. Bereavement is defined as "deprived by death of a near relative, or of one connected by some endearing tie" (8), and hence refers to the objective status of having lost someone significant (9). Grief is, however, defined as the "primarily emotional (affective) reaction to the loss of a loved one through death" (9), and hence reflects the subjective emotional experience of loss. Even though register studies cannot study grief, only bereavement, we presume that the majority of offspring bereaved by the death of a parent experiences grief. Within attachment theory, love and grief are two sides of the same coin, and grief manifests itself as a result of the loss of a loved one. Everyone, children, adolescents and adults, resist separation from primary attachment figures, and the death of a parent constitutes one of the most significant life events a child or adolescent can experience (2, 3). Indeed, child and youth survivors of parental death are multiply bereft: they lose a caregiver, a role model and the parent's unconditional love (10). The emotional closeness of the relationship will influence the bereaved children, and studies have found that the level of grief and subsequent psychiatric problems are highest in people with the closest relationship to the deceased (11).

The dual process model of coping with bereavement by Margaret Stroebe and Henk Schut is a taxonomy to describe and understand ways that people cope and come to terms with losing someone close (12). Despite originally being formulated to address coping after partner loss, the model is probably not limited to any particular type of loss (13), and has been extensively applied to bereaved children and youth (14, 15). The dual process model postulates that coping with bereavement entails an oscillation between loss-oriented processes and restoration-oriented processes. Loss-orientation is an activation of the attachment system that refers to focusing on the processing of aspects of the loss itself. It involves rumination about the deceased and the death, yearning for the deceased and grieving the loss. Restoration-orientation, on the other hand, involves distraction from grief, trying new things, attending to life changes and forming new relationships. Adaptive coping with bereavement involves a healthy oscillation between these systems (12) and is akin to a child's oscillation between exploring its surroundings and seeking a secure base. Children have "short sadness spans" as they cannot endure long periods of sadness, and they can often be seen playing shortly after the death (10). In this sense, children have a very visible oscillation between the two systems of the dual process model. Moreover, even very young children try to avoid upsetting their parents and may deliberately refrain from bringing up memories that they think might distress the surviving parent (10).

The acute grief period shortly following the death of someone close is characterised by a strong activation of the loss-oriented system and powerful deactivation of the restoration-oriented system (16). The attachment system is highly activated, and the bereaved person is consumed by grief and psychological pain, intrusive thoughts about the death, an intense yearning for the deceased and a need to be with them. In return, the deactivation of the restoration-system means that bereaved people shy away from others, find no enjoyment in other people or activities and show an unwillingness to accept the reality of the loss. Over time, the loss-oriented systems' overactivation subsides, and the restoration-oriented system is reactivated; the acute and intense grief lessens and interest in daily activities is renewed. The loss is integrated into the bereaved person's life, and life goals and plans are redefined accordingly (16).

1.3. Critical periods for later development

Evidently, loss of a primary attachment figure leads to profound grief and may entail a redefinition of the bereaved offspring's life. When such loss occurs during childhood or adolescence, the impact has been reported to be even more profound (17, 18). Within the framework of attachment theory, the attachment to the parent is considered particularly strong at a young age and the concomitant grief is particularly intense (2). Furthermore, childhood and adolescence are considered critical periods for later development (19, 20), and exposure to traumatic events during these critical periods can have a more detrimental effect than exposure that occurs at later ages (21). This approach can be interpreted within a life course framework, which suggests that the impact of social phenomena as risk and protective factors varies with the age of exposure and that exposure may have lifelong impacts (22).

There are multiple possible reasons why childhood and adolescence are critical periods for later development. First, childhood and adolescence are developmental stages associated with a high degree of biopsychosocial changes, such as neural plasticity and puberty (19, 20). As a consequence, experiencing intense stress during this age can acutely or chronically impair brain structures and neural pathways, effectively increasing the risk of physical and psychological disorders in adulthood (23). Typical of adolescence is, furthermore, a potentially growing mismatch between biological and psychosocial maturation (24). There is often a time discrepancy between biological transitions fuelled by puberty and psychological and social transitions lagging behind. This age is identified by its higher degree of impulsivity, risk-taking and sensation-seeking, as well as emotional turmoil and social change (25). As adolescence is a particularly important time for shaping individuals into adults, exposure to traumatic and life-changing events can impede a successful transition to adulthood.

Moreover, the age of the child or adolescent will affect their ability to comprehend and process the death (10). Young children have difficulty understanding the concept of death and its finality, and may believe that the deceased parent can return. Additionally, children of a young age often believe that they have the ability to prevent or cause events. As a result, they may believe that their actions or lack of actions precipitated the parent's death. Older children have a better understanding of death and its finality, but may have trouble realizing that death can happen to anyone of any age, and not just older people. Likewise, they may have difficulty understanding that someone can cause their own death, or the death of others. Adolescents' better understanding of death and suicide may lead them to become very preoccupied with the reason behind a suicide and struggle with feelings of abandonment. This rumination can consequently cause significant changes in their view of the world and their relationships (10). Children's reduced ability to comprehend and process the death of a parent, and a suicidal death in particular, may also be a reason for the large psychosocial impact observed when bereavement occurs in childhood and adolescence.

1.4. Bereavement and trauma

Attachment theory has informed us of the powerful impact of losing a parent, while the critical period hypothesis and life course framework have supplemented information on the added effects of losing a parent during childhood and adolescence. Loss of a parent from external causes of death such as suicide, accidents and homicide can also carry a supplementary factor important for later grief and mental health: The death can often be considered a traumatic event. "Psychological trauma is the unique individual experience of an event or of enduring conditions in which the individual's ability to integrate his or her emotional experience is overwhelmed, or the individual experiences a threat to life, bodily integrity, or sanity" (adapted from Pearlman & Saakvitne, 1995) (26). The definition of trauma was later amended to include when individuals learn about or witness a threat to the life or safety of a caregiver or family (27). The death of a parent to suicide, accidents or homicide frequently fall under the definition of a trauma: The death is a sudden and overwhelming event and the child or adolescent experiences a direct threat to the life of a caregiver. As a consequence, the bereaved may also have a subjective individual experience of a threat to their own life, security or sanity.

The loss of a loved one to natural causes can be both unexpected, violent and traumatic, for example death due to myocardial infarction, but deaths to most illnesses allow for some degree of psychological preparation (28). Loss due to external causes of death, however, is very often sudden, unexpected, violent and unnatural, all potentially leading to an experience of trauma(29, 30). Importantly, the event is sudden, leaving the bereaved with no or minimal ability to prepare themselves, and may be accompanied by shock, danger and/or drama, as well as strong sensory impressions or fantasies. The bereavement may be violent and induce a sense of loss of control in the offspring. These aspects will probably further lessen the offspring's ability to emotionally integrate the event, i.e. their ability to stay present, understand what is happening, integrate their feelings and make sense of the experience (26). Notably, losing a parent has been rated as the most stressful and traumatic event a child can experience by children across several different countries and cultures (3).

What we can call intentional or volitional deaths, where the death is the result of an intentional and deliberate act, such as suicide, homicide, terrorism and war, add an additional traumatic dimension to the loss. These deaths are the result of deliberate acts of harm, and the thematic content of the trauma hence differs from other sudden deaths (31). The nature of such deliberate trauma can greatly impair the bereaved individual's capacity for trusting others, feeling safe, whole and intact, and experiencing meaning in life (30). Volitional causes of death violate people's beliefs about the safety and predictability of the world, and disbelief, shock, confusion, bitterness and anger are common reactions. This is especially evident in suicidal deaths where the death is self-inflicted and violates the fundamental norms of self-preservation (32). Moreover, the suicide can be considered as an act of intentional rejection of the deceased's family and friends (29, 33). The suicide can shatter the assumptions and knowledge you have about your loved one, yourself, your relationship and the world in general (29) and challenge every notion you take for granted. Anecdotal information tells of children who have a profound fear of losing the remaining parent and display the shattered safety and altered worldview following suicide. Bereaved families talk about the day of the suicide as the day life was turned upside down, as is evident in the following quote published in a recent UK report on suicide-bereaved families and friends: "My experience of suicide is that it is the equivalent of a bomb going off in your living room while you're sitting watching telly. Afterwards you're astonished you're alive, but everything has changed and you have a million shards of glass embedded in your soul" (34).

Sometimes the suicide deceased's family, including the children, are the ones who find the deceased in the home and are responsible for alerting medical professionals and potentially attempting resuscitation (31). The extreme sensory impression of finding the deceased and potentially handling the place where the suicide occurred is naturally very traumatic. Moreover, if the suicide occurred at home, this may lead to a profound feeling of insecurity in your own home, especially when being alone (31).

Our desire to compare suicide to other unexpected and violent causes of death in order to compare to modes of death with the most similarities (28) led us to only investigate external causes of death in the present studies. Additionally, some external causes of death, such as homicide and war, share the volitional aspect of suicide. Bereavement due to natural causes of death was, as a result, not included in the studies, also because we did not have access to data on deaths by natural causes – a limitation discussed in section 5.4. concerning study limitations. Naturally, all deaths due to external causes are not experienced as traumatic since trauma is a subjective experience, but register-studies are dependent on operationalization of variables: External causes of death are probably the modes of death with the most similarities to suicide and hence function as a pragmatic comparison group. By using register data, the present studies cannot determine whether the bereaved children actually experienced the death as traumatic, but we presume that the majority of the bereaved offspring experienced the death in this way (3). Irrespective, the death is most certainly considered a psychological stressor,

In addition to the death of a parent constituting a single stressful and potentially traumatic event in a child's life, it is important to understand bereavement as a series of events that occur both before and after the death which combined influence the mental health of the bereaved (11). Factors leading up to the death which may influence bereaved offspring's later functioning, so called pre-bereavement factors, include for example the psychological closeness of the relationship with the deceased parent, parental psychiatric disorders and family dynamics. Post-bereavement factors following the loss include among others the quality of the relationship with the remaining parent and the degree of social support from family and friends (11).

1.5. Family impact following bereavement

In addition to the individual impact of losing a parent, there may be extensive and enduring family changes following the loss, especially when losing a parent to external causes of death. All individual members of the family, as well as the family as an entity, are naturally affected when a member dies. Some family changes following parental death are very tangible and easily observed in daily life, such as an increase in children's number of household tasks and chores, changes in mealtimes, allowance, rooms and bedtime, and changes regarding who takes care of them when they are sick (35). Since the family's income can be reduced after the loss of a parent, economic changes and a reduction in available resources is expected. This may be the case even in countries with a social welfare system like in Norway (36). Such family changes can have implications beyond the family's practical execution of everyday life as they may instil feelings of insecurity and uncertainty in children and adolescents.

Perhaps more importantly, relational changes in bereaved families are observed. Families who have experienced the sudden death of a family member report experiencing lower family cohesion and poorer family communication following the loss (37, 38). In particular, families who have experienced that a family member has died by suicide frequently report guilt and blaming within the family (38). These processes are naturally detrimental to the family as a whole, its restorative progress following the bereavement and individuals' personal mental health.

Emotional support from the remaining parent is crucial for children and adolescents following the loss of a parent, and parental functioning may influence surviving family members. Regrettably, studies report a deterioration of mental health in the surviving parent (39), and surviving parents are less emotionally available to the bereaved children (38). Parent's own psychosocial challenges following the loss of a spouse and co-parent will naturally have a potentially strong impact on their parenting abilities and strategies, as well as overall energy level. In addition, we would expect a reduction in their capacity to follow-up their children, resulting in, for example, less help with school-work and poorer monitoring of behaviour.

1.6. Psychosocial sequelae following parental bereavement

Given the strong attachment that normally exists between parents and children, the traumatic nature of loss due to external causes, the high plasticity of young developing minds and the potential family changes following parental death, we can expect to see substantial difficulties following parental loss due to deaths from external causes in childhood and adolescence. Society has recognised and reported on the large negative effects that bereavement has on the remaining family members for several centuries (40). The potential effect of the death of a parent on their children has, on the other hand, only been the focus of rigorous study and research since the late 1950s and early 1960s, when descriptive studies on the frequency of parental deprivation among various delinquent, orphaned or psychiatric groups compared to the frequency in control samples were common (41). Studies of such vulnerable groups, sometimes in comparison to control groups, remained common as late as the 1990s, and study samples were often small (42-45). Indeed, these studies reported that parental loss and separation were more common in patient groups compared to control groups. During the second half of the twentieth century, researchers also started to show interest in the circumstances surrounding the loss, such as the gender of the deceased parent, the age at trauma and the cause of parental death (41, 44, 46).

The early 2000s saw great development in research on parental bereavement since national, electronically-registered, individual-level data enabled register studies of large population samples. Register studies have a very large sample size, use epidemiologically acknowledged approaches such as cohort designs and nested case-control designs, and are often prospective studies. In combination, the findings can hence be considered robust and rigorous, with a high degree of external validity. The earliest register studies within the field came from Denmark and studied bereaved offspring's risks of suicide (47-49) and psychiatric disorders (50, 51). Studies on deliberate self-harm hospitalisation (18, 52) and educational attainment (53) came at a later time. Combined, these register-based studies found that people who have experienced the death of a parent to external causes have significantly higher risks of several psychiatric disorders (18, 50, 51, 54-60), DSH hospitalisation (18, 52, 56, 61-67) and suicide (18, 47, 62, 68-70). Furthermore, their risks of marital dissolution (71), lower educational attainment and school performance (53, 72), and even violent criminal acts (18, 64, 73) are also significantly higher. In addition to the impact of loss on important psychosocial aspects of offspring’s life, their physical health and well-being are found to be reduced given their increased risk of premature death in general (64). Evidently, the challenges associated with loss of a parent to external causes of death are widespread and multifaceted, involving psychiatric, behavioural, physical, interpersonal and socioeconomic problems.

Specifically, children and adolescents who had experienced the death of a parent by external causes had a 2- to 3-fold higher risk of suicide later in life than offspring of alive parents (18). The same Swedish register study reported that offspring bereaved by external causes of death had between a 1.3- and 1.9-fold higher risk of suicide attempt. A Danish register study with a broader operationalization of suicide attempt found that children, adolescents and young adults who had experienced the death of a parent due to external causes even had a 2.2- to 2.7-fold higher risk of suicide attempt compared to offspring of alive parents (67). Note that the term suicide attempt is used in these previous studies, while we use the term deliberate self-harm to denote the same type of registered events. A discussion on terminology is, however, beyond the scope of this text.

With respect to bereaved offspring’s risk of psychiatric disorders, several register-based studies have investigated different psychiatric disorders or categories of disorders. The risk of hospital admission for depressive disorders have been reported to be more than tripled in offspring who lost a parent due to external causes of death compared to offspring with alive parents, while their risk of outpatient care for depression was nearly doubled (54). Comparably, a Danish register study reported an increased relative risk of 1.55 for admission to a psychiatric hospital for depression in offspring bereaved by unnatural causes of death as compared to offspring who had not experienced parental loss (57). The same study found a 1.8-fold increased risk of bipolar disorder and a 1.5-fold increased risk of schizophrenia (57). Likewise, the risk of psychotic disorders in general have been found to range from 1.4- to 2.8-fold higher, and the risk of drug and alcohol use disorders between 1.3- and 2.3-fold higher among offspring bereaved by parental external death, depending on the age of the child and the specific cause of death (18). The present thesis is, however, the first large-scale population study to investigate bereaved offspring’s risks of anxiety disorders, childhood behavioural and emotional disorders, developmental disorders, eating disorders, reactions to severe stress, and psychiatric comorbidity.

Loss of a parent has also been found to negatively affect academic achievement. Reduced likelihood of enrolment and graduation as well as poorer mean grades (53, 72, 74) is accompanied by lower expectations and aspirations for future education and career (37) in children who have lost a parent to all causes of death compared to children who have not experienced the loss of a parent. Several previous studies investigating educational attainment in parentally bereaved offspring have, however, been restricted to paternal bereavement (72, 74-76), or have used data from the US (37, 77-79) . Since all higher education is based on tuition fees in the US, generalization to most European countries where students and families to a lesser extent pay for education is complicated. A Swedish register study that can easily be compared to a Norwegian setting found that children who had lost a parent to external causes of death had a much higher probability of school failure at age 16 compared to both children who had experienced loss due to natural causes and children with alive parents (53). Bereaved offspring's attainment of later educational levels such as University and College degrees is, however, still unclear, and the present thesis aimed to investigate this.

When investigating the psychosocial and physical sequelae following parental bereavement, it is important to note that the majority of people who have experienced sudden parental death return to normal life functioning following a period of grief, and do not display major psychosocial sequelae in later life. Limited research has investigated who will experience psychosocial or physical sequelae following parental bereavement and who will follow a healthier life-trajectory. A former study by the research fellow and supervisors investigated to what degree different interpersonal, intrapersonal and bereavement-related factors influence suicide risk in offspring bereaved by parental death from external causes (80). Results show that parentally bereaved offspring with low social support, as indicated by being unmarried, separated, divorced or widowed, and repeated changes in marital status and residence, had significantly higher suicide risks compared to bereaved offspring with higher social support. Moreover, low income and education and having an immigration background significantly increased suicide risk.

1.7. A note on posttraumatic growth

Most research on bereavement has focused on adverse outcomes, and this study is no exception. There is, however, a growing amount of studies identifying positive changes following bereavement (81, 82). Posttraumatic growth refers to positive transformations following internal changes that occur as a result of one's struggle with a traumatic event (83), such as parental suicide, accidental death or homicide. These positive changes can occur in different dimensions. Changes within self-perception can involve better self-confidence, increased personal strength, and better communication skills, while changes within interpersonal relations may include getting closer to family and friends, developing a wish to help others and gaining a greater appreciation for others. Lastly, changes in life philosophy can, for example, involve finding meaning in trauma, seeing new opportunities and learning about life in general (81-83). Anecdotal information also includes stories of children who have felt a weight lifted off their shoulders following parental suicide since they do not have to worry about the parent and feel relief and thrive after the parent has taken their own life (84). Notably, posttraumatic growth is not universal and not all bereaved family and friends will experience positive transformations. Studies such as the present thesis are unable to investigate posttraumatic growth, although we can expect it to occur within our studied population.

1.8. Bereavement-related factors

There are a range of factors that may influence individual's psychosocial functioning following the loss of a loved one (85). By using a register-based approach such as in the present studies, it is most feasible to investigate bereavement-related factors which are registered in the national registers, such as parent's cause of death, gender of the deceased parent and offspring's age at bereavement. The pre- and post-bereavement factors relating to interpersonal and internal resources are, on the other hand, more efficiently studied through other research approaches such as questionnaires or qualitative studies. We chose to investigate bereavement-related factors in the present studies, and findings on differences between different bereavement-related factors are, in general, inconclusive and sparse.

There is a general belief that suicide bereavement is different from bereavement due to other causes of death (32). When directly comparing offspring bereaved by suicide and accidents, researchers have reported an earlier onset of DSH hospitalisation in offspring following parental suicide compared to those bereaved by parental accidental death (86). This higher risk of DSH hospitalisation is, however, linked to maternal and not paternal suicide(56). When compared to people with alive parents, bereaved offspring's risk of suicide attempt has been reported to be 1.6- to 1.9-fold higher following parental suicide, and 1.3- to 1.5-fold higher following parental accidental death (18). Likewise, a comparable register study reported a 2.7-fold higher risk of suicide attempt in people who had experienced parental suicide and a 2.2-fold higher risk following parental accidental death, as compared to people with alive parents (67). Despite the higher relative risks following parental suicide compared to accidental deaths in these previous studies, it is worth noting that both parental suicide and accidental deaths are associated with significantly increased risks in offspring, and that confidence intervals are highly overlapping. Therefore, studies comparing bereaved offspring to offspring of alive parents fail to report a significant difference in DSH hospitalisation between offspring bereaved by suicide and accidents.

Previous results regarding differences in offspring's risks of psychiatric disorders following parental suicide and accidental deaths are also inconclusive and sparse. A direct comparison of suicide- and accident bereaved offspring reported that paternal, but not maternal death by suicide was associated with significantly higher risks of depressive disorder and anxiety disorder in offspring, as compared to parental accidental death (56). On the other hand, the risks of psychotic disorder, personality disorder and alcohol and drug use disorders did not differ between suicide and accident bereaved offspring (56). Again, studies where suicide- and accident bereaved offspring have been compared to offspring with alive parents report higher relative risks of depressive disorder, psychotic disorder, personality disorder and alcohol and drug use disorders following parental suicide, but overlapping confidence intervals between suicide- and accident bereaved (18).

With respect to educational attainment, no previous studies have investigated the potential effect of different external causes of death, and the present thesis is the first to address this research question. The inconclusive study results regarding potential differences between different external causes of death for offspring's risks of DSH hospitalisation and psychiatric disorders can be caused by a lack of appreciation for the diversity of the different external causes of death and different accidental deaths in particular. Different accidental deaths may be associated with different risks of psychosocial sequelae in offspring due to the heterogeneity of accidents. This can potentially account for the inconsistencies in previous studies and warrants further investigation. As a consequence, the present thesis is the first to investigate potential differences in offspring's risks of psychosocial sequelae following parental death from suicide and different types of accidental deaths.

Another important bereavement related factor worth investigating is the gender of the deceased parent. Due to differences in gender equality in different countries, both with respect to the level of involvement in parenting and economic and occupational equality, results from other countries can be difficult to generalise to a Norwegian setting. The gender of the bereaved offspring may additionally be influential with respect to the scope and nature of psychosocial sequelae following bereavement. A previous study by the research fellow and supervisors examining offspring's suicide risk following parental DBEC found no significant differences depending on the gender of the deceased parent or the gender of the offspring (17). In addition to directly comparing daughters and sons, potential interactions between the gender of the offspring and other bereavement related factors should be studied. As an example, a previous study examining the gender of the parent and offspring in combination reported that the loss of the same-sex parent seemed to have the greatest impact on suicide risk in offspring (70). Similarly, we can postulate that gender differences may vary depending on the cause of the parental death, the offspring's age at bereavement or the time since bereavement.

Our initial study concerning the suicide risk in offspring who had experienced parental death by external causes examined the effect of loss occurring from birth to late adulthood (64 years old). Results indicated that the increased suicide risk accompanying parental bereavement was most pronounced when bereavement occurred relatively early in life, before the age of 18 (17). In combination with the theoretical view of childhood and adolescence as critical periods for later development, a specific focus on these age groups is warranted. The majority of previous studies investigating the association between parental bereavement and later psychosocial sequelae have examined exposure from birth and into adulthood, while fewer studies have investigated only the potential differences associated with exposure in childhood and adolescence. Previous studies that have differentiated between subcategories within childhood and adolescence have mostly investigated very few age bands (18, 62). An example is the influential and highly cited Swedish register study by Wilcox and colleagues (18) that only differentiated two age groups of children and adolescents: 0-12 years old and 13-17 years old. Naturally, exceptions occur where researchers have thoroughly examined multiple age-bands in childhood and adolescence (53). In addition to a potential effect of age at bereavement, the length of time since parental death may also be influential. For example, previous studies have reported the highest risk of suicide attempt during the first 2 years following parental bereavement (61, 67, 86).

1.9. Knowledge gaps

Despite the recent research concerning the associations between parental bereavement and psychosocial sequelae, there are still areas of uncertainty as to the potential impact of loss in offspring. Detailed information on various psychosocial sequelae following bereavement is insufficient, and this information may aid health personnel in effectively identifying individuals at high risk and better pinpoint the targets of prevention and intervention programmes. Moreover, information on psychosocial sequelae following bereavement from large scale population-based research in Norway is limited, and the possible verification of international research results in a Norwegian context is important for Norwegian health personnel and policymakers.

For educational attainment, the possible association between maternal and paternal bereavement and attainment at all educational levels is unknown. Several previous studies have been restricted to paternal bereavement (72, 74-76), and few studies have investigated differences between losing a mother and father. Furthermore, no previous study has differentiated between various external causes of death and their potentially differing association with educational attainment.

With regard to psychiatric disorders, no large-scale population studies to date have investigated the association between parental DBEC and subsequent risks of anxiety disorders, childhood behavioural and emotional disorders, developmental disorders, eating disorders, reactions to severe stress – including acute stress reaction, posttraumatic stress disorder, and adjustment disorder – or psychiatric comorbidity. An investigation of differences in risk of developing psychiatric disorders between different external causes of death is also limited (18, 39, 54, 56, 88). Likewise, previous studies are inconclusive regarding whether offspring bereaved by suicide are at a higher risk of hospital treated DSH than those bereaved through accidents (18, 56, 67, 86),and further investigation of potential differences is warranted.

Lastly, since the co-occurrence of psychosocial sequelae following parental bereavement has not been previously studied, the scientific community has no knowledge of whether the same bereaved offspring struggle with multiple problems or if co-occurrence differs between bereaved offspring and their non-bereaved peers.

2. Research aims

The overall aim of the present thesis was to investigate the long-term psychosocial sequelae associated with experiencing the death of a parent due to external causes during childhood and adolescence from birth and until age 18. Specifically, we aimed to investigate whether people who had lost a parent to external causes of death before age 18 had an increased risk of attaining lower education (paper I), being hospitalised for deliberate self-harm (paper II) and receiving treatment for psychiatric disorders (paper III) in later life, as compared to people who had not lost a parent to external causes of death before age 18. We additionally aimed to study in detail important factors that may influence these potential associations. The specific research aims of the thesis were as follows:

1. Investigate the potential differences in risk of lower education (paper I), hospital treated deliberate self-harm (paper II) and psychiatric disorders (paper III) depending on the parent's specific external cause of death.
2. Assess the potential differences in risk of lower education (paper I), hospital treated deliberate self-harm (paper II) and psychiatric disorders (paper III) between offspring who have lost a mother, father or both parents.
3. Examine the potential differences in risk of lower education (paper I), hospital treated deliberate self-harm (paper II) and psychiatric disorders (paper III) depending on the age of the child at the time of bereavement.
4. Investigate the potential differences in risk of hospital treated deliberate self-harm associated with differences in the length of time since bereavement (paper II).
5. Investigate whether results from the above-mentioned analyses differ between bereaved daughters and sons (paper I, II and III).
6. Examine the co-occurrence of psychiatric disorders, DSH hospitalisation, and high-school non-completion in offspring who have lost a parent to external causes of death during childhood and adolescence compared to people who have not lost a parent to external causes of death during childhood and adolescence (paper IV).

3. Materials and methods

Table 1 presents an overview of the four papers included in the present thesis with regard to data sources, study design, study sample, study period, outcome measures, variables of interest and statistical analyses.

Table 1. Overview of the four studies

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Data sources	Central Population Register Cause of Death Register Statistics Norway's Events Database	Central Population Register Cause of Death Register Statistics Norway's Events Database Norwegian Patient Register (somatic)	Central Population Register Cause of Death Register Statistics Norway's Events Database Norwegian Patient Register (psychiatric)	Central Population Register Cause of Death Register Statistics Norway's Events Database Norwegian Patient Register (somatic & psychiatric)
Study design	Cohort study	Nested case-control study (matched on date of birth, gender and calendar time)	Cohort study	Cohort study
Study sample	373 104 (3 692 bereaved before age 18 and event/censoring)	12 526 cases / 222 362 controls (2 365 bereaved before age 18)	655 477 (4 723 bereaved before age 18 and event/censoring)	655 477 (4 756 bereaved before age 18)
Study period	Born: 1970-1994 Exposure time: 1970-2012 Follow up of event: 1985/1988-2012	Born: 1970-2003 Exposure time: 1970-2012 Follow up of event: 2008-2013	Born: 1970-2012 Exposure time: 1970-2012 Follow up of event: 2008-2012	Born: 1970-2012 Exposure time: 1970-2012 Follow-up of event: 1988/2008-2012
Outcome measures	Educational attainment: - compulsory education - high school - vocational education - university or college education	Hospital treated deliberate self-harm	Psychiatric disorders: - any psychiatric disorder - various specific disorders - psychiatric comorbidity	High school non-completion Hospital treated deliberate self-harm Any psychiatric disorder
Variables of interest	Bereavement status Cause of parental death Gender of deceased parent Age at bereavement Gender of bereaved offspring	Bereavement status Cause of parental death Gender of deceased parent Age at bereavement Gender of bereaved offspring Time since bereavement (sensitivity analysis)	Bereavement status Cause of parental death Gender of deceased parent Age at bereavement Gender of bereaved offspring	Bereavement status Gender of bereaved offspring Age of bereaved offspring
Statistical analyses	Cox regression Log likelihood ratio test	Conditional logistic regression Log likelihood ratio test Sensitivity analysis for unobserved confounding	Cox regression Log likelihood ratio test	Chi-square test of independence (2-tailed)

3.1. Data sources

Information from the Central Population Register, the Cause of Death Register and Statistics Norway's Events Database was utilised in all four study papers, while information from the Norwegian Patient Register was utilised in papers II-IV.

The *Central Population Register* was established in 1964, is administered by the Norwegian Tax Administration and contains demographic data for all individuals residing in Norway. The present study retrieved information about ethnicity, gender, current and former residence address, date of birth, date of death and date of emigration from this register. Additionally, this national register contains an 11-digit unique personal identification number for all Norwegian residents ("Fødselsnummer"). This number, which is usually encrypted into a unique ID code for each individual when personal data are used for research purposes, enabled the linkage of personal information across different national registers. The register also contains a link to parent's personal identification number, and these links were utilised to identify biological or adoptive parents. Note, however, that we are unable to distinguish between biological and adoptive parents in the register. A proportion of the Norwegian population has no registered link to parents because a) the person was not living with a parent in 1964, b) the person immigrated to Norway as an adult, c) the parent died before 1964, or d) the parent had emigrated from Norway before 1964. For people born between 1970 and 2012, 85.4% had a registered link to their mother while 83.1% had a registered link to their father. The proportion of people with a link to parent's personal identification number increases with time from the register's beginning in 1964. For people born in 1970, 77.5% had a link to their mother and 76.4% a link to their father, while as many as 98.2% had a link to their mother and 95.3% a link to their father in 2012.

Following the identification of parents in the Central Population Register, information on parental death by external causes was retrieved from the *Cause of Death Register*. This register contains information on the cause and date of all deaths in Norway. It has been computerised with data on an individual level since 1969 and is administered by the Norwegian Institute of Public Health. Cause of death is coded according to ICD-8 from 1969 to 1985, ICD-9 from 1986 to 1995 and ICD-10 from 1996 to 2012 (89). A recent external validation of data from the Cause of Death Register concluded that the classification of external causes of death holds high quality (90). In total, 88% of registered suicides were confirmed by experts, and only 1% of suicides were reclassified as accidents. Moreover, only 3% of accidents were reclassified as suicides. Based on the information in this register, we coded the variables bereavement status, cause of parental death, gender of deceased parent, age at bereavement, and time since bereavement.

Statistics Norway's Events Database (the FD-Trygd database), established in 1992 and administered by Statistics Norway, contains demographic and socioeconomic data. This register provided information on current and former marital status, education, annual income and sick leave pension. Notably, data on education is based on the National Education Database (91), which encompasses education statistics at an individual level dating back to 1970 (92).

The *Norwegian Patient Register* contains information concerning all contacts related to all types of treatments in specialist health care, covering all public institutions as well as private institutions and medical specialists contracted to the regional health trusts (93). As a result of the Norwegian health care system's universality and limited number of private institutions, the register has a large national coverage. This register provided information on deliberate self-harm treated at somatic hospitals and the psychiatric diagnoses at the time of treatment in paper II and paper IV, and psychiatric disorders diagnosed in specialist mental health services in paper III and paper IV. All diagnoses were coded according to ICD-10 codes. Specialist mental health services that report to the Norwegian Patient Register consist of mental health services for adults, child- and adolescent mental health services, substance misuse services and private mental health specialists contracted to a public health trust. These services encompass both inpatient and outpatient treatment (94). Information on hospital treated DSH and psychiatric diagnoses were available since 2008, except for data from substance misuse services, which were only available since 2009.

Since the Norwegian Patient Register records patients in contact with specialist health services, the register does not contain information on people who have received treatment in primary healthcare or people who have not sought treatment for their ailments. A comprehensive and rigorous survey study found that only 14.7% of Norwegian adolescents who report self-harming in the last year had received hospital treatment for their injury (95). Likewise, only

13.6% of Norwegian adolescents with mental symptom-load above the 99th percentile for depression and anxiety reported help-seeking from psychiatrists or psychologists in the last year (96). These results are in line with a recent twin study reporting that few adults who met diagnostic criteria for major depressive disorder (15%), anxiety disorder (18%) and alcohol use disorder (7%) in clinical interviews were registered with a corresponding diagnosis in the Norwegian Patient Register (97). This latter study also found that whether depression, anxiety or alcohol use disorder were measured in interviews of the general population or in the Norwegian Patient Register, the genetic risk factors responsible were largely overlapping across the data sources. As a result, etiological factors can likely be generalized across studies using different methodological approaches (97). The generalizability of register studies investigating DSH is, however, more unknown since we are the first to operationalize hospital treated DSH in this manner (see section 3.2. concerning study design and population).

3.2. Study design and population

In papers I, III and IV, we used a cohort design to study the outlined aims (98), while paper II used a nested case-control design (99) to examine risk of DSH hospitalisation. Retrieval of data from source registers and construction of working datasets for analyses in these individual studies were conducted using SAS/STAT software, version 9.4 of the SAS System for Windows. Copyright © [2019] SAS Institute Inc., Cary, NC, USA.

The cohort in papers I, III and IV consisted of a 25% random sample of all Norwegian residents who had a link to both their father and mother in the Central Population Register. The cohorts were initially the same, but they were tailored to meet the needs of individual studies. Consequently, paper I only included people born from 1970 to 1994, while papers III and IV included people born from 1970 to 2012. Since paper I studied education after offspring turned 15 or 18 years old, the cohort needed to be restricted compared to papers III and IV where psychiatric disorders were studied from birth. As a result, the cohort in paper I consisted of 373 104 people, while the cohort in papers III and IV consisted of 655 477 people.

Despite an original aspiration to use a cohort design in paper II, the nature of the data meant that a nested case-control design was more feasible. This was due to the relatively low number of patients who had received hospital treatment for deliberate self-harm during the follow-up period in the cohort consisting of a 25% random sample from the Central Population Register. Alternatively, a nested case-control study identified cases of DSH from the Norwegian Patient Register which covers the entire population and hence includes all DSH incidents in the national population. The projects data clearance gave us access to 25% of the Norwegian population in the Central Population Register and Statistics Norway's Events Database, in addition to information in these registers on all patients with diagnoses of external causes or psychiatric disorders in the Norwegian Patient Register.

In a nested case-control study, cases with the outcome under investigation, in this instance hospital treated DSH, are matched to several individuals who did not display the investigated outcome but who are at risk at the moment of treatment (99). Study cases consisted of people born between 1970 and 2003 who received acute treatment because of DSH at somatic hospitals and associated specialist health care services between 2008 and 2013. The date of birth was restricted to 2003 because we investigated DSH treatment after age 10, and the follow-up period extended to 2013. The selection of cases followed a structural multi-level approach developed by the supervisors of the present thesis (100). First, all indirect contacts, planned treatments, fatal injuries and poisonings or injuries that were clearly accidental, inflicted by others or secondary outcomes of other medical conditions were excluded. Since previous studies describe an underreporting of DSH in Scandinavian health registers (101, 102), a wider approach to inclusion of probable DSH episodes was utilised to prevent detection bias. Based on such previous studies (101) and our examination of determined episodes which were given a diagnosis of DSH (ICD-codes X6n, Y87), three hierarchical steps were followed to ascertain probable DSH episodes. Each person's first recorded contact was used as the case contact. The first step included 4 421 cases with treatment contacts due to injuries with a comorbid diagnosis of DSH (ICD-codes X6n, Y87). The second step included 3 966 cases with treatment contacts that were diagnosed with either poisoning (ICD-codes T4n, T50-T55, T57-T60, T62, T65 and T96) or injuries (ICD-codes S10-S11, S15, S19, S21, S25-S27, S31, S35-S39, S41, S45, S50-S51, S54-S56, S59, S61, S64-S65, S69, S71, S88, T01, T09, T11, T18-T19, T27-T28, T31, T68, T69, T71 and T95) and had a comorbid diagnosis of mental or behavioural problems (ICD-codes F0-F9). The final step included 4 139 cases with treatment contacts for poisoning (ICD-codes T4n, T50 and T96) that were not covered by previous steps. These hierarchical steps resulted in 12 526 cases with hospital treated DSH during the study period.

We applied a nested case-control design (99) to select up to 20 controls for each case with no recorded history of DSH hospitalisation at the time of matching. All eligible controls were included, but if more than 20 controls were eligible for a single case, 20 controls were randomly selected. Controls were drawn from a 25% random sample of all Norwegian residents who had a link to their father and mother in the Central Population Register and were matched for date of birth, gender and the date of DSH hospitalisation. This procedure resulted in 222 362 matched controls.

3.3. Variables

3.3.1. Outcome measures

Educational attainment was studied as the outcome measure in paper I, hospital treated DSH was studied as the outcome measure in paper II through a nested case-control design, and psychiatric disorders were studied as the outcome measure in paper III. In paper IV, high school non-completion, hospital treated DSH and psychiatric disorders were collectively investigated. When investigating hospital treated DSH and psychiatric disorders, the first event registered in the Norwegian Patient Register after 2008 was studied. Repeated events were not considered due to a limitation of the scope of each paper, and made comparison with previous studies possible.

Paper I investigated four outcomes related to *educational attainment* covering all educational levels in Norway: completion of compulsory education after age 15 and completion of high school, vocational education and university or college education after age 18. Compulsory education (lower secondary education) consists of 7 years at primary school and 3 years at secondary school, and all children are automatically enrolled. The education is normally completed the year children turn 16 years. Furthermore, high school (post-secondary, non-tertiary education) can either focus on preparation for further academic studies (3 years), or education within a specific craft, industry or service (4 years or more). Completion of compulsory education is required to attend high school, and every youth in Norway who has completed compulsory education is offered the opportunity to attend high school. Given that high school completion is the minimum educational level often required for employment in Norway, and that job prospects are poor without this degree, paper IV only studied *high school non-completion*. Vocational education (short-cycle tertiary education) is a further education within the particular craft studied at high school for those who chose that educational direction. Completion of high school is required to attend vocational education, which can take between 6 months and two years. Lastly, university or college education requires high school completion and includes one-year programmes, bachelor's degree programmes and master's degree programmes. Doctoral degrees were not included since research fellows in Norway are employed and receive standard salaries and social welfare benefits. The first degree was analysed for people with multiple university or college degrees.

When investigating *psychiatric disorders*, patients' first direct contact with specialist mental health services between 2008 and 2012, as reported to the Norwegian Patient Register, was studied. We investigated *any psychiatric disorder* (F00-F99), as well as specific disorders of interest: *depressive disorders* (F32-F33), *reactions to stress* (F43), *anxiety disorders* (F40-F41), *substance use disorders* (F10-F19), *developmental disorders* (F80-F89), *childhood behavioural and emotional disorders* (F90-F98), *psychotic disorders* (F20-F29), *bipolar disorder* (F30-F31), *eating disorders* (F50), and *personality disorders* (F60-F62). Both main and secondary diagnoses were included when coding specific disorders. Given that patients can be diagnosed with up to 24 psychiatric diagnoses in Norwegian specialist mental health services, we also studied psychiatric c*omorbidity*, i.e. receiving multiple psychiatric diagnoses.

3.3.2. Variables of interest

The explanatory variable of interest in the study is exposure to parental death by external causes during childhood and adolescence, referred to as parental DBEC (ICD-8 and ICD-9 codes E800-E999, and ICD-10 codes V01-Y89). Analyses compared people who had experienced parental DBEC during childhood and adolescence to people who had not experienced parental DBEC during childhood and adolescence. The term external causes of death refers to the fact that these causes of death are external to the body, such as accidents, suicide and homicide. The effect of parental DBEC before age 18 was investigated when examining completion of high school, vocational education, and university or college education, risk of DSH hospitalisation and risk of psychiatric disorders. However, the effect of parental DBEC before age 15 was investigated when examining completion of compulsory education since this education is most often completed the year children turn 16 years. Subjects were classified into categories of *bereavement status* as a) no exposure to parental DBEC or b) exposure to parental DBEC. Furthermore, specific bereavement-related factors were investigated.

In paper I, specific *causes of parental death* were classified as a) suicide (ICD-8 and ICD-9: E950-E959, ICD-10: X60-X84, b) transport accidents (including land, water and air transport methods; ICD-8: E800-E845, ICD-9: E800-E848, ICD-10: V01-V99), and c) other external causes (such as other accidents, homicide and injury with unknown intent; ICD-8: E850-E949 and E960-E999, ICD-9: E849-E949 and E960-E999, ICD-10: W00-X59 and X85-Y89). In papers II and III, accidental deaths were further differentiated, and cause of death was classified as a) suicide (ICD-8 and ICD-9: E950-E959, ICD-10: X60-X84), b) transport accidents (ICD-8: E800-E845, ICD-9: E800-E848, ICD-10: V01-V99), c) other accidents (ICD-8: E850-E929, ICD-9: E849-E869 and E880-E928, ICD-10: W00-X59), and d) other external causes (ICD-8: E930-E949 and E960-E999, ICD-9: E870-E879, E929-E949 and E960-E999, ICD-10: X85-Y89). The category of other external causes of death in paper I consisted largely of accidents (84.6%), such as poisonings (23.9%) and falls (15.4%), and can hence be somewhat compared to category c) other accidents in papers II and III. Since the number of homicides in Norway is very low (4), a separate analysis of this group was impossible, and this cause of death was hence included in the “other external causes” category.

In light of the highly increased risk of suicide in offspring who had experienced parental DBEC during childhood and adolescence (17), and the theoretical view of childhood and adolescence as critical periods for later development, we decided to only investigate bereavement during childhood and adolescence in the present thesis. We aimed to discern further differences in risks of psychosocial challenges associated with differences in offspring’s age at bereavement up until age 18. Age 18 years was specifically selected since this is when you legally become of age in Norway and the time when many adolescents move to a separate home away from their parents, enter the work force or start higher education. Accordingly, subjects were classified according to their *age at bereavement* into a) ≤ 4 years, b) 5-9 years, c) 10-14 years, and d) 15-18 years. This classification was based on the United Nations standard age classifications which recommend 5 year age groups in childhood and adolescence (103). Additionally, the age groups 10-14 years and 15-18 years align with WHOs definition of adolescence (104).

In paper II where a nested case-control design was utilised, the potential influence of time since bereavement was investigated. *Time since bereavement* refers to the time between parental DBEC and DSH hospitalisation or matching and was classified as a) up to 5 years, b) 5-9 years, and c) 10-15 years. Papers I and III did not directly study the time since bereavement because these studies used cohort designs. An investigation of time between exposure and the outcome in question is an innate aspect of a cohort design and cox regression analysis, since the analysis incorporates both the likelihood of the outcome and the timing of the outcome in the risk estimate (98).

When both parents had died from external causes of death, cause of death, age at bereavement and time since bereavement were classified according to the parent who died first since this marks the beginning of children's bereavement-related exposure.

Lastly, g*ender of deceased parent* was classified as a) father, b) mother, and c) both parents, and the potential interactions between the above-mentioned variables of interest and *gender of the bereaved offspring* were assessed.

3.3.3. Covariates

In papers I and III, year of birth, gender and ethnicity were included as covariates in the multivariate analyses, while the multivariate analyses in paper II included the covariates ethnicity, highest education at the time of DSH hospitalisation or matching, taxable income the year before DSH hospitalisation or matching, marital status at DSH hospitalisation or matching, marital stability, residential stability, number of sick leave episodes the last 3 years before DSH hospitalisation or matching, and diagnosis of sick leave episode the last 3 years before DSH hospitalisation or matching. The specific covariates were selected because of their probable influence on individual's risk of psychosocial problems. A previous study by the research fellow found that most of the variables listed above influenced bereaved offspring's suicide risk (80), while a recent study from our research group reported that the variables constituted risk factors for DSH hospitalisation in the general population (105).

Ethnicity was classified as a) born in Norway with two Norwegian born parents, b) immigrant, c) born in Norway with immigrant parents or one parent born abroad, and d) born abroad with one or two Norwegian born parents. *Highest education* at the time of DSH hospitalisation or matching was classified as a) no education or unknown education, b) compulsory education, c) high school and vocational education, and d) higher education (university or college). We calculated *taxable income* the year before DSH hospitalisation or matching based on the Norwegian National Insurance Scheme's basic amount G, which is adjusted for annual national wage inflation(106). Taxable income was classified as a) up to 2G, b) 2-4G, c) 4G and more, and d) unknown. *Marital status* at DSH hospitalisation or matching was classified as a) married, b) never married, c) separated, d) divorced, e) widowed and f) unknown. *Marital stability* and *residence stability* refer to the number of changes in marital status and residence address, respectively, and were classified as a) 0, b) 1, and c) 2 or more. *Number of sick leave episodes* the last 3 years before DSH hospitalisation or matching was classified as a) 0, b) 1, c) 2, d) 3-4, and e) 5 or more. *Diagnosis of sick leave episode* the last 3 years before DSH hospitalisation or matching was classified as a) no sick leave, b) depression, c) other psychiatric conditions, d) musculoskeletal conditions, and e) other.

3. 4. Statistical analyses

3.4.1. Cox regression

Cohort studies in paper I and paper III were analysed with cox regression analyses where differences in hazard ratios (HRs) with 95% confidence intervals (95% CIs) were estimated. Cohort members could be censored due to death or emigration from birth, i.e. 1970. Educational attainment in paper I was followed from age 15 or 18, i.e. 1985 or 1988, while psychiatric disorders in paper III was followed from January 1st 2008 since this was when data became available in the Norwegian Patient Register. Both cohorts were followed to the date of the outcome measure in question, or the date of death, emigration from Norway or December 31st 2012, whichever came first. No parental DBEC functioned as the reference category in all analyses, and analyses were conducted in Stata, version 15 (107). The potential effects of bereavement variables were estimated in the crude models, while the adjusted models included the covariates ethnicity, year of birth and gender.

The multivariate analyses in paper I were additionally adjusted: Completion of compulsory education is required for attending high school, so high school completion was adjusted for completion of compulsory education. Likewise, graduating from high school is required for attending vocational, university and college education, so completion of these educations were adjusted for completion of high school. Sensitivity analyses, where the sample was restricted to only include the individuals who had completed the required educational level, instead of controlling for this previous completion, were also performed. Accordingly, the start of follow-up was set to the date of graduation from the required education rather than from birth.

In paper I, we studied parental DBEC before age 15 (compulsory education) or 18 (high school, vocational education, and university or college education), and educational attainment after this age. In paper III, on the other hand, we studied exposure before age 18 and psychiatric disorders from birth, meaning that the exposure status can change during the follow-up period. Therefore, the time before exposure was considered as unexposed, and the time after exposure was considered as exposed in the cox regression analyses of paper III.

3.4.2. Conditional logistic regression

The nested case-control study of paper II was analysed with a conditional logistic regression analysis (108) where the odds ratios (ORs) and 95% CIs of DSH hospitalisation were estimated using IBM SPSS Statistics, version 25 (109). A conditional logistic regression must be used in nested case-control studies to account for the matching of cases and controls and compare each case to its respective controls. No parental DBEC functioned as the reference category in all analyses. We analysed the regression models in multiple steps, starting with univariate analyses yielding crude ORs only controlled for age, gender and time of DSH hospitalisation through matching. Furthermore, multivariate analyses included all covariates to yield adjusted ORs (see section 3.3.3. concerning covariates). These multivariate analyses were additionally stratified in two supplementary analyses: A stratified analysis for strata where the case had received a psychiatric diagnosis at DSH hospitalisation or not received a diagnosis, and a stratified analysis for strata that were identified through the three different steps in the inclusion process (see section 3.2. concerning study design and population). Lastly, a hierarchical regression estimated the relative contribution of each covariate to identify the covariates with predictive power after statistically controlling for the effect of parental DBEC. The order of inclusion of covariates into the model, which must be set by the researcher, was partially based on a related previous study by the authors (80), and was as follows: diagnosis of sick leave episode, number of sick leave episodes, marital status, taxable income, marital stability, highest education, residential stability and ethnicity.

We wished to study offspring's first DSH hospitalisation in paper II and investigated a subsample of cohort members born from 1998 onwards. The restriction of the sample to this subset meant that we had complete information on DSH hospitalisation in the Norwegian Patient Register during the entire follow-up period for participants' who turned 10 years old in 2008 at the earliest. In this subsample of participants (186 cases and 3 418 controls), we investigated bereavement status and time since bereavement as independent variables. Since participants in this subsample were young, information on marital status, education, income and sick leave were irrelevant. The analyses hence only included ethnicity and residence stability as covariates.

3.4.3. Log likelihood ratio test

Papers I-III used log likelihood ratio tests to investigate the potential interaction between bereavement related variables and gender of the bereaved offspring based on results from the multivariate regression analyses. Additionally, paper II used this statistical test to investigate the potential interactions between cause of death and gender of the deceased parent, and cause of death and offspring's age at bereavement. These interactions with cause of death were, however, based on univariate analyses since coefficients in the multivariate analyses did not converge. Log likelihood ratio tests were performed using both IBM SPSS Statistics, version 25 (paper II) (109) and Stata, version 15 (papers I and III) (107). Regardless of software, the log likelihood ratio test compares a full model, including the main effects of all variables and the interaction between the indicated variable (for example gender) and each category of all variables, with the same model, excluding only the interaction in question. The likelihood values of these models are compared in a chi square test alongside the difference in degrees of freedom between the models, and if the model including the interaction in question has a better data fit, we conclude that there is a significant interaction.

3.4.4. Sensitivity analysis for unobserved confounding

In paper II, we used a sensitivity analysis for unobserved confounding (110) in order to investigate the unobserved confounding stemming from parents' history of psychiatric hospitalisation. This analysis presupposes that the researcher selects certain parameters based on previous studies: The prevalence of a history of psychiatric hospitalisation in parents who died from suicide ($p(u|x=1)$) was set to 0.45 (18), while the prevalence of a history of psychiatric hospitalisation in the general population ($p(u|x=0)$) was set to 0.06 (18). Finally, the odds ratio for the relationship between parents' history of psychiatric hospitalisation and offspring's DSH hospitalisation (OR_{yu}) was set to 2.09 (62). Markedly, we opted to use the prevalence of psychiatric hospitalisation in parents who died from suicide (45%) as opposed to the corresponding prevalence in parents who died from accidents (21%) (18) since the former prevalence is larger and hence yields the most conservative estimate of the adjusted OR. After selection, the above-mentioned parameters were used to determine an adjustment factor, and the OR was adjusted for this factor. Through this process we obtain the OR for the true association, free of bias from both observed and unobserved confounding.

3.4.5. Chi-square test of independence (2-tailed)

We performed chi-square tests of independence (111) in IBM SPSS Statistics, version 25 (109) in order to investigate the research aim of paper IV. Chi-square tests of independence are used to investigate differences in frequency data between groups, in this case the number of people with co-occurring sequelae among offspring bereaved by parental DBEC during childhood and adolescence and offspring who had not experienced parental DBEC during childhood and adolescence. First, we added together the frequencies across the groups as an estimate of the distribution in the population and calculated the expected frequency per group. The observed frequencies were then compared to the expected frequencies to ascertain whether there is a significant difference between the null hypothesis, given by the expected frequencies, and the observed distribution. If the groups were very different from each other, the difference between the observed and expected frequencies was large, and we could thus reject the null hypothesis (111).

3.5. Ethical approvals

This doctoral thesis is part of a large register-based research project that was approved by the Regional Committee for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the relevant registers. All research activities in the thesis are hence covered by these approvals and have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Data from the Norwegian Patient Register has been used in papers II, III and IV. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred.

3.6. User involvement

Since the present thesis is based on register data, we did not have direct contact with the study participants during the collection of data material, and user involvement was ensured through other measures. The research fellow and supervisors have had regular contact with representatives from the Norwegian organisation LEVE (the national association for bereaved by suicide) and the organisations' youth group, Unge LEVE. The research fellow has, in particular, had regular conversations with the former leader of Unge LEVE in both the preparation and execution of the project. All published research material has been conveyed to LEVE. Moreover, the research fellow has attended the annual LEVE conference for several years, a conference aimed to merge the perspectives of bereaved family and friends with the perspectives of mental health professionals and researchers. At these conferences, the research fellow has had several insightful and valuable informal conversations with bereaved family members. Lastly, the research fellow has gained valuable insight through conversations with the leader of NSSFs panel of experience, a panel where members have experience as users, next of kin or bereaved. These conversations were especially insightful with respect to the interpretation and practical and clinical implications of the study results.

3.7. Funding

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4. Results

4.1. Paper I

Educational attainment in offspring bereaved by sudden parental death from external causes: A national cohort study from birth and throughout adulthood

For most educations, a lower percentage of people who had been exposed to parental DBEC finished the different educational levels compared to offspring who had not experienced parental DBEC (compulsory education: 95.8% vs 95.1%, high school: 56.3% vs 67.2%, vocational education: 3.1% vs 3.9%, university or college education: 24.9% vs 33.4%). Furthermore, bereaved offspring often finished the education at a later age compared to non-exposed individuals (compulsory education: 16.0 years for both groups, high school: 20.4 vs 19.9 years, vocational education: 24.7 vs 23.4 years, university or college education: 24.1 vs 23.5 years).

In the multivariate analyses, people who had lost a parent to external causes of death during childhood and adolescence had significantly lower HRs of completing all educational levels compared to individuals who had not experienced parental DBEC during childhood and adolescence (compulsory education: HR: 0.94, 95% CI: 0.91-0.98, high school: HR: 0.68, 95% CI: 0.65-0.71, vocational education: HR: 0.78, 95% CI: 0.65-0.94, and university or college education: HR: 0.75, 95% CI: 0.70-0.80). In the sensitivity analyses, which restricted the sample to individuals who had completed the prerequisite education level, HRs were significantly reduced for completion of high school (HR: 0.69, 95% CI: 0.66-0.72) and university or college education (HR: 0.79, 95% CI: 0.74-0.85), but not for vocational education.

When further investigating different causes of parental death in the multivariate analyses, all external causes of death were associated with lower HRs for completing high school (suicide: HR: 0.71, 95% CI: 0.66-0.76, transport accidents: HR: 0.69, 95% CI: 0.64-0.75, other external causes: HR: 0.63, 95% CI: 0.58-0.69) and university or college education (suicide: HR: 0.70, 95% CI: 0.63-0.78, transport accidents: HR: 0.81, 95% CI: 0.72-0.90, other external causes: HR: 0.75, 95% CI: 0.66-0.85). For completion of compulsory education, only transport accidents were associated with a significantly reduced risk (HR: 0.92, 95% CI: 0.86-0.98), while only suicide was associated with a significantly lower risk of completing vocational education (HR: 0.72, 95% CI: 0.53-0.98). No large differences in HRs depending on cause of death were evident for any educational level.

Likewise, no large differences in HRs depending on the gender of the deceased parent were evident for any educational level. Paternal bereavement was associated with significantly reduced HRs of completing all educations (compulsory education: HR: 0.93, 95% CI: 0.90-0.97, high school: HR: 0.68, 95% CI: 0.65-0.72, vocational education: HR: 0.82, 95% CI: 0.67-1.00, university or college education: HR: 0.75, 95% CI: 0.69-0.80). Maternal bereavement was associated with significantly reduced HRs of completing high school (HR: 0.68, 95% CI: 0.61-0.75) and university or college education (HR: 0.76, 95% CI: 0.65-0.89). Bereavement of both parents was only associated with significantly reduced HRs of completing high school (HR: 0.62, 95% CI: 0.43-0.91).

When investigating differences in offspring's age at bereavement, all ages of bereavement were associated with significantly reduced HRs of completing high school (≤ 4 years: HR: 0.67, 95 % CI: 0.61-0.73, 5-9 years: HR: 0.65, 95 % CI: 0.59-0.70, 10-14 years: HR: 0.72, 95 % CI: 0.66-0.77, 15-18 years: HR: 0.69, 95 % CI: 0.63-0.76) and university or college education (≤ 4 years: HR: 0.78, 95% CI: 0.68-0.89, 5-9 years: HR: 0.72, 95% CI: 0.63-0.82, 10-14 years: HR: 0.74, 95% CI: 0.66-0.83, 15-18 years: HR: 0.78, 95% CI: 0.67-0.90). For compulsory education, bereavement between the ages of 5 and 10 years was associated with a significantly reduced HR of completion (HR: 0.89, 95% CI: 0.83-0.95), while bereavement before age 5 (HR: 0.60, 95% CI: 0.39-0.91) and between 10 and 15 years (HR: 0.64, 95% CI: 0.44-0.93) was associated with reduced HRs of completing vocational education. Again, no large differences were evident depending on offspring's age at bereavement for any educational level.

Log likelihood ratio tests did not indicate any significant interactions between the gender of the bereaved offspring and bereavement status, gender of deceased offspring or age at bereavement for any educational level. A significant interaction between gender and cause of death was found for completion of compulsory education, indicating that parental suicide and transport accidents reduced the HRs of completing compulsory education slightly more in sons than in daughters.

Supplemental comment

A comment on the understanding and interpretation of reduced ratio measures below 1 as opposed to increased ratio measures above 1 with regard to this paper: The hazard ratio goes from 0 to infinity with a starting point of 1 when there is no significant difference, and this influences the interpretation. Ratio measures such as HRs need to be expressed and interpreted on a logarithmic scale rather than an arithmetic scale (112). With the appropriate use of a logarithmic scale, we interpret a reduced risk of 0.5 as equivalent in magnitude and distance from 1 as an increased risk of 2.0. A HR of 0.5 means that the risk is halved, while a HR of 2 means that the risk is doubled. Likewise, a risk of 0.25 is equivalent in magnitude and distance from 1 as a risk of 4.0.

4.2. Paper II

Parental death by external causes and risk of hospital treated deliberate self-harm in bereaved offspring

In the present cohort, 56.4% were females, and the mean ages of DSH hospitalisation were 24.3 years for females and 27.3 years for males.

People who had lost a parent to external causes of death during childhood and adolescence had a significantly increased risk of DSH hospitalisation compared to people who had not lost a parent to external causes of death during childhood and adolescence (adjusted OR: 1.83, 95% CI: 1.60-2.10). The associated risk was somewhat reduced in the multivariate analysis compared to the univariate analysis, and the hierarchical regression showed that all covariates significantly predicted DSH hospitalisation when the effect of parental DBEC was accounted for. The association remained significant after controlling for the unobserved confounding from parents' history of psychiatric hospitalisation (OR: 1.31, 95% CI: 1.14-1.50), and was especially evident for the first DSH hospitalisation in the subsample of subjects born after 1998 (OR: 7.97, 95% CI: 3.63-17.49). Moreover, no large differences were evident for subjects who received a psychiatric diagnosis at DSH hospitalisation and subjects who did not receive a diagnosis in the stratified analysis. Likewise, no large differences were observed in the stratified analysis for the three DSH identification steps.

When investigating cause of parental death in the multivariate analyses, we found that parental suicide (OR: 2.32, 95% CI: 1.92-2.80) and death by other accidents such as poisonings and falls (OR: 1.79, 95% CI: 1.38-2.33) were associated with significantly increased risks of DSH hospitalisation, while parental death by transport accidents (OR: 1.26, 95% CI: 0.93-1.69) and other external causes (OR: 1.13, 95% CI: 0.55-2.31) were not associated with significantly increased risks. As is evident, parental suicide was associated with the highest risk of DSH hospitalisation. Log likelihood ratio tests for the interaction between cause of death and gender of the deceased parent was non-significant, with parental suicide and death by other accidents being associated with the largest risks regardless of losing a mother or father. Similarly, the log likelihood ratio test for the interaction between cause of death and offspring's age at bereavement was non-significant, with parental suicide and death by other accidents being associated with the greatest risks across all ages of bereavement.

In the multivariate analysis investigating gender of the deceased parent, paternal death (OR: 1.76, 95% CI: 1.51-2.06), maternal death (OR: 2.00, 95% CI: 1.51-2.66) and death of both parents (OR: 3.09, 95% CI: 1.30-7.36) were all associated with significantly increased risks of DSH hospitalisation, and no large differences between losing a father and mother were evident.

When investigating offspring's age at bereavement in the multivariate analysis, loss of a parent until 18 years was associated with significantly increased risks of DSH hospitalisation (≤ 4 years: OR: 1.69, 95% CI: 1.29-2.23, 5-9 years: OR: 1.77, 95% CI: 1.37-2.30, 10-14 years: OR: 1.81, 95% CI: 1.42-2.32, 15-18 years: OR: 2.14, 95% CI: 1.60-2.87).

In the sensitivity analysis investigating the first DSH hospitalisation in the subsample of individuals born after 1998, the examination of time since bereavement found significantly increased risks of DSH hospitalisation the first 10 years after bereavement (up to 5 years: OR: 15.61, 95% CI: 4.07-59.92; 5-9 years: OR: 7.03, 95% CI: 2.33-21.18), but no significantly increased risk 10 to 15 years after bereavement (OR: 3.49, 95% CI: 0.40-30.24).

Lastly, log likelihood ratio tests investigating the interactions between gender of the bereaved offspring and bereavement status, cause of death, gender of deceased and age at bereavement were all non-significant.

4.3. Paper III

Parental death by external causes during childhood and risk of psychiatric disorders in bereaved offspring

For the follow-up period 2008-2012, 7.5% (353) of people who had experienced parental death by external causes during childhood and adolescence were diagnosed with a psychiatric disorder, compared to 3.0% (19 406) of people who had not experienced parental DBEC during childhood and adolescence. The mean ages of diagnoses ranged from 22.6 years to 29.4 years for depressive disorders, reactions to stress, anxiety disorders, substance use disorders, psychotic disorders, bipolar disorder, personality disorders and eating disorders. On the other hand, the mean age at diagnosis was 12.9 years for developmental disorders and 14.9 years for childhood behavioural and emotional disorders.

People who had lost a parent to external causes of death during childhood and adolescence had a significantly increased risk of developing any psychiatric disorder compared to people who had not experienced parental DBEC during childhood and adolescence (adjusted HR: 2.19, 95% CI: 1.97-2.43). Specifically, offspring bereaved by parental DBEC had increased risks of depressive disorders (HR: 2.09, 95% CI: 1.68-2.62), reactions to stress (HR: 1.90, 95% CI: 1.43-2.51), anxiety disorders (HR: 1.45, 95% CI: 1.03-2.05), substance use disorders (HR: 2.75, 95% CI: 2.13-3.57), developmental disorders (HR: 2.47, 95% CI: 1.63-3.73), childhood behavioural and emotional disorders (HR: 2.64, 95% CI: 2.13-3.28), psychotic disorders (HR: 2.42, 95%CI: 1.33-4.39), bipolar disorder (HR: 2.30, 95%CI: 1.23-4.30), and personality disorders (HR: 2.60, 95%CI: 1.59-4.28), but not eating disorders (HR: 0.53, 95%CI: 0.17-1.66).

When further investigating different causes of parental death in the multivariate analyses, all external causes of death were associated with a significantly increased risk of any psychiatric disorder (suicide: HR: 2.57, 95% CI: 2.21-2.99, transport accidents: HR: 1.49, 95% CI: 1.18-1.89, other accidents: HR: 2.35, 95% CI: 1.93-2.87, other external causes: HR: 2.33, 95% CI: 1.47-3.70). Parental suicide was associated with a significantly increased risk of all the specific diagnoses examined, while other accidents was associated with a significantly increased risk of depressive disorders, reactions to stress, substance use disorders, developmental disorders and childhood behavioural and emotional disorders. Moreover, death due to transport accidents was only associated with a significantly increased risk of substance use disorders, while death by other external causes was only associated with a significantly increased risk of childhood behavioural and emotional disorders.

Results from the multivariate analysis investigating the gender of the deceased parent found that offspring who had lost a father (HR: 2.10, 95% CI: 1.87-2.37), mother (HR: 2.48, 95% CI: 1.97-3.12) and both parents (HR: 3.21, 95% CI: 1.53-6.73) had a significantly increased risk of developing any psychiatric disorder. Paternal bereavement was associated with a significantly increased risk of all the specific diagnoses investigated, while maternal bereavement was associated with significantly increased risks of depressive disorders, substance use disorders, and childhood behavioural and emotional disorders. Loss of both parents was associated with a significantly increased risk of substance use disorders, developmental disorders and childhood behavioural and emotional disorders.

When investigating the effect of different ages at bereavement, the multivariate analysis found that loss at all ages before age 18 was associated with increased risks for developing any psychiatric disorder (≤ 4 years: HR: 2.09, 95% CI: 1.70-2.57, 5-9 years: HR: 2.49, 95% CI: 2.07-2.98, 10-14 years: HR: 2.09, 95% CI: 1.71-2.56, 15-18 years: HR: 1.96, 95% CI: 1.48-2.59). Different age groups were, however, associated with significantly increased risks for different specific disorders: From birth to 15 years for depressive disorders and substance use disorders, from 5 to 15 years for reactions to severe stress, from birth to 5 years and 15 to 18 years for anxiety disorders, from birth to 10 years and 15 to 18 years for childhood behavioural and emotional disorders, and from 5 to 10 years for developmental disorders.

Log likelihood ratio tests did not indicate any significant interactions between gender of the bereaved offspring and bereavement status for developing any psychiatric disorder or any of the specific diagnoses investigated. Moreover, log likelihood ratio tests did not indicate any significant interactions between gender and cause of death or gender of deceased for developing any psychiatric disorder. A significant interaction between gender and age at bereavement was, however, found for developing any psychiatric disorder, indicating that bereavement before age 10 was more detrimental to sons than daughters, while bereavement after age 10 was more detrimental to daughters than sons.

In total, 1.2% (56) of bereaved offspring received multiple diagnoses, while 0.5% (3 486) of non-bereaved people received multiple diagnoses. Childhood comorbidity often consisted of multiple diagnoses of childhood behavioural and emotional disorders or these disorders combined with developmental disorders. Adulthood comorbidity often consisted of various combinations of depression, anxiety, and substance use disorder. Offspring bereaved by parental DBEC had a significantly increased risk of psychiatric comorbidity compared to offspring who had not experienced parental DBEC (HR: 1.97, 95% CI: 1.51-2.56).

4.4. Comparison of study results across papers I-III

The potential effects of several variables are investigated in papers I-III: bereavement status, cause of parental death, gender of deceased parent, offspring's age at bereavement and gender of the bereaved offspring. Table 2 provides a summary of the study results in papers I-III with regard to these coinciding variables.

Table 2. Overview of comparable study results from papers I-III

	Paper I – Educational attainment	**Paper II – DSH hospitalisation**	**Paper III – psychiatric disorders**
Bereavement status	* significantly increased risk of non-completion	* significantly increased risk	* significantly increased risks
Cause of parental death	* suicide, transport accidents and other external causes associated with reduced risks of high school and university/college * vocational edu. has low power to identify reduced risks * no large differences between categories	* suicide and other accidents associated with increased risks * transport accidents and other external causes not associated with significantly increased risks	* suicide, transport accidents, other accidents and other external causes associated with increased risks of any psychiatric disorder * suicide associated with increased risks of all specific disorders, other accidents associated with increased risks of many specific disorders * transport accidents and other external causes associated with increased risks of one specific disorder each
Gender of deceased parent	* loss of father associated with reduced risks of all educations * loss of mother associated with reduced risks of high school and university/college * no large differences between categories	* loss of father, mother and both parents associated with increased risks * no large differences between categories	* loss of father, mother and both parents associated with increased risks of any psychiatric disorder * loss of father associated with increased risks of all specific disorders * loss of mother associated with increased risks of 3 specific disorders
Age at bereavement	* all ages associated with reduced risks of high school and university/college * loss age 5-10 associated with reduced risk of compulsory edu. * loss age 0-5 and 10-15 associated with reduced risks of vocational edu. * no large differences between categories	* all ages associated with increased risks * no large differences between categories	* all ages associated with increased risks of any psychiatric disorder * different age groups associated with increased risks of specific disorders
Gender of bereaved offspring	* one significant interaction between gender and cause of death for compulsory edu. * mainly no significant interactions with gender	* no significant interactions with gender	* one significant interaction between gender and age at bereavement for any psychiatric disorder * mainly no significant interactions with gender

4.5. Paper IV

Co-occurrence of psychosocial sequelae in bereaved offspring

In the cohort, 48.6% (318 554) were female. Altogether, 4756 people had experienced the death of a parent due to external causes of death before age 18, and the mean age at bereavement was 8.8 years (SD=5.2 years). Of these, 3818 (80.3%) had lost a father, 876 (18.4%) a mother and 62 (1.3%) both parents. When categorising cause of parental death according to the parent who died first, 1938 (40.7%) died from suicide, 1333 (28.0%) from transport accidents, 1267 (26.6%) from other accidents, and 218 (4.6%) from other external causes.

For offspring bereaved by parental DBEC, 39.5% had one adverse outcome, 5.3% had two and 1.0% had all three outcomes. The corresponding percentages for people who had not experienced parental DBEC were 32.0%, 2.4% and 0.4%. As a result, bereaved offspring had a significantly higher likelihood of having one (χ^2: 129.68, df: 1, p: <0.01), two (χ^2: 170.41, df: 1, p: <0.01) and three (χ^2: 50.35, df: 1, p: <0.01) adverse outcomes. These significant differences were evident in both females and males and for all ages. Furthermore, each specific combination of outcomes was individually investigated.

Offspring bereaved by parental DBEC had a significantly higher co-occurrence of psychiatric disorders and high school non-completion compared to people who had not experienced parental DBEC (χ^2: 13.32, df: 1, p: <0.01): In bereaved offspring, 66.2% with psychiatric disorders did not finish high school, while the co-occurrence in non-bereaved people was 55.9%. This difference was evident in females (59.9% vs 49.9%, χ^2: 6.55, df: 1, p: <0.05), males (73.6% vs 62.5%, χ^2: 7.47, df: 1, p: <0.01) and people aged 18-30 years old (75.8% vs 64.2%, χ^2: 10.32, df: 1, p: <0.01), but not in people aged 30-43 years (53.4% vs 45.7%, χ^2: 3.14, df: 1).

In contrast, offspring bereaved by parental DBEC had a moderate but not significantly higher co-occurrence of DSH hospitalisation and high school non-completion compared to people who had not experienced parental DBEC (χ^2: 2.01, df: 1): In bereaved offspring, 75.4% with DSH hospitalisation did not finish high school vs 66.8% in non-bereaved people. This difference was not significant for females (77.1% vs 63.0%, χ^2: 2.96, df: 1), and males (73.1% vs

71.1%, χ^2: 0.05, df: 1), or for people aged 18-30 years (82.5% vs 71.5%, χ^2: 2.34, df: 1) and 30-43 years (61.9% vs 60.4%, χ^2: 0.02, df: 1).

Compared to people who had not lost a parent to external causes, offspring who had experienced parental DBEC did not have a significantly higher co-occurrence of DSH hospitalisation and psychiatric disorders (χ^2: 3.56, df: 1): In bereaved offspring, 83.6% with DSH hospitalisation had a psychiatric disorder, while the co-occurrence in non-bereaved people was 76.8%. The difference was significant for people aged 18-30 years old (82.5% vs 76.1%, χ^2: 4.17, df: 1, p: <0.05), , but not significant for people aged 30-43 years (85.7% vs 77.6%, χ^2: 0.22, df: 1), females (88.6% vs 79.8%, χ^2: 3.69, df: 1), and males (76.9% vs 73.3%, χ^2: 0.44, df: 1).

5. Discussion

5.1. Discussion of the main findings

The core findings of papers I-IV are presented in the previous sections, while a discussion of the main findings will be presented in the following sections.

5.1.1. Bereavement status, psychosocial sequelae and co-occurrence

Together, the findings in papers I-III show that people who have experienced parental death by external causes during childhood and adolescence have a significantly increased risk of psychosocial sequelae, specifically lower educational attainment, DSH hospitalisation and psychiatric disorders, compared to people who have not experienced parental DBEC during childhood and adolescence. This thesis is the first to identify increased risks of lower educational attainment at all levels and an increased risk of psychiatric comorbidity, and the first large-scale population study to identify increased risks of anxiety disorders, childhood behavioural and emotional disorders, developmental disorders, and reactions to severe stress. The study is also the first to report no increased risks of eating disorders given that this has not been previously studied. The present findings reporting increased risks of several types of psychosocial sequelae are in line with our previous study on bereaved offspring's suicide risk, which reported that bereaved offspring have a significantly increased risk of later suicide compared to peers who have not experienced such loss (17). Evidently, the loss of a parent to external causes of death has widespread and diverse adverse outcomes, ranging from socioeconomic difficulties to increased morbidity and mortality.

Potential explanations for bereaved offspring's increased risks of psychosocial sequelae may be located in a combination of factors both preceding and following the loss, so-called pre- and post-bereavement factors. Instead of viewing the death of a parent as a single stressful event, the death should be perceived as a series of events that occur both before and after the death (11). Interestingly, previous studies have indicated that there may exist a dose-response relationship between the number of pre- and post-bereavement factors and the severity of psychosocial sequela (11). The present thesis is, unfortunately, unable to investigate the influence of the preand post-bereavement factors envisioned to influence bereaved offspring's psychosocial challenges.

Relevant potential pre-bereavement factors leading up to the death include lower household income, parental unemployment and lower parental education (113). Furthermore, studies have reported that psychiatric disorders are more common in both parents in families where one parent will later die a sudden death (37, 39). As a consequence of these pre-bereavement factors related to all external causes of death, bereaved offspring are more likely to grow up in households where the family environment is characterised by discord and instability. Such pre-bereavement factors may influence the risks of both parental death and offspring psychopathology and hence function as confounders in the present studies. Additionally, the emotional closeness of the relationship with the deceased has been reported to influence the mental health of the bereaved after the loss (11).

Following the loss of a parent, multiple post-bereavement factors may also contribute to the development of psychosocial sequelae. Even though Norway has strong compensational benefits when a parent dies (36), we may expect the household finances and overall resources to decline following the loss of a parent and wage earner. As mentioned in the introduction section, the living caregiver has a further increased risk of mental ill-health (37, 39), naturally impacting their parenting abilities and follow-up of the child. Indeed, studies have reported lower family cohesion and social support following bereavement from sudden death (37), and a poor relationship with the remaining parent increases offspring's risk of mental ill health (11). The offspring's personal resources can also be impaired following bereavement, as the offspring may suffer from sleep disturbances (114), reduced stress resilience (115), lower coping skills (116), impaired concentration (117) and a lower sense of mastery and self-esteem (118). These and other post-bereavement factors function as mediators and contribute to the total effect of bereavement on psychopathology.

In combination, the pre- and post-bereavement factors listed above may create a negative spiral or developmental cascade (119) where one problem enhances another, again fuelling further challenges. The psychosocial sequelae found to follow bereavement, such as mental ill-health, deliberate self-harm, low school performance, violent crime (73) and marital dissolution

(71) will also play a part in this downward spiral of poorer functioning. As an example, impaired concentration paired with reduced stress resilience may lead to poorer school performance, which again reduces self-esteem and increases feelings of loneliness and stigma, ultimately leading to depression. Paper IV is, to our knowledge, the first study to examine bereaved offspring's psychosocial sequelae in combination, and it reported an increased risk of co-occurrence of psychosocial sequelae in bereaved offspring compared to their non-bereaved peers. Despite the limited insight provided by this short report, we postulate that the increased co-occurrence may be a result of the negative spiral or developmental cascade described above. As a result of these interactive and potentially causal mechanisms, bereaved offspring's initially increased risk of individual psychosocial sequelae may also entail an increased risk of co-occurrence of sequelae.

Despite the present studies' inability to determine the causal mechanisms behind the study results, the conclusions are clear: bereaved offspring have an increased risk of vast and long-lasting psychosocial sequelae. The investigation and description of the increased risk is important, and the study results call for intervention. This vulnerable group should be given extensive follow-up, no matter the causal mechanisms behind their troubles.

5.1.2. Parental cause of death

In combination, the results from analyses of Norwegian register data show that the loss of a parent to all external causes of death is associated with psychosocial sequelae in offspring, but that loss due to other accidents such as poisonings and falls are associated with higher risks, and that loss due to suicide is associated with the highest risks. This was, however, not evident for educational attainment, where no large differences between different causes of death were evident. Since an external validation of data from the Norwegian Cause of Death Register reported that suicides are seldom misclassified as accidental deaths (90), misclassification is a fairly unlikely reason for the present findings. The present studies are the first to investigate the effect of different external causes of death on educational attainment, and to examine potential differences in risks of DSH hospitalisation and psychiatric disorders between different types of accidents. Deviating risks of DSH hospitalisation and psychiatric disorders between transport accidents and other accidents such as falls, poisoning and drowning may be the reason for previous inconsistencies regarding differences between parental suicide and accidental deaths in general. Ideally, we would also have liked to investigate parental homicide and domestic homicide-suicide as separate categories in the analyses, but the very low number of homicides in Norway makes this impossible (4). We can only assume that parental homicide would have a very large impact on offspring's later risks of psychosocial sequelae.

All external causes of death increased offspring's risks of suicide (17), lower education and psychiatric disorders, probably due to the significant impact the loss of a parent has on offspring and the family as a whole. As previously presented, the loss of a primary attachment figure, especially in childhood and adolescence, has large impacts on the individual and family, specifically when the loss constitutes a traumatic event. Several factors in combination probably explain why parental loss due to suicide and accidents such as falls, poisoning and drowning are associated with higher risks than loss due to transport accidents. Firstly, previous research has reported that the risk of psychiatric disorders is significantly higher in probands who later die from accidental poisonings and falls compared to probands who die in transport accidents (120). Psychiatric disorders are also especially prevalent in families where members have died by suicide (39). Moreover, both parental suicide and accidental poisoning by medications may involve a period of physical illness preceding the death (121). As a result of mental and physical illness preceding the death, the family environment prior to the death of a parent from suicide or accidental poisoning or falls may have been especially problematic, marked by family discord, insecurity, instability and even maltreatment and abuse (39, 122).

The explanation for the highest risks being associated with parental suicide may be found in grief specific variables. The fact that suicide is an intentional act of self-harm can often lead to a more complex trauma and loss experience (33). Suicide-bereaved family and friends experience more difficulties related to the grief, such as guilt and feelings of responsibility, rejection and abandonment, anger at the deceased, and a ruminative need to make sense of the death and understand the suicidal motivation (32, 33, 82, 87). Given that suicide is still associated with taboo and stigma, the bereaved may feel a need to conceal the cause of death. Alternatively, they may experience social isolation, shame and stigma (33, 87, 117). The relational and grief specific challenges specifically related to suicide may lead to suicidal behaviour and psychiatric disorders through the development of complicated grief, depression, anxiety, posttraumatic stress disorder or general psychosocial stress (87, 123). Additionally, genetic transmission of factors reported to highly influence mental health, such as psychiatric disorders, neurocognitive deficits and certain personality traits has been reported to be prevalent and influential in children and adolescents bereaved by parental suicide (124). Familial clustering of suicide is highly influenced by genetic factors, as suicide risk increases with the amount of genetic material shared with the suicide deceased proband (124). Such genetic transmission will, naturally, not apply to the low number of adoptive children in the present studies.

After this short presentation of the possible reasons why accidental poisonings and falls and particularly suicide is associated with the largest risks of psychiatric disorders, DSH hospitalisation and suicide (17), we may be able to locate explanations for why there were no differences between different causes of death with regard to educational attainment. In our studies, educational attainment was the only socioeconomic measure that was not directly related to mental health. The explanations presented above hence seem to be more important in influencing offspring's mental health than their overall functioning. In particular, genetic transmission of factors reported to influence mental health and the psychologically detrimental grief process following bereavement may affect educational attainment to a lesser degree. In contrast, the loss itself, its economic and familial implications and the offspring's reduced personal resources, such as sleep disturbances (114), reduced stress resilience (115), lower coping skills (116), impaired concentration (117) and a lower sense of mastery and self-esteem (118), may be most influential in impairing educational attainment. According to the dual process model of coping with bereavement, the deactivation of the restoration-oriented system during the acute grief period shortly following the death means that the bereaved children and adolescents have very little interest in school work (12). The combined reduction in interest and concentration may render the bereaved completely detached from school work.

Moreover, children and adolescents who grow up in a household where one parent has died may receive less help with school work and less overall follow-up and monitoring of their behaviour. As a result, they are less likely to do their homework and get help in understanding their homework, and their academic development may suffer. This is both a result of the remaining parent's reduced time and resources since all domestic chores now fall on one parent, as well as the remaining parent's reduced personal capacities due to their own grief and mental ill-health (39). The reduced follow-up may exacerbate an already non-ideal academic situation consisting of instability and insecurity in the family, parental psychiatric disorders and lower educational levels of the parents (37, 39, 113). Indeed, previous studies have found that lower education in parents predict lower education in their children (125).

5.1.3. Gender of deceased parent

The present studies reported comparable risks of suicide (17), educational attainment, DSH hospitalisation and psychiatric disorders in offspring who had lost a mother and father – no substantial differences were evident depending on the gender of the deceased parent. These results are in accordance with previous Scandinavian register studies investigating offspring's risks of DSH hospitalisation (52, 63, 67) and educational attainment (53). Consequently, the gender of the deceased parent and the gender of the remaining caregiver seem to be of limited importance to the risks of psychosocial sequelae in bereaved offspring.

The lack of gender differences reported throughout these register studies may reflect a high level of gender equality in Nordic countries during the study period. Instead of being gender-defined, the role of primary caregiver, displays of affection and attachment, child rearing responsibilities, time spent in the home and other factors which have traditionally differed between mothers and fathers may now be more individually based and hence vary between different families (126, 127). Consequently, both parents may function as the primary attachment figure, or the remaining parent will be willing and able to assume the role of primary attachment figure following the loss. In addition, increased economic and occupational gender equality (128) can more effectively enable the remaining parent of both genders to maintain household resources following the loss of the co-parent.

Given that few people lose both parents to external causes of death, low statistical power means that the present studies cannot draw conclusions with regard to the impact of losing both parents. We may, however, assume that the loss of both parents is associated with higher risks of psychosocial sequelae compared to losing one parent, and results from the present thesis support this assumption. Losing both parents will probably lead to more extensive changes in care-taking routines and residence since children and adolescents will be in the care of child protective services or extended family members. From an attachment viewpoint, losing both parents means losing both primary attachment figures.

5.1.4. Gender of bereaved offspring

The log likelihood ratio test was used to investigate possible interactions between the gender of the bereaved offspring and bereavement status, parental cause of death, gender of the deceased parent and offspring's age at bereavement. In paper IV, chi square tests of independence were used to investigate differences in co-occurrence between bereaved and non-bereaved males and females. Across all studies, there were no significant differences between bereaved daughters and sons regarding their risks of suicide (17), educational attainment, DSH hospitalisation, psychiatric disorders, or co-occurrence of high school non-completion, DSH hospitalisation and psychiatric disorders. These findings are in line with previous Nordic register studies which have failed to report gender differences for offspring's risks of educational sequelae (53, 74) and DSH hospitalisation (52, 61, 63, 65). When investigating the interaction between offspring's gender and cause of death, gender of the deceased parent and age at bereavement across all three studies, only two significant interactions were evident. The differences in the associated effect sizes were, however, minimal, and we hence state that the influence of cause of death, gender of deceased and age at bereavement did not substantially differ between daughters and sons. The comparable effect of losing a parent in daughters and sons may also be explained by gender equality, leaving both genders with equal ability to express their feelings, seek social support and process the bereavement.

The data registers naturally register the biological sex of each individual, and not their personal gender identity. As a result, we cannot say whether the individuals classified as male or female indeed identified as such. Since the present findings did not report any differences depending on the biological sex of the individual, we postulate that there will not be any significant differences between individuals who identify as either men or women. This is, however, impossible to investigate using register data.

5.1.5. Offspring's age at bereavement

Present results report increased risks of lower educational attainment, DSH hospitalisation and psychiatric disorders following bereavement throughout childhood and adolescence. These results are in line with previous findings indicating increased risks for lower educational attainment, poorer school performance and DSH hospitalisation throughout childhood and adolescence (18, 53, 62-64, 66, 72), as well as the critical period hypothesis' view of childhood and adolescence as highly important periods for later development (19, 20). Moreover, present results report a lack of differences between different age groups. Previous studies have, however, reported decreasing risks of psychiatric disorders with increasing age (18, 50, 54, 57, 60), and no systematic changes in associations with regard to age at bereavement (18, 129), somewhat dependent on the type of disorder investigated. Direct comparisons with previous studies are difficult given that many studies investigate all causes of death combined (50, 54, 57, 129) and different age classifications are used.

We should, however, be aware that this lack of age difference may mask different developmental processes from bereavement to psychosocial sequelae depending on the offspring's age at bereavement. Pre-bereavement factors, such as psychiatric disorders in the parent who later dies, may to a larger extent influence development of psychosocial sequelae in offspring who have experienced bereavement in later adolescence. On the contrary, when bereavement occurs in early childhood, post-bereavement factors, such a family discord and difficulties growing up in a single parent household, may account for the majority of offspring's bereavement-related sequelae. Conversations with bereaved families have also alerted us to the potentially significant impact of losing what might have been. When a child loses a parent in early childhood before a mature relationship has been formed, the child will lose the possibility of knowing their parent and having a good and loving relationship. The loss consists of never getting to know the parent and can also highly influence the child's later functioning.

5.1.6. Time since bereavement

Time since bereavement was investigated in paper II concerning bereaved offspring's risk of DSH hospitalisation, and the results indicated that the first 10 years after the loss, and especially the first 5 years, was associated with the largest risks. This result is in accordance with previous studies reporting the highest risks of suicide attempt the first 2 years after parental bereavement (61, 67, 86). The immediate effects following bereavement may be a direct effect of the trauma and loss itself, and especially the grief specific variables and social isolation related to parental suicide (33). The more long-term effects may, on the other hand, to a larger extent be the result of genetic heritability and post-bereavement factors (124).

5.2. Methodological considerations

5.2.1. Use of register data

The use of individual level data from Norwegian longitudinal registers to investigate parental bereavement and offspring's psychosocial sequelae has several advantages. Data in Norwegian registers are collected systematically and uniformly, the data quality has been found to be high (90, 93, 130), and the registers are systematically and continuously monitored, analysed and corrected (93, 131, 132). The personal identification number held by all Norwegian residents enables the linkage of several registers, as well as following individual persons over long time periods. Furthermore, the identification of parents in the Central Population Register enables us to link information on parents and offspring and examine information in a multi-generational perspective.

Due to the national coverage of Norwegian registers, the utilisation of register data enables the inclusion of a large number of subjects in each study. This yields good statistical power and enables the investigation of relatively infrequent events such as parental death by external causes, DSH hospitalisation and psychiatric disorders. Given the high number of participants, we were able to finely classify variables such as parental cause of death, offspring's age at bereavement and the specific types of psychiatric disorder, hence gaining deeper insight into the associations between parental DBEC and offspring's psychosocial sequelae. Naturally, there are still some categories that include few study subjects, which may make this fine-masked analysis problematic or limited.

Additional strengths of register data can be found in the lack of important and often influential biases. Firstly, since register studies are not originally collected for research purposes, the risk of differential misclassification bias is low – participants are unlikely to be systematically assigned to a different category than the one they actually belong to (133). Moreover, register studies do not suffer from biases related to sampling and selection. As previously mentioned, the sample is representative of the population as a whole since the register covers the entire population uniformly. Likewise, register studies are free from attrition, i.e. that participants leave the study during the course of the study (133). As opposed to self-report studies, which collect data through interviews or questionnaires, register studies do not suffer from recall bias. Recall bias introduces systematic error due to differences in the accuracy or completeness of memories of past events recalled by participants (133). Alternatively, study participants may intentionally or unintentionally alter self-reports of individual information to appear more socially desirable or in line with the perceived purpose of the study.

There are, naturally, limitations and drawbacks to register studies that must also be taken into consideration when interpreting findings. Since the focus of the study was to examine the multi-generational effect of parental DBEC, we only included study participants with a registered link to parents in the Central Population Register. Because we excluded offspring without a link to mother and father, our studies probably disproportionately excluded many first generation immigrants given that their parents are not registered in Norwegian registers.

The most important drawback to register studies is, however, that some desirable information is not available in the registers, and the inclusion of variables is dependent on their availability in the registers. Information concerning important pre- and post-bereavement factors, such as family environment, household socioeconomic status, living situation, parental psychiatric disorders and genetic vulnerability, are unavailable in the registers used here. Pre-bereavement factors can be considered as confounders, and controlling for their effect would be beneficial. Post-bereavement factors, on the other hand, function as mediators, so including this type of information could have helped explain the observed associations between parental DBEC and offspring's psychosocial sequelae, hence pinpointing the direct effect of the loss itself.

We argue that the present studies hold a high degree of internal validity due to the excellent data quality in Norwegian registers and the lack of important biases listed above. The lack of inclusion of potential pre-bereavement confounders, however, contributes to reducing the internal validity somewhat. We also argue that external validity and generalisability of the studies is high. Since Norwegian registers cover the entire population, our study sample is representative of the population with regard to, for example, age, gender, socioeconomic status and geographic location. Likewise, all parental deaths due to external causes are registered in the Cause of Death Register.

5.2.2. Study design

In papers I and III we used a cohort design to address the studies' research aims, and this enabled us to investigate several outcome measures in each study (educational attainment at several levels in paper I and different types of psychiatric disorders in paper III). In a cohort study, an entire cohort is followed across time from the start of follow up to the outcome in question. Both exposure and outcome are hence monitored across the study period (98). Hazard ratios estimated in cohort studies are based on incidence estimates and can be interpreted as relative risks.

In the nested case-control study of paper II, cases consisted of all individuals hospitalised for DSH in the defined population over a specified time period, and the controls were chosen from the members of the population who were at risk at the time each case occurred, i.e. from the "risk set" (99). In order to increase the strength of the study, 20 controls were chosen for each case. By using this sampling approach in a nested case-control design, odds ratios of rare events can be interpreted as relative risks. As a result, hazard ratios in papers I and III and odds ratios in paper II can all be interpreted as relative risks and are hence comparable.

A further strength of cohort studies lies in their ability to suggest causal relationships to a larger extent than case-control or cross-sectional studies. Case-control studies, and nested case-control studies in particular, are second best at inferring causality after cohort studies (134). We cannot, however, conclude that the associations observed in the present thesis are causal. Cohort and nested case-control studies examine associations and can only infer or suggest causality. Two obstacles hinder drawing clear conclusions about causal relationships in such studies: the third-variable problem and the directionality problem (135). The directionality problem is not an issue in the present studies since we know that the exposure occurred before the outcome, but the third-variable problem may influence the results. A third confounding variable, for example pre-bereavement factors, may influence the observed relationship between exposure and outcome.

Accordingly, previous studies report an influence of pre-bereavement factors, but nevertheless indicate significantly increased risks of psychiatric disorders after controlling for these factors (39).

In paper I, we studied parental DBEC before age 15 (compulsory education) or 18 (high school, vocational education, and university or college education), and educational attainment after this age. The start of follow-up was from birth since cohort members could be censored due to death or emigration, introducing immortal time – a period of follow-up during which the study outcome cannot occur. The same is true for cohort members who are born before 2008 – the start of follow-up of the event - in paper III. Because these immortal time periods do not differ between exposed and unexposed individuals, either through misclassification of the immortal time or exclusion of the immortal time, immortal time bias is not introduced. Indeed, we performed the same analyses in paper I with the start of follow-up at age 15 or 18, depending on the education in question, and the results were identical.

5.2.3. Categorisation and operationalisation of variables

During the categorisation and operationalisation of study variables, choices were made that influence the way we interpret the present study results. We chose to only investigate the first registered DSH contact (papers II and IV) and the first registered contact with mental health services (papers III and IV). These choices were a result of a limitation of the scope of each paper and made comparison with previous studies possible. As a result, we chose not to investigate the potential association between parental DBEC and repeated events, the frequency of these events, the length of follow-up in specialist health care nor the time to remission. Previous studies, as well as preliminary analyses at our centre, have found that repeated DSH hospitalisations more often coincide with psychiatric disorders as compared to single events of DSH hospitalisation (136). Our analyses in paper II found no large differences in the association between bereavement and DSH hospitalisation between subjects who received a psychiatric diagnosis at hospitalisation and subjects who did not receive a diagnosis. This may indicate that bereaved offspring have an increased risk of DSH hospitalisation regardless of whether we investigate the first registered event or several events. To our knowledge, no previous studies have investigated the associations between bereavement and repeated DSH hospitalisations or repeated psychiatric illness.

When both parents died, parental cause of death, age at bereavement and time since bereavement were classified according to the parent who died first since this marked the beginning of the offspring's exposure to parental death by external causes. We could naturally have classified these variables differently. As a comparison, research concerning child maltreatment often use a hierarchical taxonomy of types of maltreatment in cases where multiple forms of maltreatment are reported. Abuse, and particularly sexual abuse, is considered worse than neglect, and children who have experienced both abuse and neglect are classified as abused (137). By following the general belief that suicide is worse than death by other causes, we could have classified parental cause of death in a similar manner where parental suicide was at the top of the hierarchy. We did not, however, want the present studies to be coloured by any predisposed ideas or beliefs, and hence chose to categorise cause of death in a more neutral fashion.

5.3. Ethical considerations

The advantages of register studies are vast, and we can soundly argue that undertaking register studies within psychiatry is beneficial. There are also ethical advantages in register studies. Importantly, register studies do not entail a burden or pressure on research subjects, and this is a great advantage when researching vulnerable groups such as people suffering from psychiatric disorders or the loss of a loved one. People who have experienced a traumatic event will not be at risk of re-traumatisation due to the research endeavour. In general, register studies may yield valuable information at minimal risk to study subjects, hence rendering these studies ethically sound.

However, there are naturally ethical and judicial challenges associated with register studies, and the Norwegian National Research Ethics Committee calls register studies a "gold mine with challenges" (138). Several aspects of register studies make informed consent from participants difficult, even impossible. Register studies often include a very large number of participants over a long time period, and the data was not initially collected for research purposes (139, 140). Therefore, the Regional Committee for Medical and Health Research Ethics (REK

South East) waivered the demand for informed consent from participants in our study. Because of this, participants will be unable to refrain from participating in the study. The right of self-determination is among the most important principals for good and sound medical and health related research (141), and the values it upholds must be protected by other means if informed consent is abandoned (138).

In particular, trust is of paramount importance to undertaking justifiable and ethically sound register research without informed consent. Legitimate trust in register studies involves assuring minimal risk to research subjects by, for example, guaranteeing that information is not misused or shared (142). We have received data in which personal identifications were encrypted and information de-identified. Importantly, de-identified data is not the same as anonymous data, and there can be ways to trace study subjects back to their identity. The registers include a vast range of information which is combined on an individual level, and the individual researcher's morale is hence important for subject's security and anonymity. Naturally, only a minimal number of researchers have access to the data, and data have been stored on a secure server without internet connection.

Since subjects are unaware that they are a part of research and are unable to refrain from participation, avoiding stigma and ensuring anonymity in research publications is of especially great importance. Topics within the field of psychiatry are especially sensitive and need to be addressed with respect and complexity. The most important principle when undertaking research, the human dignity principle (141), was hence upheld.

5.4. Limitations

The present study's results must be interpreted in light of some limitations. As mentioned in section 5.2.1 concerning the use of register data in research, some desired covariates were impossible to include in the analyses due to restrictions in the contents and scope of Norwegian registers. In particular, we would have liked to include factors like family environment, household socioeconomic status, living situation and parental psychiatric disorders in order to pinpoint the direct effect of losing a parent.

Due to the nature of register studies, there is naturally information that cannot be registered in national governmental registers, but which would have been of importance in the present studies. Register data cannot inform researchers about some variables relevant to bereavement outcome, such as the quality of the parent-child relationship, the individual's appraisal of the bereavement, or offspring's coping mechanisms following the loss (11, 85). Likewise, psychiatric disorders and DSH that are not treated in specialist health services are not registered in the Norwegian Patient Register, and the subgroup of patients who receive medical help differs from the population as a whole. For example, cutting is the most common self-harm method in community studies, while poisoning is the most common method in individuals receiving treatment at hospitals [50]. Results from the present study consequently cannot be generalised to all types of deliberate self-harm or psychiatric disorders.

A further limitation concerns the limited time scope of the Norwegian Patient Register, which renders information on DSH hospitalisation and psychiatric disorders available from 2008. As a consequence, some of the study participants may have received treatment for DSH or psychiatric disorders prior to this study period. A cohort study will censor these participants due to death, emigration or the end of follow up (paper III), while a nested case-control study will classify them as controls (paper II). Their contribution will also be missed in paper IV where the co-occurrence of psychosocial sequelae will be lower than expected. In reality, these individuals should be treated as possessing the outcome measure in question. This misclassification may lead to a type II error, which potentially reduces the chances of significant findings.

The present results may also be subject to a further type II error since the study results were not controlled for the potential influence of parental death by natural causes. This information was not available due to restrictions of the ethical approval of the study. Previous research has indicated that parental death from natural causes can increase offspring's risks of suicide attempts and psychiatric disorders (18), although to a lesser degree than parental death due to external causes.

Lastly, since the use of the X6n deliberate self-harm code is insufficiently used in Norwegian registers, we widened the operationalisation of DSH hospitalisation to additionally include other ICD-codes, as explained in section 3.2. concerning study design and population. As a result, actual acts of self-harm may have been omitted from the study while some accidents may have been erroneously classified as DSH. Nevertheless, the sensitivity analysis where we stratified the analysis based on the step of DSH identification showed similar results across the three hierarchical inclusion steps.

6. Conclusions

In conclusion, the present thesis indicates that the loss of a parent from external causes of death during childhood and adolescence have broad and long-term associations with psychosocial sequelae. Particularly, offspring bereaved by parental death by external causes before age 18 displayed increased risks of lower educational attainment, hospital treated deliberate self-harm, several psychiatric disorders and psychiatric comorbidity compared to people who had not experienced parental DBEC before age 18. These associations were somewhat affected by factors related to the bereavement, and specific conclusions to be drawn from the present thesis include:

1. Parental loss by all external causes of death is associated with psychosocial sequelae in offspring. Death due to accidental falls and poisonings are associated with higher risks, while suicide is associated with the highest risks. For educational attainment, however, no differences depending on cause of death were evident.
2. Offspring who had lost a mother and offspring who had lost a father had similarly increased risks of lower educational attainment, DSH hospitalisation and psychiatric disorders.
3. Risks of lower educational attainment, DSH hospitalisation and psychiatric disorders were increased following bereavement throughout childhood and adolescence, and no substantial differences were evident between different age groups.
4. The first 5 years after the loss of a parent was associated with the largest risks of DSH hospitalisation.
5. Bereaved daughters and sons had equally increased risks of lower educational attainment, DSH hospitalisation and psychiatric disorders, regardless of the cause of death, gender of deceased parent or age at bereavement.
6. Offspring bereaved by parental DBEC had a significantly higher likelihood of developing two and three co-occurring adverse outcomes compared to people who had not experienced parental DBEC. This was particularly evident for the co-occurrence of psychiatric disorders and high school non-completion.

7. Implications and future research

7.1. Implications

“Postvention are those activities developed by, with, or for suicide survivors, in order to facilitate recovery after suicide, and to prevent adverse outcomes including suicidal behaviour” (143). However, since the present study indicates that offspring who have experienced losing a parent to all external causes of death during childhood and adolescence have increased risks of psychosocial sequelae, we suggest a broader use of the postvention term. Postvention should encompass follow-up of all those bereaved by external causes of death, such as suicide, accidents and homicides. We advocate that all bereaved offspring should be routinely offered supportive follow-up in primary healthcare and hence have the opportunity to seek help easily. This active outreach from the community is also requested by the bereaved themselves (34, 144, 145), and this vulnerable group of young people may be especially unable to advocate for themselves and seek the support they need. In addition, the remaining caregiver and surrounding family may have an impaired ability to advocate on the children’s behalf due to their own strong grief and trauma, giving bereaved children the term “the forgotten mourners” (144).

For the majority of bereaved people who follow a normal grief trajectory, this “open-door” policy may be all the support they need. Primary healthcare, especially general practitioners, school health services and public health centres, should be aware of the enormity and severity of losing a parent to suicide during childhood and adolescence, and should often refer this group to specialised care. Moreover, information concerning local survivor organisations should be routinely provided. Primary healthcare can also directly provide support and help to bereaved offspring suffering from mild to moderate sequelae through easily accessible means such as online guided self-help tools (146). Importantly, this active outreach and multifaceted offer should be provided immediately following the loss and must be repeatedly offered over a long time period. Information concerning parental loss should be registered in the patient’s medical record, enabling later interpretation and treatment of physical and psychiatric issues in light of this loss. Likewise, general practitioners should inquire about previous loss experiences and other psychosocial issues in new patients. We understand the practitioners limited time for each consultation, and we have heard of a general practitioner who asks her new patients to write a letter about themselves and their life and bring it to the first consultation, hence overcoming this time limitation.

Academic support, for example closer contact with the class teacher and smaller groups, should additionally be offered to all bereaved offspring given that bereaved offspring have increased risks of lower educational attainment. The present finding that more than 40% of bereaved offspring did not graduate from high school indicates that this educational level is particularly vulnerable. Since a high school diploma is the basic education needed for a majority of jobs in Norway, academic support for bereaved offspring is especially important in high school. Educational challenges add to the psychosocial sequelae experienced by bereaved offspring following the loss, and plays a role in a negative spiral which may follow the bereavement (119). Given the psychosocial and somatic problems found to be related to poor school performance (147, 148), academic support is important. It is also important to specify that bereaved children and adolescents must be met with understanding and be given some leeway at school. However, understanding and support of bereaved offspring within the school system does not mean that this group should be free of responsibility, demands and sanctions. Teachers can do the children a disservice by imposing too few demands and sanctions, and the children can be shaped into underachieving. Moreover, stability and continuity at school can provide safety and predictability for the child, as well as an opportunity to receive social support from friends (145). An individual balance between academic support and demands on one side and understanding and adaptation on the other is needed.

In addition to the broad support given to all bereaved offspring within primary healthcare and education, our findings call for an emphasised focus on children and adolescents who have been bereaved by parental suicide. Suicide bereaved offspring should be offered follow-up in specialised child and adolescent mental health services on a routine basis due to the higher risks associated with parental suicide compared to other external causes of death. Both prevention programmes following the death and interventions for people suffering from psychosocial sequelae are especially relevant for this vulnerable group. Given the increased risks, grief specific challenges and social stigma experienced by this group, suicide bereaved should be offered separate support groups and intervention programmes specifically tailored to this type of bereavement. We recommend a particularly proactive follow-up in mental health services of this bereaved group, and studies have indeed reported reductions in psychopathology following individual counselling and support groups in bereaved adolescents (149). However, little is known about the effectiveness of supportive interventions for bereaved youth, and further development of evidence-based intervention measures is needed (149-151). In addition, bereaved family members frequently express that they have received inadequate help from public health services (34, 144, 152).

Practitioners in both primary and secondary health services would benefit from updated and in-depth information concerning the long-term effects of parental bereavement in children and adolescents. This increased knowledge of high-risk groups should be incorporated into risk assessments for suicide and self-harm. Of equal importance is to screen for a history of childhood parental bereavement in patients with mental illness to more effectively identify important targets for treatment. Such screenings could lead psychologists and psychiatrists to more specific diagnoses, such as complicated grief disorder (named prolonged grief disorder in ICD-11 (153)) or bereavement-related depression (87, 123). Effective treatments, for example Complicated Grief Treatment, are available for disorders directly related to loss (16) and should be provided for bereaved offspring struggling with grief related challenges such as complicated grief disorder. Importantly, health care interventions aimed at bereaved children and adolescents cannot only focus on psychological challenges, but need to address challenges related to familial and interpersonal problems, cognitive challenges and at-risk behaviour in a holistic manner.

As a supplement to prevention and intervention within the healthcare system, peer support for suicide bereaved families is important, and local authorities should organise a contact between bereaved families and survivor organisations (144). In Norway, the voluntary organisation LEVE (the national association for bereaved by suicide) has local organisations in each county offering, for example, grief support groups, social activities, alternative methods of expressing grief through art or nature experiences and peer-to-peer support. There has been a great development in these support services in recent years. The organisations' youth group, Unge LEVE, is especially aimed at helping young suicide bereaved (154), and professionals working with youth should be aware of this group. Peer support may be very important for bereaved families, especially for youths given that they instil feelings of acceptance, social inclusion and not being alone (145).

In addition to an increased awareness of and focus on parental bereavement in health care, other professionals working with children and adolescents should be targeted for increased awareness and knowledge of bereavement related sequelae in children and adolescents. These community gatekeepers, including for example teachers, school nurses, child well-fare services, police and clergy, are well placed to identify bereaved offspring in need of support and guide them to further help. In particular, the school system can function as first responders to this vulnerable group by identifying and monitoring bereaved youth, as well as provide support through school counselling services. Furthermore, the schools' close relations to specialised care such as child and adolescent psychiatric clinics, child protective services and educational and psychological counselling services fully enables teachers and school nurses to refer bereaved youth for further help. Postvention measures can also originate from other actors in society, and a national telephone helpline for survivors has, for example, been established in the UK (155). Several organisations in Norway offer general psychosocial support through telephone helplines or online chat forums, and such services may especially appeal to children and youth.

Lastly, knowledge held by policy makers about the increased risks associated with parental bereavement in general and suicide bereavement in particular can improve procedures for follow-up after bereavement. A statement by Kari Dyregrov, an influential bereavement researcher in Norway, still holds true today: "Although survivors' wishes for ideal support coincide with recommendations by experts in the field, local authorities lack the organization to fulfil such expectations" (144). The Norwegian government, through the Norwegian Health Directorate, published a new action plan to prevent suicide in September 2020 (152). The plan admits to insufficient, incidental and varying bereavement support in Norway, and has dedicated a short chapter to the topic. The plan highlights the importance of immediate and long-term follow up of bereaved individuals, and the Norwegian government will assess the need for standardised follow-up for all people bereaved by suicide. A recent UK report on suicide bereaved families and friends also highlighted the need for a national set of minimum standards in postvention services (34). We are initially positive to this standardisation which secures postvention for all bereaved individuals but highlight that standardised follow-up must be combined with individual adaptation. Given the vast variety in suicide survivors' reactions following the loss of a loved one, standardised postvention must be balanced by differentiated and individually adapted follow-up.

To conclude, the extensive, complex and long-lasting sequelae of parental bereavement in general, and parental suicide in particular, call for a multi-faceted and comprehensive follow-up approach of this vulnerable group. Prevention as postvention needs to address all aspects of bereavement support, and bereavement-related challenges must be understood and treated in combination. Community outreach must be early and long-lasting (144, 152). Hopefully, this proactive approach can decrease the inter-generational transfer of mental disorder and early mortality.

7.2. Future research

In addition to the clinical and preventive implications presented above, some important implications for future research can be drawn from the present study results. As previously mentioned, we have chosen to investigate the first DSH hospitalisation (paper II) and the first contact with specialist mental health services (paper III). To our knowledge, no previous study has investigated the association between parental bereavement and other aspects of these challenges, such as the frequency of these types of treatment, the length of follow-up in specialist health care or the time to remission, and future studies should aim to study these aspects. Likewise, the magnitude or severity of such events, based on, for example, the extent of medical care due to self-harm, should also be studied to gain further insights into the impact of parental death on offspring’s psychosocial sequelae. A deeper understanding of the association between bereavement and psychosocial outcomes can also be gained by studying such associations across three generations, not just the two-generational perspective adhered to in current studies. We would be very interested to see whether the inter-generational transfer of psychosocial sequelae endures over multiple generations. Long-term investigations of this kind, however, require national registers with a very long history of registration since information stretching across a long time period is needed.

Our preliminary exploration of the data indicated that domestic homicide-suicide, where one parent, most often the father, kills the other parent before taking their own life, is associated with a greatly increased risk of offspring suicide. Since this is a very small group of subjects, we did not investigate them as a separate group in this thesis. Offspring bereaved by homicide-suicide have experienced an extreme form of trauma. They have a likelihood of being injured or witnessing the event, and the homicidal intent of the perpetrator has often lead to a history of domestic violence and aggression (156). Very few studies have investigated the later effects in offspring who have experienced domestic homicide-suicide (156), and future studies, possibly in a Nordic collaborative effort pooling register data from several countries, could isolate and specifically investigate this group separately.

Studies examining the effects of parental bereavement in offspring have, to this date, mostly pinpointed the negative outcomes following loss (81). A deeper understanding of the impact of bereavement would hence be gained by more direct investigation of the positive impacts following bereavement, so-called posttraumatic growth, and register-based research should aim to identify the group of bereaved offspring who experience positive transformations following parental loss. By identifying this group, we can gain better insight into the context surrounding the bereavement and offspring. A further investigation of risk and protective factors for psychosocial sequelae and posttraumatic growth would be beneficial and can aid health-care personnel to better identify the offspring in need of follow-up. Additionally, the identification of risk and protective factors can inform postvention efforts by indicating important aspects which protect against bereavement related sequelae. A previous study by the research fellow and supervisors indicated risk and protective factors for suicide in bereaved offspring (80), and future studies should examine if the same factors are influential in developing other psychosocial sequelae following bereavement. Qualitative studies can also yield great insight into bereaved offspring's own experience of loss and mental health, how they cope with the loss, and why some bereaved offspring experience later psychosocial sequela while others don't.

Furthermore, future research should study the causal mechanisms between bereavement and psychosocial sequelae given that the present study can only suggest some causal pathways. To study causal mechanisms, additional data are needed. In Norway, we can, for example, gain access to genetic information from the large Norwegian Mother, Father and Child Cohort Study (MoBa) (157), and information concerning aptitude tests from the Norwegian Armed Forces' Health register (158). Large twin cohorts can also be used to investigate causal pathways.

Lastly, a deeper understanding of the co-occurrence, interaction and mediating mechanisms between different psychosocial sequelae is needed. Paper IV is the first study to investigate several adverse outcomes in combination, but the study is limited in scope and insight. Further information concerning whether the same bereaved offspring struggle with multiple problems or if different people struggle with different problems is important. If psychosocial sequelae co-occur, is there a particular order or sequence of development that is often followed, and do some sequelae function as mediators for other problems? We are particularly interested in whether offspring suicide is preceded by other sequelae, and if these problems mediate the association between bereavement and suicide.

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ORIGINAL PAPER

Educational attainment in offspring bereaved by sudden parental death from external causes: a national cohort study from birth and throughout adulthood

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Abstract

Purpose Previous research has linked loss of a parent during childhood to reduced educational aspirations, school performance, and educational attainment later in life. The potential effect of maternal and paternal bereavement on attainment at all educational levels is, however, unknown. The present study aimed to investigate the potential influence of parental death by external causes on completion of compulsory education, high school, vocational education, and University or College education.

Methods The study was based on data from three national longitudinal registers in Norway. The study population comprised 373,104 individuals born between January 1st 1970 and December 31st 1994. Information concerning deceased parents' cause and date of death and offspring's education and sociodemographic data were retrieved. Data were analysed with Cox regression.

Results Children who had experienced parental death by external causes had a significantly reduced hazard ratio (HR) of completing all educational levels compared to children who did not have such experiences. The largest effects were evident for completion of high school (HR 0.68, 95% CI 0.65–0.71) and University or College education (HR 0.75, 95% CI 0.70–0.80). No differences were evident for different causes of death, genders of deceased or ages at bereavement, and generally no significant interactions between gender of the bereaved offspring and predictor variables were evident for completion of all educational levels.

Conclusion Parental death by external causes has vast and long-lasting impacts on offspring's educational attainment at all levels. Health care interventions aimed at supporting bereaved children and adolescents should focus on challenges related to educational progress.

Keywords Parental bereavement · Educational attainment · Cohort study · Population registers

Introduction

The sudden death of a parent from an accident, suicide or homicide constitutes one of the most traumatic and significant life events a child or adolescent can experience [1]. Related to such a traumatic loss, offspring have an increased risk of severe psychosocial problems, including psychiatric disorders, marital dissolution, violent crime and suicide [2–4]. Parental loss has also been found to negatively affect offspring's school performance and educational attainment: Reduced likelihood of enrolment and graduation as well as lower mean grades [5–7] is accompanied by reduced expectations and aspirations for future education and career [8] in bereaved children compared to children who have not experienced the loss of a parent. Furthermore, poor school performance is again associated with psychosocial and somatic problems [9–11] which further impairs school performance, effectively creating a negative spiral or developmental cascade [12]. Higher education, on the other hand, is associated with higher life satisfaction and happiness [13].

Several previous studies investigating educational attainment in parentally bereaved children and adolescents have been restricted to paternal bereavement [5, 7, 14, 15], or

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have used data from the US [8, 16–18] where all higher education is based on tuition fees paid by students and/or their families. This complicates generalization to most European countries where students and families to a lesser extent have to pay for education. A recent register-based cohort study by Berg and colleagues [6] investigated both maternal and paternal bereavement in the Swedish population and found that parental death was associated with a lower probability of school graduation in offspring aged 16 years. What the subsequent educational trajectory will be after bereaved offspring have finished the final compulsory school year at age 16 is still unclear.

The present register-based cohort study aims to expand current knowledge by investigating the influence of parental death by external causes during childhood and adolescence on completion of compulsory education, high school, vocational education, and University or College education. We, furthermore, aim to study the effects of specific causes of parental death, genders of the deceased parent and ages at bereavement on educational attainment into adulthood. External causes of death refer to deaths where the cause is external to the body, such as accidents, suicides and homicides, and is a classification of mortality in the ICD coding system. Given the aims of the study, we did not include parental death due to natural causes.

Methods

Data sources

We retrieved individual data from three Norwegian longitudinal registers and merged them by means of the personal identification number. The first register is the Central Population Register, which has been computerized since 1964 and contains demographic data and a personal identification number for all individuals residing in Norway. The register also contains a link to parents, which was utilized in order to identify the mother and father of the cohort members. The second register is the Cause of Death Register, which has been computerized since 1969 and contains the cause and date of all deaths in Norway coded according to ICD-8 (International Classification of Deceases, Eight Revision) from 1969 to 1985, ICD-9 from 1986 to 1995 and ICD-10 from 1996 to 2012 [19]. Last, the third register is Statistics Norway’s Events Database (the so-called FD-Trygd database) which contains demographic and socioeconomic data, such as information concerning education and ethnicity. Data on education in this register is based on the National Education Database [20], and encompasses education statistics at an individual level dating back to 1970 [21].

The study was approved by the Regional Ethical Committee for Medical and Health Research (REK sør-øst) and owners of the relevant registers. Informed consent from participants was deemed unnecessary and impossible by the ethical committee because this was a population-based study with de-identified register data.

Study design and population

The present study is a retrospective cohort study which aims to investigate whether exposure is associated with outcome incidence through continuous observation over time [22]. The use of a cohort study and cox regression analyses enabled the investigation of educational attainment across the subject’s age span in order to analyse both the likelihood of attainment and its age dispersion. The study population consisted of a 25% random sample of all Norwegian residents born between January 1st 1970 and December 31st 1994 who had a link to both their father and mother in the Central Population register. The cohort comprised 373,104 individuals.

Variables of interest

Educational attainment

The present study investigated four outcomes related to educational attainment at all the different educational levels in the Norwegian school system: completion of compulsory education after age 15, and high school, vocational education and University or College education after age 18. The educational information was retrieved from Statistics Norway’s Events Database [23].

First, completion of *compulsory education after age 15* (lower secondary education) was investigated. The compulsory education in Norway consists of 7 years at primary school and 3 years at secondary school, and all children are automatically enrolled in this education. The education is normally completed the year children turn 16 years.

We furthermore investigated completion of *high school after age 18* (post-secondary non-tertiary education). This education can either focus on preparation for further academic studies, or on becoming a craftsman within a particular craft, industry or service. The former education often takes 3 years, while the latter often takes 4 years or more. Completion of compulsory education is required for attending high school, and every youth in Norway who have completed compulsory education have the right to attend high school.

Completion of *vocational education after age 18* (short-cycle tertiary education) was also investigated. Vocational education is a further education within a particular craft, and it builds on the craft studied at high school for the individuals who chose this educational direction. The education can take between 6 months and 2 years, and completion of high school is required for attending vocational education.

Last, we investigated completion of *University or College education after age 18*. This education includes one-year programs, bachelor's degree programs, and master's degree programs, which all require completion of a high school education. If an individual had completed several University or College degrees, the date of the first degree was included in the analyses. Doctoral degrees were not included in the analyses because PhD students in Norway are employed and receive a standard salary and social welfare benefits on the same level as all other Norwegian employees.

Parental bereavement

The explanatory variable of interest in the study is exposure to parental death by external causes during childhood, referred to as parental DBEC (codes E800-E999 in ICD-8 and ICD-9 and V01-Y89 in ICD-10). When examining completion of compulsory education, the effect of parental DBEC before age 15 was investigated, while the effect of parental DBEC before age 18 was investigated when examining completion of high school, vocational education, and University or College education. Data concerning potential maternal and/or paternal DBEC were retrieved from the Cause of Death Register, and subjects were classified into two categories of *bereavement status* as (a) no exposure to parental DBEC or (b) exposure to parental DBEC. Specific *causes of parental death* were further classified as (a) suicide, (b) transport accident (including land, water and air transport methods), and (c) other external causes (such as other accidents, homicide and injury with unknown intent). *Gender of deceased parent* was classified as (a) father, (b) mother, and (c) both parents. Subjects were classified according to their *age at bereavement* into (a) ≤ 4 years, (b) 5–9 years, (c) 10–14 years, and (d) 15–18 years. If both parents died, cause of death and age at bereavement were classified according to the parent who died first since this marks the beginning of children's bereavement-related exposure.

Covariates

Several covariates were controlled for in the multivariate analyses. Ethnicity was classified as (a) born in Norway with two Norwegian born parents, (b) immigrant, (c) born in Norway with immigrant parents or one parent born abroad, and (d) born abroad with one or two Norwegian born parents. Additionally, analyses were adjusted for cohort members' year of birth due to the change in the level of educational attainment over time, and gender due to gender differences in educational attainment.

Statistical analyses

The study cohort was followed from birth to date of educational attainment at the different educational levels, or date of death, emigration from Norway or at most December 31st 2012, whichever came first. Differences in hazard ratios (HRs) with concomitant 95% confidence intervals were estimated using Cox regression analyses. The potential effects of bereavement variables on completion of the different educational levels were estimated in the crude models, while the adjusted models included all covariates, i.e. ethnicity, year of birth and gender. Since completion of compulsory education is required for attending high school, high school completion was also adjusted for completion of compulsory education in the multivariate analyses. Similarly, since graduating from high school is required for attending vocational education and University or College education, completion of these educational levels was adjusted for completion of high school in the multivariate analyses. Sensitivity analyses restricting the sample to individuals who have completed the required educational level, rather than controlling for previous completion, were also performed. In these analyses, the start of follow-up was set to the date of graduating from the required education. Interactions between variables of study with gender were assessed with the log likelihood ratio test based on results from the multivariate analyses. All analyses were conducted in Stata, version 15 [24].

Results

In the current cohort of 373,104 individuals, 51.4% (191,840) were males, and 48.6% (181,264) were females. Before age 18, 3844 people were censored due to death and 9837 people were censored due to emigration. Overall, 3692 individuals (1918 males and 1774 females) had experienced parental death by external causes before age 18. Distribution of the study variable categories in the cohort by completion of the different educational levels is presented in Table 1. For compulsory education, 95.1% of people who had not experienced parental death by external causes completed the education, while 95.8% of people who had been exposed to parental death by external causes completed this education. The corresponding percentages were 67.2% and 56.3% for completing high school, 3.9% and 3.1% for completing vocational education, and 33.4% and 24.9% for completing University or College education. The mean age for completion of compulsory education was 16.0 years for exposed and non-exposed offspring, while the mean age for completion of high school was 19.9 years for offspring who had not experienced parental DBEC and 20.4 years for offspring who had experienced such loss. The corresponding mean ages were 23.4 and

Table 1 Distribution (%) of the study variable categories in the cohort, by completion of the different educational levels

Variable	Total ($N=373{,}104$)		Completed compulsory education ($N=354{,}902$)[a]	Completed high school ($N=250{,}389$)[b]	Completed vocational education ($N=14{,}349$)[b]	Completed University or college education ($N=124{,}274$)[b]
	Bereaved age 15	Bereaved age 18				
Bereavement status						
No exposure to parental DBEC	370,123	369,412	352,045 (95.1)	248,309 (67.2)	14,235 (3.9)	123,355 (33.4)
Exposure to parental DBEC	2981	3692	2857 (95.8)	2080 (56.3)	114 (3.1)	919 (24.9)
Cause of death						
No exposure to parental DBEC	370,123	369,412	352,045 (95.1)	248,309 (67.2)	14,235 (3.9)	123,355 (33.4)
Suicide	1160	1452	1127 (97.2)	846 (58.3)	41 (2.8)	346 (23.8)
Transport accident	965	1126	912 (94.5)	649 (57.6)	37 (3.3)	313 (27.8)
Other external causes	856	1114	818 (95.6)	585 (52.5)	36 (3.2)	260 (23.3)
Gender of deceased						
No exposure to parental DBEC	370,123	369,412	352,045 (95.1)	248,309 (67.2)	14,235 (3.9)	123,355 (33.4)
Father	2422	2949	2347 (96.9)	1690 (57.3)	97 (3.3)	747 (25.3)
Mother	498	672	469 (94.2)	363 (54.0)	17 (2.5)	157 (23.4)
Both parents	61	71	41 (67.2)	27 (38.0)	0 (0)	15 (21.1)
Age at bereavement						
No exposure to parental DBEC	370,123	369,412	352,045 (95.1)	248,309 (67.2)	14,235 (3.9)	123,355 (33.4)
<4 years	904	904	851 (94.1)	495 (54.8)	21 (2.3)	222 (24.6)
5–9 years	974	974	928 (95.3)	533 (54.7)	38 (3.9)	232 (23.8)
10–14 years	1103	1103	1078 (97.7)	649 (58.8)	28 (2.5)	282 (25.6)
15–18 years		711		403 (56.7)	27 (3.8)	183 (25.7)

[a] The percentages of completion was based on bereavement before age 15

[b] The percentages of completion was based on bereavement before age 18

24.7 for completion of vocational education, and 23.5 and 24.1 for completion of University or College education.

Table 2 presents the crude and adjusted HRs with 95% confidence intervals for completion of the different educational levels associated with the variables under study. In the multivariate analyses adjusted for ethnicity, gender, year of birth and the prerequisite educational level, individuals who had experienced parental death by external causes had significantly lower HRs of completing all educational levels compared to individuals who had not experienced parental DBEC: Compulsory education (HR 0.94, 95% CI 0.91–0.98), high school (HR 0.68, 95% CI 0.65–0.71), vocational education (HR 0.78, 95% CI 0.65–0.94), and University or College education (HR 0.75, 95% CI 0.70–0.80). The percentage of completion of high school and University or College education by offspring's age for the different bereavement groups is visualized in Figs. 1 and 2, respectively, again depicting the difference in completion between exposed and non-exposed individuals. As is evident from the figures, the difference between exposed and non-exposed offspring is sustained into adulthood.

Sensitivity analyses restricting the sample to individuals who have completed compulsory education showed that individuals exposed to parental DBEC still had significantly lower HRs of completing high school (HR 0.69, 95% CI 0.66–0.72). Likewise, exposed individuals still had significantly lower HRs of completing a University or College education when the sample was restricted to high school graduates (HR 0.79, 95% CI 0.74–0.85). For vocational education, however, there was no longer a difference between the exposed and unexposed groups when restricting the sample to individuals who had completed high school (HR 0.87, 95% CI 0.69–1.08).

Specific causes of parental death

Parental bereavement from transport accidents was associated with a significantly reduced HR of completing compulsory education in the multivariate analysis, while

Table 2 Crude and adjusted HRs with 95% confidence intervals for completion of the different educational levels associated with the variables under study

Variable	Crude HR				Adjusted HR			
	Compulsory education	High school	Vocational education	University or college education	Compulsory education[a]	High school[b]	Vocational education[c]	University or college education[c]
Bereavement status								
Exposure to parental DBEC	0.98 (0.95–1.02)	0.69 (0.66–0.72)‡	0.77 (0.64–0.93)†	0.66 (0.62–0.71)‡	0.94 (0.91–0.98)†	0.68 (0.65–0.71)‡	0.78 (0.65–0.94)†	0.75 (0.70–0.80)‡
Cause of death								
Suicide	1.00 (0.94–1.05)	0.72 (0.67–0.77)‡	0.72 (0.53–0.98)*	0.64 (0.58–0.71)‡	0.95 (0.90–1.01)	0.71 (0.66–0.76)‡	0.72 (0.53–0.98)*	0.70 (0.63–0.78)‡
Transport accident	0.96 (0.90–1.02)	0.70 (0.65–0.76)‡	0.78 (0.56–1.08)	0.71 (0.64–0.79)‡	0.92 (0.86–0.98)*	0.69 (0.64–0.75)‡	0.79 (0.57–1.09)	0.81 (0.72–0.90)‡
Other external causes	1.00 (0.93–1.07)	0.64 (0.59–0.70)‡	0.84 (0.61–1.17)	0.64 (0.57–0.73)‡	0.96 (0.90–1.03)	0.63 (0.58–0.69)‡	0.86 (0.62–1.19)	0.75 (0.66–0.85)‡
Gender of deceased								
Father	0.97 (0.94–1.01)	0.69 (0.66–0.73)‡	0.81 (0.66–0.99)*	0.66 (0.61–0.71)‡	0.93 (0.90–0.97)‡	0.68 (0.65–0.72)‡	0.82 (0.67–1.00)*	0.75 (0.69–0.80)‡
Mother	1.05 (0.96–1.15)	0.69 (0.62–0.76)‡	0.67 (0.42–1.08)	0.67 (0.58–0.79)‡	1.02 (0.93–1.11)	0.68 (0.61–0.75)‡	0.67 (0.42–1.08)	0.76 (0.65–0.89)‡
Both parents	0.81 (0.60–1.10)	0.62 (0.42–0.90)*	-	0.75 (0.45–1.24)	0.78 (0.57–1.05)	0.62 (0.43–0.91)*	–	0.89 (0.54–1.47)
Age at bereavement								
≤4 years	1.00 (0.93–1.07)	0.68 (0.62–0.74)‡	0.59 (0.38–0.90)*	0.67 (0.59–0.77)‡	0.94 (0.88–1.01)	0.67 (0.61–0.73)‡	0.60 (0.39–0.91)*	0.78 (0.68–0.89)‡
5–9 years	0.92 (0.86–0.98)†	0.65 (0.60–0.71)‡	0.97 (0.71–1.34)	0.61 (0.54–0.70)‡	0.89 (0.83–0.95)‡	0.65 (0.59–0.70)‡	0.98 (0.71–1.35)	0.72 (0.63–0.82)‡
10–14 years	1.04 (0.98–1.10)	0.73 (0.68–0.79)‡	0.63 (0.44–0.92)*	0.68 (0.61–0.77)‡	1.00 (0.94–1.06)	0.72 (0.66–0.77)‡	0.64 (0.44–0.93)*	0.74 (0.66–0.83)‡
15–18 years		0.71 (0.64–0.78)‡	0.95 (0.65–1.38)	0.70 (0.60–0.81)‡		0.69 (0.63–0.76)‡	0.97 (0.66–1.41)	0.78 (0.67–0.90)‡

No exposure to parental DBEC as reference

*$p < .05$, †$p < .01$, ‡$p < .001$

[a] The HRs derived from these models were adjusted for ethnicity, year of birth, and gender

[b] The HRs derived from these models were adjusted for ethnicity, year of birth, gender and completion of compulsory education

[c] The HRs derived from these models were adjusted for ethnicity, year of birth, gender, and completion of high school

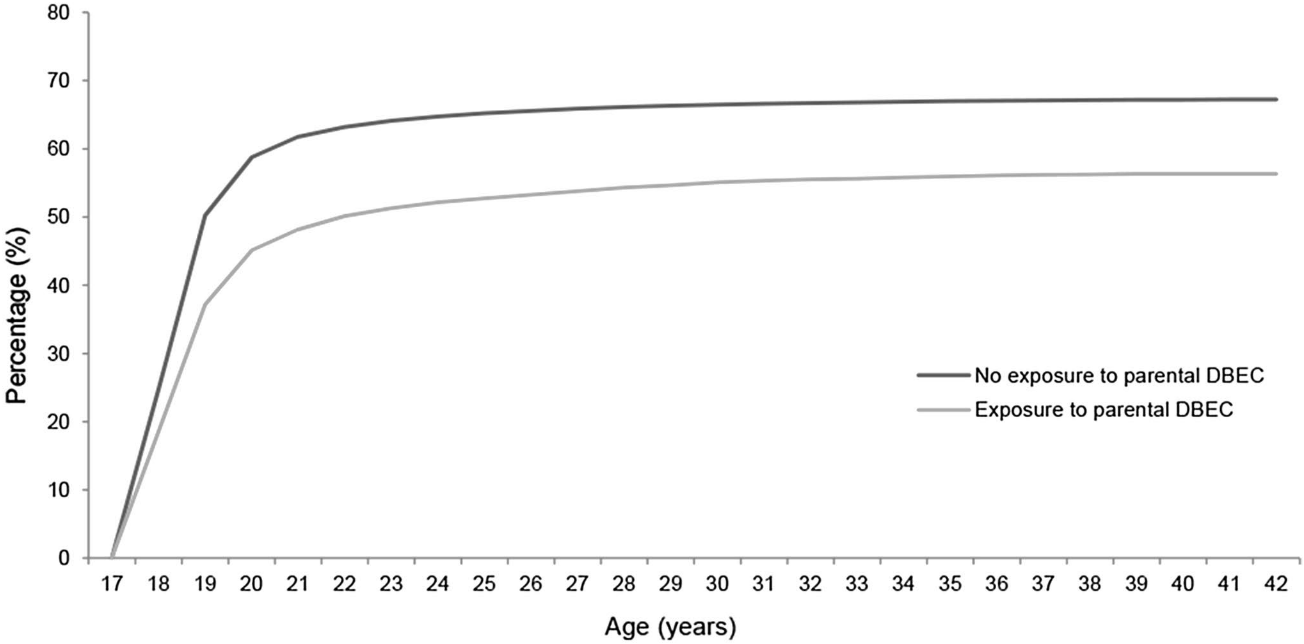

Fig. 1 Percentage of completion of high school by offspring's age for the different bereavement groups

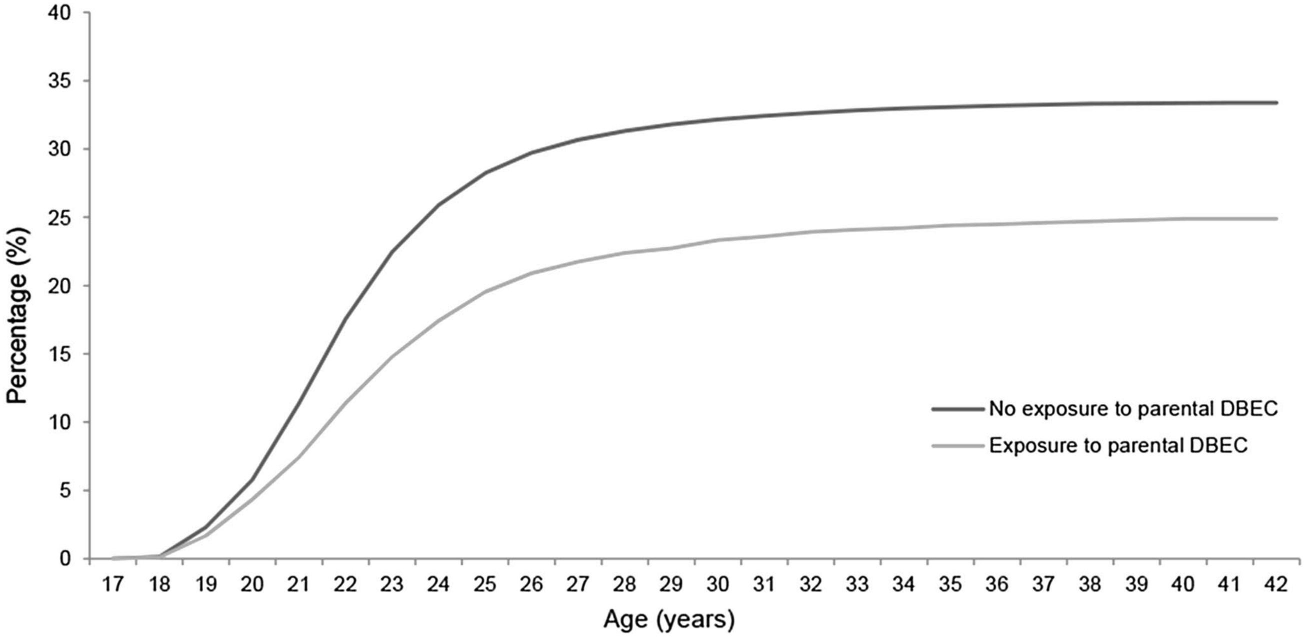

Fig. 2 Percentage of completion of University or College education by offspring's age for the different bereavement groups

parental suicide and other external causes of death did not lead to a significantly decreased HR of completion. For completion of high school, all external causes of death were associated with a significantly reduced HR of completing. Parental suicide was the only specific cause of death associated with a significantly reduced HR of completing vocational education, while all causes of death were associated with significantly reduced HRs of completing University or College education. The category of other external causes of death consisted largely of accidents (84.6%), such as poisonings (23.9%) and falls (15.4%), and homicide (11.1%). In general, no large differences depending on cause of death were evident for any educational level.

Gender of deceased parent

No large differences depending on the gender of the deceased parent were evident for any educational level. Paternal bereavement was associated with a significantly reduced HR of completing all levels of education, while maternal bereavement was associated with significantly reduced HRs of completing high school and University or College education. Bereavement of both parents was associated with significantly reduced HRs of completing high school.

Age at bereavement

For compulsory education, bereavement between the ages of 5 and 10 years was associated with a significantly reduced HR of completion, while all ages of bereavement were associated with significantly reduced HRs of completing high school. Bereavement before age 5 years and between 10 and 15 years was associated with reduced HRs of completing vocational education, and all ages of bereavement were associated with significantly reduced HRs of completing University or College education. In general, no large differences were evident depending on offspring's age at bereavement for any educational level.

Gender of bereaved offspring

No significant interactions between gender of the bereaved offspring and bereavement status were evident for all educational levels, indicating that parental DBEC reduced the HR of completing all educational levels equally for daughters and sons (data not shown). Log likelihood ratio tests for interactions between gender of the offspring and cause of death, gender of deceased and age at bereavement for all educational levels only resulted in one significant interaction between gender and cause of death for completion of compulsory education. Evidently, parental suicide and transport accidents reduced the HRs of completing compulsory education slightly more in sons than in daughters (data not shown).

Discussion

To our knowledge, this is the first study to investigate the potential effect of maternal and paternal bereavement by external causes on completion of all educational levels. The present study shows that children and adolescents who have experienced parental death by external causes have a significantly lower probability of completing all educational levels, from compulsory education to University or College education, compared to individuals who have not experienced parental DBEC. The largest effects were evident for completion of high school and University or College education. Furthermore, no large differences were evident depending on cause of death, gender of deceased parent, age at bereavement, and gender of bereaved offspring.

Association between bereavement status and educational attainment

The present study adds to previous literature stating that individuals who have experienced parental death by external causes have an increased risk of suffering from a range of unfortunate psychosocial challenges such as psychiatric disorders, marital dissolution, suicide, and criminal activity [2–4, 25]. In addition to a reduced likelihood of completing compulsory education, similar to what has been previously reported by Berg and colleagues [6], bereaved children have a significantly reduced probability of attaining all educational levels. A previous Norwegian register study investigating paternal death by all causes, however, only reported a significant difference between bereaved and non-bereaved children for completion of compulsory education and high school, but not completion of University or College education [7]. As opposed to the present study, this study did not include maternal bereavement and investigated all causes of death.

Potential reasons for the reduced probability of educational attainment in bereaved offspring may be found in a combination of pre- and post-bereavement factors. Relevant pre-bereavement factors preceding the loss probably include lower household income and parental education [26], parental psychiatric illness [8, 27], and an associated turbulent family environment. Post-bereavement factors probably consist of offspring's psychiatric disorders caused or aggravated by the loss [28, 29], lower family cohesion and social support [8], and challenges specifically related to education, such as impaired concentration [30], lower sense of mastery and self-esteem [31], and lower school attendance [32]. This study is unfortunately unable to investigate the influence of these pre- and post-bereavement factors on offspring's educational attainment due to data limitations.

Cause of death

Previous studies have investigated potential differences in school performance between children bereaved by parental death from external causes and parental death from natural causes [5, 6], but no study to date has differentiated between various external causes of death. Clearly, the higher suicide risk in offspring who have been bereaved by parental suicide compared to parental death by other external causes [2, 25, 33] does not transfer to a difference in educational attainment given that the present study failed to identify differences across all educational levels when comparing different external causes of death. External causes of death have several similarities in that they happen suddenly, leaving the bereaved with no or very little chance to prepare themselves or say goodbye, and are accompanied by shock, drama, and a potentially traumatic impact. These types of death may induce a sense of loss of control in the bereaved, are often associated with strong sensory impressions or fantasies, and may lead to rumination and counterfactual thoughts about the death. Additionally, many problems that typically trouble suicide bereaved families have in fact also been found to influence families where a parent has died from other causes, such as low household income and education, high family discord, and psychiatric impairment in the adult caregiver [8, 26, 34]. Likewise, even though suicide is often preceded by mental illness, accidental deaths, especially poisonings and falls, are also often associated with pre-existent mental disorders [27, 35].

Gender of deceased parent and bereaved offspring

The present study did not find any significant difference in educational attainment at any level by gender of the deceased parent, and minimal differences by gender of the bereaved offspring. These findings are in accordance with previous studies reporting similar educational sequela following maternal and paternal bereavement [6], and loss in daughters and sons [5, 6, 18]. The lack of gender differences is also in accordance with our recent study from Norway reporting no differences in bereaved offspring's suicide risk depending on gender of the deceased parent and gender of the bereaved offspring [25].

The similar impact of parental bereavement regardless of gender of the deceased parent and bereaved offspring may reflect a high level of gender equality in Norway today. The role of primary caregiver, displays of affection and attachment, and other factors that have traditionally differed between mothers and fathers may now be more individually based and hence differ between different families [36, 37]. As a consequence, both parents may function as primary attachment figures, or the remaining parent may be willing and able to take on the role as primary attachment figure following the loss of the co-parent. Moreover, economic and occupational gender equality [38] may enable the remaining parent to more effectively uphold household resources in the absence of the co-parent. Gender equality may also explain the lack of significant differences in the mourning experiences of bereaved daughters and sons due to more equal ability to express their feelings and receive social support.

Age at bereavement

Evidently, losing a parent throughout childhood and adolescence is detrimental to educational attainment. The lack of large differences depending on children's age at bereavement corresponds well with previous studies reporting similar effects for different ages at bereavement for school performance and educational attainment [6, 7]. In a similar vein, a recent large-scale register study in Norway reported an especially increased suicide risk in offspring bereaved by parental death by external causes during childhood and adolescence [25], again indicating the importance of these age periods as developmentally critical periods [39]. Even though we do not see large effects depending on children's age at bereavement, different developmental processes may be responsible for determining offspring's educational attainment at varying ages of bereavement. Post-bereavement factors may account for educational challenges following bereavement in early childhood, such as family discord, offspring's psychiatric disorders and developmental difficulties associated with growing up in a one-parent household [28, 29, 34, 40, 41]. On the other hand, pre-bereavement factors may be more influential when bereavement occurs in later adolescence, including parental psychiatric disorders and poor socioeconomic status [8, 26]. Challenges directly related to education, such as impaired concentration, lower sense of mastery and self-esteem, and lower school attendance and follow-up at home are probably influential following bereavement at all developmental periods [30–32].

Strengths and limitations

The major strengths of the present study include the long follow-up time of offspring from birth and throughout adulthood and the investigation of all educational levels from compulsory education until University or College education. Moreover, the utilization of national longitudinal registers enables a large sample size, effectively increasing statistical power when investigating a rare event such as parental death by external causes. Data in Norwegian registers cover the entire population and are collected systematically and uniformly. The data quality has been found to be high [42, 43] and the registers are continuously monitored and corrected [44, 45]. Register studies do not suffer from problems related to sampling and attrition, and eliminate biases such as recall bias. Last, cohort studies such as the present study are able to infer causal relationships to a much larger extent than case–control or cross-sectional studies [46].

Results from the present study are naturally subject to limitations, chief among them being the lack of information concerning family socioeconomic status and parental psychiatric disorders, enabling identification of the potential effects of these underlying factors. Since a requirement for inclusion in the study was a registered link to both mother and father in the Central Population Register, our sample probably consisted of fewer individuals with an immigration background compared to the frequency in the population as a whole. Last, to ensure that bereavement occurred before the outcome under investigation, the cut-off age at bereavement was set to 15 years for compulsory education and 18 years for later educations. This will to a degree underestimate the number of people who have experienced parental DBEC, and some offspring exposed before finishing the education in question will be classified as un-exposed. This limitation will, however, lead to a type II error and hence reduce the chance of significant findings.

Conclusions and implications

In conclusion, individuals who have experienced parental death by external causes during childhood and adolescence have a significantly lower probability of completing all educational levels compared to individuals who have not experienced parental DBEC, regardless of cause of death, gender of deceased parent, age at bereavement, and gender of bereaved offspring. Parental death by external causes evidently has vast and long-lasting impacts on offspring's educational attainment, and the educational level may be hard to improve in adulthood.

The findings from the present study suggest that schools at all educational levels should offer more educational support services to students who have experienced bereavement in order to prevent educational decline. Educational difficulties add to the psychosocial problems already found to be associated with parental bereavement, and the somatic, psychological, social, and developmental challenges experienced by bereaved offspring may manifest as a negative spiral or developmental cascade. As a result, health care interventions aimed at supporting bereaved children and adolescents should not only focus on psychological challenges, but also challenges related to familial and interpersonal problems and educational progress, especially due to the detrimental impact of low socioeconomic status on health risk behaviours, drug abuse, mental health problems, somatic diseases, and even suicide [9–11, 47]. The comprehensive and interlinked nature of the extensive psychosocial sequela following parental death from external causes stress the importance of understanding and treating bereavement-related challenges in association.

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Author contributions All authors contributed to the study conception, and PQ & LVB outlined the study design. PQ prepared the data material, and LVB performed the analyses. All authors interpreted the data results, and the article was written by LVB. All authors revised the article and approved the finale manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approvals in human and animal studies The manuscript does not contain clinical studies or patient data.

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ORIGINAL CONTRIBUTION

Parental death by external causes and risk of hospital-treated deliberate self-harm in bereaved offspring

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Abstract

Previous studies have reported an increased risk of hospital-treated deliberate self-harm (DSH) in offspring who have lost a parent, but inconclusive findings regarding differences between loss from suicide and accidents. The present study aimed to investigate the association between parental death by external causes before age 18 and hospital-treated DSH, and potential differences between different accidents and suicide. This nested-case–control study was based on data from longitudinal Norwegian registers. Subjects comprised 12,526 people born between 1970 and 2003 who received acute somatic treatment because of DSH at hospitals and associated services between 2008 and 2013 (cases), and 222,362 controls matched for gender and date of birth with no recorded DSH treatment. Information concerning deceased parent's death and offspring's DSH treatment and socioeconomic data was merged. Data were analysed with conditional logistic regression. Results indicated that offspring who had lost a parent to suicide (OR 2.32, 95% CI 1.92–2.80) and death by accidents such as falls, poisoning, and drowning (OR 1.79, 95% CI 1.38–2.33) had a significantly increased risk of hospital-treated DSH compared to offspring who had not experienced such loss. Parental bereavement from transport accidents and other external causes were not associated with significantly increased risks. No differences were evident for different genders of deceased, ages at bereavement, or genders of bereaved. The improved identification of bereaved offspring at particular risk of hospital-treated DSH should be utilized to implement effective prevention and treatment programs in specialist healthcare aimed at the individuals at highest risk.

Keywords Deliberate self-harm · Parental bereavement · Suicide · Register study · Childhood · Adolescence

Introduction

Approximately 30 million people experience the death of a close family member or friend to suicide, accidents, or homicide worldwide every year [1, 2]. Naturally, the children of the deceased are highly impacted by this loss given the broken attachment to a primary care giver [3] and the direct effect of loss on daily life [4]. The sudden death of a parent is consequently associated with an increased risk of long-term psychosocial sequela [5–7], and several Scandinavian population-based register studies have reported an increased risk of hospital treatment for deliberate self-harm (DSH) in bereaved offspring [5, 8–17]. When directly comparing offspring bereaved by suicide and accidents, researchers have reported an earlier onset of DSH hospitalization in offspring following parental suicide compared to those parentally bereaved by accidental death [9]. This higher risk of DSH hospitalization seems, however, to be linked to maternal, but not paternal suicide [8]. Studies comparing bereaved offspring to offspring of alive parents, however, fail to report a significant difference in DSH hospitalization between offspring bereaved by suicide and accidents [5, 17]. Since results are inconclusive regarding whether offspring bereaved by suicide are at a higher risk of hospital-treated DSH than those bereaved through accidents, further research is warranted. In particular, different accidental deaths may be associated with different risks of hospital-treated DSH in offspring due to the heterogeneity of accidents, potentially accounting for the inconsistencies in the previous studies. Further knowledge concerning the groups of bereaved offspring at highest risk may be helpful in tailoring postvention efforts and making them more targeted.

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The present register study aims to investigate the association between parental death by external causes during childhood and adolescence and risk of hospital-treated DSH into adulthood. External causes of death refer to deaths where the cause is external to the body, such as accidents, suicides, and homicides, and is a classification in the ICD coding system. We aim to address the following research questions:

- To what extent are different external causes of death associated with an increased risk of hospital-treated DSH, and how do the risks associated with different external causes of death vary depending on other bereavement-related aspects?
- How does offspring's risk of hospital-treated DSH vary depending on the gender of the deceased parent, the gender of the bereaved offspring, offspring's age at bereavement, and the time since bereavement?

Methods

Data sources

The present nested-case–control study retrieved individual-level data from four longitudinal Norwegian registers and merged them by utilizing the personal identification number. The Central Population Register provided data on gender and residence address and contains a link to parent's personal identification number, enabling identification of biological or adoptive parents. Statistics Norway's Events Database provided information on ethnicity, marital status, education, income, and sick leave pension. Data concerning parental death were retrieved from the Cause of Death Register which contains the cause and date of all deaths in Norway coded according to ICD-8 (International Classification of Deceases, Eight Revision) from 1969 to 1985, ICD-9 from 1986 to 1995, and ICD-10 from 1996 to 2012 [18]. Finally, the Norwegian Patient Register provided data on hospital-treated DSH and the psychiatric diagnosis at the time of treatment. This register contains information on all contacts related to all types of treatments in specialist health care, covering all public institutions and private institutions and medical specialists contracted to the regional health authorities [19]. As a result of the Norwegian health care system's universality and the register's broad coverage, the register includes all cases of hospital-treated DSH in Norway since 2008, coded according to ICD-10. The study was approved by the Regional Committees for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the relevant registers.

Study design and population

In the present study, deliberate self-harm refers to intentional self-poisoning and self-injury, irrespective of suicidal intent [20, 21].

Cases were individuals born between 1970 and 2003 who received acute somatic treatment because of DSH at hospitals and associated services (i.e., specialist healthcare services), and who were hence recorded in the Norwegian Patient Register (NPR), between January 1st 2008 and December 31st 2013. We considered only cases who were at least 10 years old at the time of DSH treatment and excluded all indirect contacts, planned treatments, fatal injuries, and poisonings or injuries that were clearly accidental, inflicted by others or secondary outcomes of other medical conditions. Due to underreporting of DSH in the Scandinavian health registers [22, 23], we adopted a broader approach to include episodes of probable DSH to prevent detection bias. Based on the previous register-based research [22] and our examination of data on determined incidents which were given a diagnosis of DSH (ICD-codes X6n, Y87), three steps were followed in a hierarchical fashion to ascertain probable DSH episodes. The first step was to include 4421 cases with treatment contacts because of injuries with a comorbid diagnosis of DSH (ICD-codes X6n, Y87). The second step was to include 3966 cases with treatment contacts that had a diagnosis of either poisoning (ICD-codes T4n, T50–T55, T57–T60, T62, T65, and T96) or injuries (ICD-codes S10–S11, S15, S19, S21, S25–S27, S31, S35–S39, S41, S45, S50–S51, S54–S56, S59, S61, S64–S65, S69, S71, S88, T01, T09, T11, T18–T19, T27–T28, T31, T68, T69, T71 and T95), and had a comorbid diagnosis of mental or behavioural problems (ICD-codes F0–F9). The final step was to include 4139 cases with treatment contacts for poisoning (ICD-codes T4n, T50, and T96) that were not covered by the previous steps. The first recorded contact by a person was used as the case contact, resulting in 12,526 cases with DSH treated in specialist healthcare services during the study period. We will use the term DSH hospitalization to denote these registered hospital contacts.

A nested-case–control design [24] was then applied to select up to 20 controls for each case with no recorded history of DSH hospitalization in the study period. Controls were matched for date of birth, gender, and the date of DSH hospitalization, and were drawn from a 25% random sample of the population registered in the Central Population Register. This procedure resulted in 222,362 matched controls. Only individuals with a registered link to both their father and mother were included in the study.

Variables of interest

The explanatory variable of interest is exposure to parental death by external causes (parental DBEC) before age 18 (ICD-8 and ICD-9 codes E800–E999; ICD-10 codes V01–Y89). Subjects were classified into categories of *bereavement status* as (a) no exposure to parental DBEC, or b) exposure to parental DBEC. Specific c*auses of parental death* were classified as a) suicide (ICD-8 and ICD-9: E950–E959, ICD-10: X60–X84), (b) transport accidents (ICD-8: E800–E845, ICD-9: E800–E848, ICD-10: V01–V99), (c) other accidents (ICD-8: E850–E929, ICD-9: E849–E869 and E880–E928, ICD-10: W00–X59), and (d) other external causes (ICD-8: E930–E949 and E960–E999, ICD-9: E870–E879, E929–E949 and E960–E999, ICD-10: X85–Y89). The low number of homicides in Norway makes separate analyses impossible, and homicides were hence included in the "other external causes" category. *Gender of deceased parent* was further classified as (a) father, (b) mother, and (c) both parents. Furthermore, subjects were classified according to their *age at bereavement* into (a) ≤ 4 years, (b) 5–9 years, (c) 10–14 years, and (d) 15–18 years. Finally, *time since bereavement* refers to the time between parental DBEC and DSH hospitalization or matching, and subjects were classified as (a) up to 5 years, (b) 5–9 years, and (c) 10–15 years. If both parents died, bereavement-related variables were classified according to the parent who died first.

Several covariates were included in the multivariate analyses. *Ethnicity* was classified as (a) born in Norway with two Norwegian born parents, (b) immigrant, (c) born in Norway with immigrant parents or one-parent born abroad, and (d) born abroad with one or two Norwegian born parents. *Highest education* at the time of DSH hospitalization or matching was classified as (a) no education or unknown education, (b) compulsory education, (c) high school and vocational education, and (d) higher education (University or College). *Taxable income* the year before DSH hospitalization or matching was calculated based on the Norwegian National Insurance Scheme's basic amount G which is adjusted for annual national wage inflation [25]. Taxable income was classified as (a) up to 2G, (b) 2–4G, (c) 4G and more, and (d) unknown. *Marital status* at DSH hospitalization or matching was classified as (a) married, (b) never married, (c) separated, (d) divorced, (e) widowed, and (f) unknown. *Marital stability* and *residence stability* refer to the number of changes in marital status and residence address, respectively, and were classified as (a) 0, (b) 1, and (c) 2 or more. The *Number of sick leave episodes* the last 3 years before DSH hospitalization or matching was classified as (a) 0, (b) 1, (c) 2, (d) 3–4, and (e) 5 or more. *Diagnosis of sick leave episode* the last 3 years before DSH hospitalization or matching was classified as (a) no sick leave, (b) depression, (c) other psychiatric conditions, (d) musculoskeletal conditions, and (e) other.

Statistical analyses

The outcome variable of interest was DSH hospitalization, and risk was estimated by a conditional logistic regression analysis [26]. Odds ratios (ORs) and 95% confidence intervals (95% CI) were estimated, and the analyses were conducted using IBM SPSS Statistics, version 25 (IBM Corp., Armonk, NY). Regression models were analysed in multiple steps. First, univariate analyses yielded crude ORs controlled for age, gender, and time of DSH hospitalization through matching. Second, multivariate analyses included all covariates to yield adjusted ORs. Finally, a hierarchical regression investigated the relative contribution of each covariate to identify the covariates with predictive power when statistically controlling for the effect of parental DBEC. The order of inclusion of covariates into the model was partially based on a related previous study by the authors [27], and was as follows: diagnosis of sick leave episode, number of sick leave episodes, marital status, taxable income, marital stability, highest education, residence stability, and ethnicity.

In the present study, 48.6% of cases received a primary or secondary psychiatric diagnosis at the time of DSH hospitalization. We performed a stratified multivariate regression for strata where the case had received a psychiatric diagnosis at DSH hospitalization and strata where the case had not received a diagnosis. Additionally, we performed a stratified multivariate regression for strata that were identified through the three different steps in the inclusion process.

Since study participants were born from 1970 and information about DSH hospitalization was available from 2008, participants may have had prior DSH events that were not included in the register. To investigate offspring's first DSH hospitalization, we restricted the data set to people born from 1998 who hence turn 10 years when we have registered information in the NPR. For this subset of participants (186 cases and 3418 controls), we investigated bereavement status and time since bereavement as independent variables. We included only ethnicity and residence stability as covariates, since the young age of the participants rendered information on marital status, education, income, and sick leave irrelevant.

Furthermore, a sensitivity analysis for unobserved confounding [28] was implemented to adjust for the unobserved confounding from parents' history of psychiatric hospitalization. The parameters which we selected were based on previous studies, and the odds ratio for the relationship between parents' history of psychiatric hospitalization and offspring's DSH hospitalization (OR_{yu}) was set to 2.09 [12]. The prevalence of a history of psychiatric hospitalization in parents who died from suicide [$p(u|x=1)$] was set to 0.45 [5], and the prevalence of a history of psychiatric hospitalization in the general population [$p(u|x=0)$] was set to 0.06 [5]. We used these parameters to determine an adjustment factor, and the OR was adjusted for this factor to obtain the OR for the true association, free of bias from observed and unobserved confounding. Notably, the prevalence of psychiatric hospitalization in parents who died from suicide (45%) is markedly higher than the corresponding prevalence in parents who died from accidents (21%) [5], and was utilized in this analysis to yield the most conservative estimate of the adjusted OR.

Interactions between variables of study and gender of the bereaved, cause of death and gender of the deceased parent, and cause of death and the offspring's age at bereavement were investigated using the log-likelihood ratio test. Interactions with gender of the bereaved were based on multivariate analyses, while interactions with cause of death were based on univariate analyses, since coefficients in the multivariate analyses did not converge.

Results

Of the 12,526 people who had received treatment in specialized health care for DSH during the observation period, 56.4% were females. The mean age at DSH hospitalization was 24.3 years for females and 27.3 years for males. Overall, 287 cases and 2078 controls had experienced parental death by external causes before they turned 18 years. The distribution of the variable categories is presented in Table 1.

Table 2 displays the results from the univariate and multivariate regression analyses, for all subjects and for daughters and sons separately. Children and adolescents who had experienced parental death by external causes had a significantly increased risk of DSH hospitalization compared to offspring who had not experienced such loss (adjusted OR 1.83, 95% CI 1.60–2.10). The associated risks were somewhat reduced in the multivariate analyses after controlling for all covariates, and the hierarchical regression indicated that all covariates significantly predicted DSH hospitalization when the effect of parental DBEC was accounted for. After controlling for the unobserved confounding from parents' history of

Table 1 Distribution (%) of the study variable categories among cases with hospital-treated deliberate self-harm and matched controls, for all subjects and males and females separately

	All subjects		Females		Males	
	(*N* = 234,888)		(*N* = 132,562)		(*N* = 102,326)	
	Cases	Controls	Cases	Controls	Cases	Controls
Variable	(12,526)	(222,362)	(7097)	(125,465)	(5429)	(96,897)
Bereavement status						
No exposure to parental DBEC	12,239 (97.7)	220,284 (99.1)	6931 (97.7)	124,330 (99.1)	5308 (97.8)	95,954 (99.0)
Exposure to parental DBEC	287 (2.3)	2078 (0.9)	166 2.3)	1135 (0.9)	121 (2.2)	943 (1.0)
Cause of death						
No exposure to parental DBEC	12,239 (97.7)	220,284 (99.1)	6931 (97.7)	124,330 (99.1)	5308 (97.8)	95,954 (99.0)
Suicide	148 (1.2)	871 (0.4)	88 (1.2)	468 (0.4)	60 (1.1)	403 (0.4)
Transport accidents	54 (0.4)	592 (0.3)	24 (0.3)	327 (0.3)	30 (0.6)	265 (0.3)
Other accidents	76 (0.6)	517 (0.2)	47 (0.7)	299 (0.2)	29 (0.5)	218 (0.2)
Other external causes	9 (0.1)	98 (0.05)	7 (0.1)	41 (0.03)	2 (0.04)	57 (0.1)
Gender of deceased						
No exposure to parental DBEC	12,239 (97.7)	220,284 (99.1)	6931 (97.7)	124,330 (99.1)	5308 (97.8)	95,954 (99.0)
Father	216 (1.7)	1637 (0.7)	121 (1.7)	898 (0.7)	95 (1.7)	739 (0.8)
Mother	63 (0.5)	412 (0.2)	39 (0.5)	215 (0.2)	24 (0.4)	197 (0.2)
Both parents	8 (0.1)	29 (0.01)	6 (0.1)	22 (0.02)	2 (0.04)	7 (0.01)
Age at bereavement						
No exposure to parental DBEC	12,239 (97.7)	220,284 (99.1)	6931 (97.7)	124,330 (99.1)	5308 (97.8)	95,954 (99.0)
≤ 4 years	67 (0.5)	509 (0.2)	32 (0.5)	279 (0.2)	35 (0.6)	230 (0.2)
5–9 years	74 (0.6)	544 (0.2)	47 (0.7)	292 (0.2)	27 (0.5)	252 (0.3)
10–14 years	83 (0.7)	627 (0.3)	53 (0.7)	349 (0.3)	30 (0.6)	278 (0.3)
15–18 years	63 (0.5)	398 (0.2)	34 (0.5)	215 (0.2)	29 (0.5)	183 (0.2)

Data are given as number (percentage) of each group. Percentages may not total 100 because of rounding

DBEC death by external causes

Table 2 Odds ratios (95% confidence intervals) from the univariate and multivariate conditional logistic regression analyses indicating risk of hospital-treated deliberate self-harm associated with the variables under study, for all subjects and males and females separately. Log-likelihood ratio tests for gender differences

Variable	Crude OR[a]	Adjusted OR[b]			Interaction with gender[c]	
	All subjects	All subjects	Females	Males	χ^2	p
Bereavement status					1.30	0.25
No exposure to parental DBEC	1 (reference)	1 (reference)	1 (reference)	1 (reference)		
Exposure to parental DBEC	2.49 (2.20–2.83)‡	1.83 (1.60–2.10)‡	1.98 (1.66–2.36)‡	1.69 (1.37–2.08)‡		
Cause of death					4.31	0.37
No exposure to parental DBEC	1 (reference)	1 (reference)	1 (reference)	1 (reference)		
Suicide	3.07 (2.58–3.66)‡	2.32 (1.92–2.80)‡	2.54 (1.99–3.24)‡	2.06 (1.53–2.78)‡		
Transport accidents	1.62 (1.23–2.15)‡	1.26 (0.93–1.69)	1.12 (0.72–1.73)	1.42 (0.94–2.15)		
Other accidents	2.69 (2.11–3.42)‡	1.79 (1.38–2.33)‡	1.97 (1.42–2.75)‡	1.63 (1.07–2.49)*		
Other external causes	1.66 (0.84–3.29)	1.13 (0.55–2.31)	1.72 (0.73–4.05)	0.54 (0.13–2.28)		
Gender of deceased					2.16	0.54
No exposure to parental DBEC	1 (reference)	1 (reference)	1 (reference)	1 (reference)		
Father	2.38 (2.06–2.74)‡	1.76 (1.51–2.06)‡	1.85 (1.51–2.26)‡	1.71 (1.35–2.16)‡		
Mother	2.78 (2.13–3.63)‡	2.00 (1.51–2.66)‡	2.37 (1.64–3.42)‡	1.58 (1.00–2.48)		
Both parents	5.12 (2.34–11.20)‡	3.09 (1.30–7.36)*	3.19 (1.19–8.53)*	2.82 (0.50–15.79)		
Age at bereavement					3.35	0.50
No exposure to parental DBEC	1 (reference)	1 (reference)	1 (reference)	1 (reference)		
$\leq$4 years	2.38 (1.84–3.07)‡	1.69 (1.29–2.23)‡	1.64 (1.12–2.42)*	1.80 (1.22–2.68)†		
5–9 years	2.46 (1.93–3.14)‡	1.77 (1.37–2.30)‡	2.09 (1.50–2.91)‡	1.41 (0.92–2.16)		
10–14 years	2.37 (1.88–2.98)‡	1.81 (1.42–2.32)‡	2.02 (1.48–2.76)‡	1.53 (1.02–2.31)*		
15–18 years	2.90 (2.22–3.78)‡	2.14 (1.60–2.87)‡	2.18 (1.47–3.23)‡	2.15 (1.40–3.31)‡		

DBEC death by external causes

*$p<0.05$, $^{\dagger}p<0.01$, $^{\ddagger}p<0.001$

[a] The ORs derived from these models were adjusted for age, gender, and calendar time through matching

[b] The ORs derived from these models were further adjusted for ethnicity, highest completed education, taxable income, marital status, marital stability, residence stability, number of sick leave pension episodes, and diagnosis of sick leave pension episode

[c] Interactions with gender of bereaved offspring were based on multivariate analyses

psychiatric hospitalization, the risk of DSH hospitalization in offspring who had experienced parental DBEC remained significantly increased (OR 1.31, 95% CI 1.14–1.50).

When performing a stratified multivariate regression for subjects who received a psychiatric diagnosis at DSH hospitalization and subjects who did not receive a diagnosis, no large differences were evident; OR 1.92, 95% CI 1.58–2.32 for DSH treatment with a psychiatric diagnosis, and OR 1.76, 95% CI 1.45–2.14 for DSH treatment without a psychiatric diagnosis. Similarly, no large differences were observed in the stratified analysis for the three DSH identification steps; OR 1.88, 95% CI 1.49–2.37 for step 1, OR 1.97, 95% CI 1.55–2.51 for step 2, and OR 1.87, 95% CI 1.46–2.39 for step 3.

The analysis of the first DSH hospitalization in subjects born after 1998 found that children and adolescents exposed to parental DBEC had close to eight times higher risk of DSH hospitalization compared to their non-exposed peers (OR 7.97, 95% CI 3.63–17.49). Markedly, only 10 cases and 21 controls had experienced parental DBEC in this subsample.

In the multivariate regression investigating cause of death, offspring exposed to parental suicide and death by other accidents showed a significantly increased risk of DSH hospitalization, while parental death by transport accidents and other external causes were not associated with a significantly increased risk (Table 2). The category of other accidents consisted of a large proportion of poisonings (39.0%), including overdoses from narcotics, medications and alcohol, and falls (16.2%). Parental suicide was associated with the highest odds ratio with more than a doubled risk of DSH hospitalization, and the non-overlapping confidence intervals shows that suicide is associated with a significantly higher risk of DSH hospitalization than transport accidents.

The log-likelihood ratio test for the interaction between cause of death and gender of the deceased parent was non-significant (χ^2: 4.99, p: 0.55), with parental suicide and death by other accidents being associated with the largest risks regardless of losing a mother or father (Fig. 1). Likewise, the log-likelihood ratio test for the interaction between cause of death and offspring's age at bereavement was non-significant (χ^2: 6.05, p: 0.74), with parental suicide and death by other accidents being associated with the greatest risks across all ages of bereavement (Fig. 2).

In the multivariate regression investigating gender of the deceased parent, paternal death, maternal death, and death of both parents were all associated with a significantly increased risk of DSH hospitalization in offspring (Table 2). Furthermore, no large differences between losing a father and mother were evident. The loss of both parents was associated with the highest risk of DSH hospitalization, but this group only consisted of 37 people.

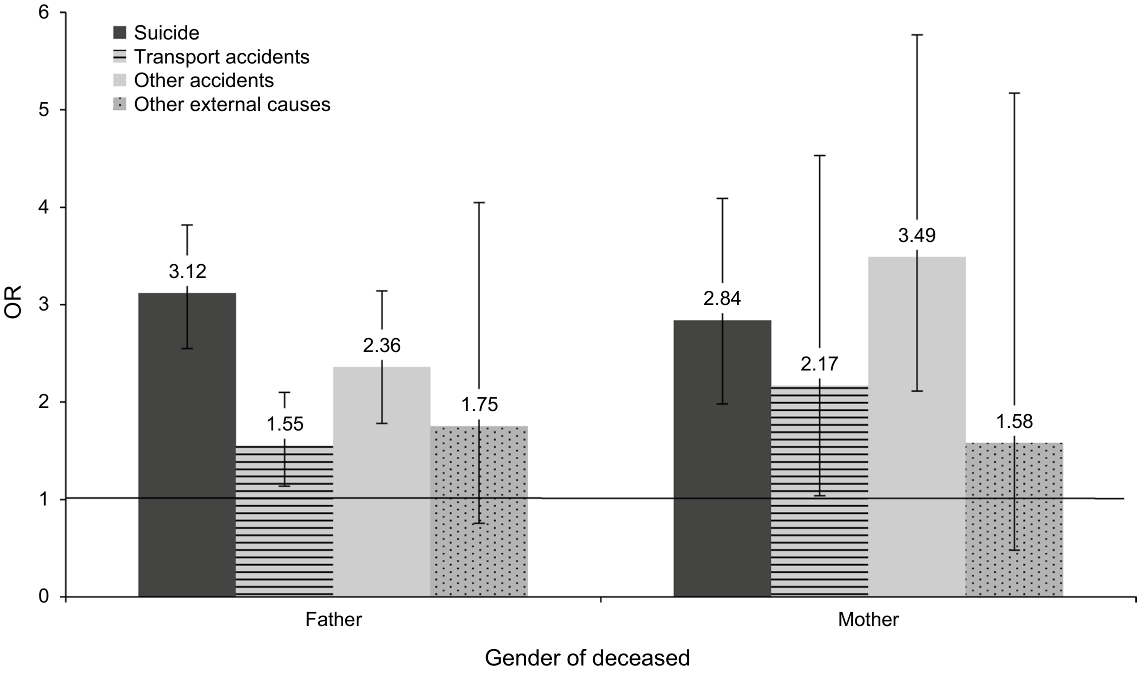
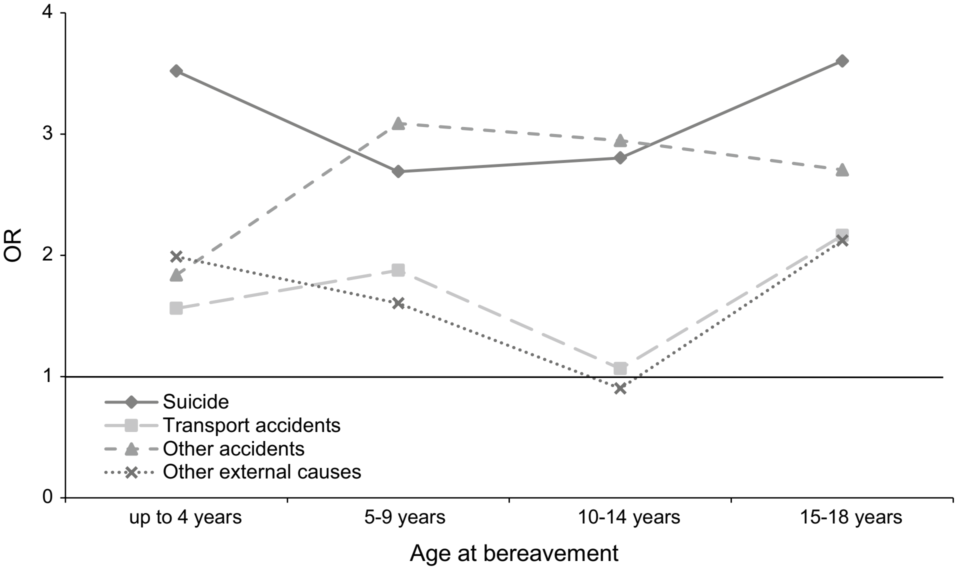


Fig. 1 Odds ratios (95% confidence intervals) for the interaction between cause of death and the gender of the deceased parent. The horizontal line marks an OR of one

Fig. 2 Odds ratios for the interaction between cause of death and offspring's age at bereavement. The horizontal line marks an OR of one



When examining offspring's age at bereavement, loss of a parent until 18 years was associated with a significantly increased risk of DSH hospitalization (Table 2). For offspring born after 1998 where the DSH hospitalization is the first episode, the investigation of time since bereavement found significantly increased risks of DSH hospitalization the first 10 years after bereavement (up to 5 years: OR 15.61, 95% CI 4.07–59.92; 5–9 years: OR 7.03, 95% CI 2.33–21.18), but no significantly increased risk 10–15 years after the loss (OR 3.49, 95% CI 0.40–30.24). Notably, the lower sample sizes in these subgroups are evident in the large confidence intervals.

The log-likelihood ratio tests investigating interactions between all bereavement-related variables and gender of the bereaved offspring were non-significant, indicating comparative associations between parental DBEC and DSH hospitalization in daughters and sons (Table 2).

Discussion

In the present study, we found that children and adolescents who lost a parent to external causes of death had a significantly increased risk of hospital-treated DSH compared to offspring who had not experienced such loss. This increased risk can be attributed to parental suicide and death by accidents such as falls, poisoning, and drowning, and was evident in both daughters and sons. Offspring displayed an increased risk following bereavement throughout their childhood and adolescence and after loss of a mother, father, and both parents.

The present study is the first to discern the effects of transport accidents and other accidents on risk of DSH hospitalization in the bereaved offspring, and found different risks associated with different types of accidents. Previous register studies have reported an association between DSH hospitalization and parental bereavement from suicides and accidents in general [5, 17]. However, in the present study, offspring bereaved by parental death from suicide and accidents such as poisoning and falls had significantly increased risks, while deaths from transport accidents and other external causes were not associated with significantly increased risks. These results persisted irrespective of the gender of the deceased parent or the offspring's age at bereavement. A misclassification of suicides as accidental deaths in the Norwegian Cause of Death Register is uncommon [29] and hence an unlikely explanation for the present findings.

Researchers have reported that the risk of mental disorder is significantly higher in people who die from accidental poisonings and falls than people who die in transport accidents [30]. The psychopathology related to accidental poisonings and falls will probably have influenced the family environment prior to the death of the parent, leading to an upbringing with insecurity, instability, and family discord. This may also be a reason for the increased risk of DSH hospitalization in offspring bereaved by parental suicide, given that a problematic family environment consisting of psychiatric disorders, maltreatment, abuse, and family discord is particularly present in families where members have died by suicide [31, 32]. Likewise, both suicide and accidental poisoning by medications may entail a period of physical illness preceding the death [33]. Genetic transmission of factors reported to highly influence suicidal behaviour, such as psychiatric disorders, neurocognitive deficits, and certain personality traits, may also explain the increased risk of DSH hospitalization following parental suicide and death from the other accidents [34]. Parental suicide was associated with the highest risk of DSH hospitalization in the present study, potentially due to grief specific variables related to suicide bereavement, stigma of suicide, feelings of responsibility, social isolation, anger at the deceased, and a ruminative need to understand the suicidal motivation [35–37].

The comparable risks of DSH hospitalization in offspring who have lost a mother and father are in accordance with the previous register-based studies investigating parental suicide [11] and death from all causes [13, 17]. Likewise, the lacking differences in risk between daughters and sons support previous findings [10, 11, 13, 15]. This lack of gender differences can potentially best be explained by the relative gender equality in Scandinavian countries with respect to child rearing responsibilities [38, 39], leading to comparable psychosocial impacts of maternal and paternal bereavement. Additionally, gender equality may yield both daughters and sons the ability to express their feelings, seek support, and process the bereavement. In accordance with previous studies [5, 12–14, 16], the present study found that bereavement throughout childhood and adolescence is associated with a significantly increased risk of DSH hospitalization. Developmental psychology has consistently stressed the importance of early experiences on later development, and adolescence has especially been conceptualized as a sensitive period, since experiencing traumatic events at this age can have a larger detrimental effect compared to exposure at other ages [40–42]. Furthermore, the first 5 years following bereavement were associated with the largest risks of DSH hospitalization, a finding similar to previous studies reporting the highest risk the first 2 years after bereavement [9, 10, 17]. The immediate effects following bereavement may be a direct effect of the trauma and loss itself, while the more long-term effects may be a result of developmental challenges related to growing up in a one-parent home and genetic heritability of suicidal behaviour and psychiatric disorder [34].

Results from the present study reporting an increased risk of DSH hospitalization in bereaved offspring are consistent with prior Scandinavian register studies [5, 10–15, 17], and add to the literature, suggesting that many bereaved offspring in Norway suffer from extensive psychosocial sequela [6, 7]. The explanation for the increased risk following bereavement may to a certain degree lie in the covariates included in the study, since the associations were attenuated in the multivariate analyses and all covariates significantly predicted DSH hospitalization. These interpersonal, intrapersonal, and health-related covariates may function as mediators in the association between parental bereavement and hospital-treated DSH. The interpersonal resources of being married and having stable residence and marital status may reflect social support and community network, and have previously been found to be protective against suicide in bereaved offspring [27]. Furthermore, reduced intrapersonal resources due to low income and education may entail reduced skills and life competence [43], further reducing capacities for coping and recovery. The covariates of greatest importance may be related to mental and physical health, reflected in the number of sick leave episodes and the diagnosis of the last sick leave episode, since the loss of an important attachment figure may cause or aggravate psychiatric disorders [36, 44–46]. In addition to the effect of these potential mediators, there seems to be a direct effect of bereavement on DSH, since the increased risk persisted after controlling for covariates and unobserved confounding. This direct effect may be because the sudden nature of external causes of death means that the bereaved have no or very little chance to prepare themselves or say goodbye, inducing a sense of loss of control. Moreover, the death is often accompanied by shock and strong sensory impressions, and may be experienced as a trauma. This in turn may lead to rumination and counterfactual thoughts about the death, in addition to the grief following bereavement in general.

For the study of low-frequency phenomena such as DSH hospitalization and parental DBEC, the present study has its strength in the use of national registers covering the entire population, enabling a large sample size and increased statistical power. Moreover, register studies do not suffer from problems with selection and attrition, nor biases related to observation or interviewing. Data in Norwegian registers are collected systematically and uniformly, and the data have been found to have high quality [19, 29, 47]. The registers are monitored, analysed, and corrected continuously [19, 48, 49]. Together, the strengths of the present study indicate that the study results have high external validity.

Results from the present study must be interpreted in light of some limitations. DSH is operationalized in a manner enabling the use of registers where the X6n deliberate self-harm code is insufficiently used. Because of this, we have widened the inclusion of DSH hospital treatment to include other ICD-codes, as explained in the Methods section. Therefore, some accidents may have been erroneously classified as deliberate self-harm, and actual acts of self-harm may have been mistakenly omitted. The sensitivity analysis stratifying by step of DSH identification, nevertheless, shows similar results. In community studies, cutting is the most common method of self-harm, while poisoning is the most common self-harm method in individuals presenting to hospitals [50]. Results from the present study consequently cannot be generalized to all the other self-harm studies. A further limitation relates to data access and the inability to include potential covariates, such as family socioeconomic status, whether the parents are the child's primary caregivers, and the quality of the parent–child attachment. Finally, because the study excluded all offspring without a registered link to parents in the Central Population Register, our sample probably excluded disproportionately many first generation immigrants, since their parents are not registered in Norwegian registers.

In conclusion, children and adolescents bereaved by parental suicide and accidents such as poisoning and falls have a significantly increased risk of hospital-treated DSH. This increased risk is evident in both daughters and sons, following the loss of a mother, father or both parents. Clearly, the effects of bereavement on DSH hospitalization are extensive, and early exposure has long-lasting impacts.

Given the increased risk of DSH hospitalization in bereaved offspring, all bereaved offspring should be offered follow-up in primary healthcare and hence have the opportunity to seek help easily. For children and adolescents parentally bereaved through suicide, follow-up in specialized child and adolescent mental health services should additionally be offered on a routine basis. Wherever available, peer-group support specifically targeting families and youth bereaved through suicide should also be offered. We believe that it is important to use the data from this research to more effectively identify vulnerable groups and implement effective prevention and treatment programs in specialist healthcare aimed at the individuals at highest risk. Indeed, counselling and support groups for children and adolescents bereaved by suicide can be beneficial in reducing psychopathology [51]. The increased knowledge of high-risk groups should also be incorporated into risk assessments. Additionally, the school system can function as first responders to this vulnerable group through identifying and monitoring those at risk and offering support through school counselling services. The close association between schools and specialized care such as clinics for child and adolescent psychiatry and child protective services makes educators and school nurses well suited at referring bereaved children and adolescents for further follow-up. Identification of bereaved offspring at particular risk of psychosocial sequela is well underway, paving the way for more effective and specialized postvention.

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Author contributions All authors contributed to the study conception, Qin and Burrell outlined the study design. Qin prepared the data material, and Burrell performed the analyses. All authors interpreted the data results, and the article was written by Burrell. All authors revised the article and approved the finale manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval The study was approved by the Regional Committees for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the relevant registers, and have, therefore, been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The ethics committee waivered the demand for informed consent from participants, because this was a population-based study with de-identified register data.

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Parental death by external causes during childhood and risk of psychiatric disorders in bereaved offspring

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Background: Previous studies have reported increased risks of psychiatric disorders in offspring who have lost a parent, but knowledge is lacking on the risks of several specific disorders and comorbidity. The present study investigated the influence of parental death by external causes during childhood and adolescence on risk of a range of psychiatric disorders and comorbidity. **Method:** The study cohort comprised 655,477 individuals born 1970–2012 with a link to both parents. Data on deceased parent's cause and date of death between 1970 and 2012 and offspring's psychiatric disorders between 2008 and 2012 were retrieved from four longitudinal Norwegian registers. Data were analyzed with Cox regression. **Results:** Compared to nonexposed offspring, offspring exposed to parental death by external causes had a significantly increased risk of depressive disorders, reactions to stress, anxiety disorders, substance use disorders, developmental disorders, childhood behavioral and emotional disorders, psychotic disorders, bipolar disorder, personality disorders, and psychiatric comorbidity, but not eating disorders. These increased risks were especially evident following parental suicide and accidental falls and poisoning. No differences were evident depending on gender of the deceased or age at bereavement, and generally no significant interactions with gender of the bereaved offspring were evident. **Conclusions:** The improved insight into several different psychiatric disorders and psychiatric comorbidity should guide postvention measures aimed at children and adolescents at greatest risk of future sequelae.

Key Practitioner Message

- Previous studies have reported increased risks of psychiatric disorders in offspring who have lost a parent to external causes of death.
- The present study is the first large-scale population study to report an increased risk of anxiety disorders, developmental disorders, childhood behavioral and emotional disorders, reactions to severe stress, and psychiatric comorbidity following parental death by external causes, as well as no increased risk of eating disorders.
- The study is also the first to uncover higher risks associated with parental suicide and accidental deaths such as poisoning and falls compared to deaths due to transport accidents.
- All bereaved offspring should be offered supportive follow-up in primary health care, and offspring bereaved by parental suicide should receive additional follow-up in mental health care.
- Clinicians should screen for a history of childhood parental bereavement in people suffering from mental illness to more effectively identify important targets for treatment.

Keywords: Psychiatric disorders; parental bereavement; population registers; childhood; adolescence

Introduction

The death of a parent during childhood or adolescence is one of the most life changing and potentially traumatic events a child can experience (Bowlby, 1969) and is accordingly associated with an increased risk of long-term psychosocial sequelae (Burrell, Mehlum, & Qin, 2017, 2020a; Høeg et al., 2018; Wilcox et al., 2010). Several population-based studies have reported an increased risk of a range of psychiatric disorders following parental death, including depression, bipolar disorder, substance use disorder, personality disorders, and schizophrenia (Berg, Rostila, & Hjern, 2016; Kessing, Agerbo, & Mortensen, 2003, 2004; Kuramoto et al., 2010; Laursen, Munk-Olsen, Nordentoft, & Mortensen, 2007; Mortensen, Pedersen, Melbye, Mors, & Ewald, 2003; Ostergaard, Waltoft, Mortensen, & Mors, 2013; Sorensen et al., 2014; Tsuchiya, Agerbo, & Mortensen, 2005; Wilcox et al., 2010). Investigation of the potential influence of bereavement-related variables, such as gender of the deceased parent and offspring's age at bereavement, is, however, sparse, and an investigation of differences between different external causes of death is especially limited (Berg et al., 2016; Brent, Melhem, Donohoe, & Walker, 2009; Kuramoto et al., 2010; Melhem, Walker, Moritz, & Brent, 2008; Wilcox et al., 2010). Based on national data from Norway, we have recently identified an increased risk of deliberate self-harm (DSH) hospitalization in offspring following parental death by suicide and accidents such as falls, poisoning, and drowning, but not following transport accidents (Burrell, Mehlum, & Qin, 2020b). No previous study has investigated possible differences in risk of psychiatric disorders following parental death from different accidents, potentially accounting for previous inconclusive study results and warranting further investigation.

Moreover, no large-scale population studies to date have investigated the association between death by a parent and subsequent risk of anxiety disorders, childhood behavioral and emotional disorders, developmental disorders, eating disorders, and reactions to severe stress, including acute stress reaction, posttraumatic stress disorder (PTSD), and adjustment disorder. Investigations of these diagnoses are therefore necessary, alongside analyses investigating psychiatric comorbidity.

The present study aims to investigate the association between parental death from external causes during childhood and adolescence and risk of psychiatric disorders in the bereaved offspring. We aim to investigate potential differences in the risk of psychiatric disorders depending on the gender of the deceased parent, the gender of the offspring, offspring's age at bereavement, and parental cause of death. Several specific diagnoses and psychiatric comorbidity will be investigated. External causes of death are a classification in the ICD coding system and refer to deaths where the cause is external to the body, such as accidents, suicides, and homicides.

Methods

Data sources

Individual data from four longitudinal Norwegian registers were retrieved and merged. The Central Population Register provided data on gender, date of birth, death and emigration, and a link to parent's personal identification number. This link enabled the identification of biological or adoptive parents, but note that we are unable to distinguish between biological and adoptive parents in the register. The link also enabled the retrieval of information on parental death by external causes from the Cause of Death Register. This register contains the cause and date of all deaths in Norway coded according to ICD-8 (International Classification of Deceases, Eight Revision) from 1969 to 1985, ICD-9 from 1986 to 1995, and ICD-10 from 1996 to 2012 (Statistics Norway, 2012a). Statistics Norway's Events Database provided information on ethnicity. The Norwegian Patient Register (NPR) contains information concerning all contacts in specialist health care, including all public institutions as well as private institutions and medical specialists contracted to the regional health trusts (Bakken, Ariansen, Knudsen, Johansen, & Vollset, 2019). Specialist mental health services in Norway are composed of mental health services for adults, child- and adolescent mental health services, substance misuse services, and private mental health specialists contracted to a public health trust. These services all report to the NPR and encompass both inpatient and outpatient treatment (The Norwegian Health Directorate, 2016).

The study was approved by the Regional Committee for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the registers. The ethics committee waivered the demand for informed consent from participants because this was a population-based study with deidentified data.

Study design and population

The present study is a cohort study, and the study population consisted of a 25% random sample of all Norwegian residents born between 1970 and 2012 who had a link to both parents in the Central Population register. The cohort comprised 655,477 individuals.

Variables of interest

The present study investigated psychiatric disorders reported to the NPR from patient's first direct contact with specialist mental health services between 2008 and 2012. Data from substance misuse services were only available from 2009. Diagnoses were coded according to ICD-10 codes, and *any psychiatric disorder* included codes F00-F99. Specific disorders of interest were *depressive disorders* (F32-F33), *reactions to stress* (F43), *anxiety disorders* (F40-F41), and *substance use disorders* (F10-F19). Disorders in childhood and adolescence were *developmental disorders* (F80-F89) and *childhood behavioral and emotional disorders* (F90-F98). Lastly, less prevalent disorders were *psychotic disorders* (F20-F29), *bipolar disorder* (F30-F31), *eating disorders* (F50), and *personality disorders* (F60-F62). We considered both main and secondary diagnoses when coding specific disorders.

The explanatory variable of interest is parental death by external causes before age 18, referred to as parental DBEC (ICD-8 and ICD-9 codes E800-E999, ICD-10 codes V01-Y89), and investigated between 1970 and 2012. Given the aims of the study, we did not include parental death due to natural causes. Subjects were classified into categories of *bereavement status* as (a) no exposure to parental DBEC, and (b) exposure to parental DBEC. *Gender of deceased* parent was classified as (a) father, (b) mother, and (c) both parents. Furthermore, *cause of parental death* was classified as (a) suicide (ICD-8 and ICD-9: E950-E959, ICD-10: X60-X84), (b) transport accidents (ICD-8: E800-E845, ICD-9: E800-E848, ICD-10: V01-V99), (c) other accidents (ICD-8: E850-E929, ICD-9: E849-E869 and E880-E928, ICD-10: W00-X59), and (d) other external causes (ICD-8: E930-E949 and E960-E999, ICD-9: E870-E879, E929-E949, and E960-E999, ICD-10: X85-Y89). Lastly, subject's *age at bereavement* was classified as (a) ≤4 years, (b) 5–9 years, (c) 10–14 years, and (d) 15–18 years. Variables were classified based on the parent who died first when both parents died.

Multivariate analyses were adjusted for cohort members' year of birth, gender, and *ethnicity*: (a) born in Norway with two Norwegian born parents, (b) immigrant, (c) born in Norway with immigrant parents or one parent born abroad, and (d) born abroad with one or two Norwegian born parents.

Statistical analyses

The cohort was followed from January 1, 2008, to date of psychiatric diagnosis, death, emigration, or December 31, 2012, whichever came first. Cohort members could be censored due to death or emigration from birth. When a specific diagnosis was investigated, people who received other diagnoses were censored due to death, emigration, or the end of follow-up alongside people who had not received a diagnosis. For bereaved offspring, we assured that bereavement occurred before the psychiatric diagnosis in order to avoid the directionality problem and infer causality (Bordens & Abbott, 2007). Differences in hazard ratios (HRs) with 95% confidence intervals (95% CI) were estimated using Cox regression, and the analyses were conducted in Stata, version 15 (StataCorp, 2017). Since exposure status can change during the follow-up period, the time before exposure is considered as unexposed and the time after exposure is considered as exposed in the analyses.

In the univariate analyses, the potential effect of bereavement variables on receiving psychiatric diagnoses was estimated, while the multivariate analyses included covariates to yield adjusted HRs. Interactions between variables of study and gender were assessed with the log likelihood ratio test based on results from the multivariate analyses. For any psychiatric disorder, we investigated univariate analyses, multivariate analyses, and gender interactions for all bereavement-related predictors. For the specific diagnoses depressive disorders, reactions to stress, anxiety disorders, substance use disorders, developmental disorders, and childhood behavioral and emotional disorders, we investigated multivariate analyses for all predictors and gender interaction for bereavement status. Lastly, for the less common diagnoses psychotic disorders, bipolar disorder, eating disorders, and personality disorders, we only investigated multivariate analyses for bereavement status. These restrictions were due to low statistical power for less prevalent diagnoses since information in the NPR was only available from 2008 to 2012. Results were also investigated with Bonferroni corrected alpha levels of .001 (0.05/50) in order to highlight the most robust results. The results that remained significant after Bonferroni correction are indicated in the tables with the sign ‡.

In Norwegian specialist mental health services, patients can be diagnoses with up to 24 psychiatric diagnoses. We performed a multivariate cox regression to compare the risk of *comorbidity* (receiving multiple psychiatric diagnoses) between bereaved and nonbereaved peers.

Results

In the present cohort of 655,477 individuals, 48.6% (318,554) were females. In total, 4723 individuals (2265 females and 2458 males) had experienced parental DBEC before age 18. For the follow-up period 2008–2012, 3.0% (19,406) of people who had not experienced parental DBEC were diagnosed with a psychiatric disorder, while 7.5% (353) of people who had experienced parental DBEC received a diagnosis. Frequencies of psychiatric disorders according to the study variable categories are presented in Table 1. The mean age at diagnosis was 25.6 for depressive disorders, 22.9 for reactions to stress, 25.0 for anxiety disorders, 27.9 for substance use disorders, 28.2 for psychotic disorders, 28.6 for bipolar disorder, 29.4 for personality disorders, 22.6 for eating disorders, 12.9 for developmental disorders, and 14.9 for childhood behavioral and emotional disorders.

Table 2 presents the crude and adjusted HRs with 95% CIs for any psychiatric disorder (F00-F99) associated with the variables under study. Children and adolescents who had experienced parental DBEC had a significantly increased risk of developing any psychiatric disorder compared to offspring who had not experienced parental DBEC. Table 3 presents the adjusted HRs with 95% CIs for the most common specific disorders associated with the variables under study. Offspring who had experienced parental DBEC had significantly increased risks of depressive disorders, reactions to stress, anxiety disorders, substance use disorders, developmental disorders, and childhood behavioral and emotional disorders compared to nonexposed people. Of the lesser common disorders, bereaved offspring had significantly increased risks of psychotic disorders (HR: 2.42, 95%CI: 1.33–4.39), bipolar disorder (HR: 2.30, 95%CI: 1.23–4.30), and personality disorders (HR: 2.60, 95%CI: 1.59–4.28). Bereaved offspring did not have an increased risk of eating disorders (HR: 0.53, 95%CI: 0.17–1.66) compared to people who had not experienced such loss.

Causes of parental death

Offspring exposed to parental suicide, transport accidents, other accidents such as falls, poisoning, and drowning, and other external causes had a significantly increased risk of any psychiatric disorder compared to people who had not experienced parental DBEC (Table 2). Parental suicide was associated with the highest risk, with offspring being approximately 2.5 times more likely to develop a disorder, while parental death due to transport accidents was associated with the lowest risk. Parental suicide was associated with a significantly increased risk of all the specific diagnoses investigated, while death due to transport accidents was only associated with a significantly increased risk of substance use disorders (Table 3). Other accidents such as falls, poisoning, and drowning were associated with a significantly increased risk of depressive disorders, reactions to stress, substance use disorders, developmental disorders, and childhood behavioral and emotional disorders. Parental death by other external causes was only associated with a significantly increased risk of childhood behavioral and emotional disorders.

Gender of deceased parent

Children and adolescents who had lost a father, mother, and both parents had a significantly increased risk of developing any psychiatric disorder (Table 2). Loss of a father was associated with a significantly increased risk of all the specific diagnoses, while loss of a mother was associated with a significantly increased risk of depressive disorders, substance use disorders, and childhood behavioral and emotional disorders (Table 3). Loss of both parents was associated with a significantly increased risk of substance use disorders, developmental disorders, and childhood behavioral and emotional disorders. Note, however, that the confidence intervals for maternal and paternal bereavement were highly overlapping and that considerably more fathers than mothers died from external causes. Similarly, very few people had lost both parents.

Age at bereavement

Parental DBEC was associated with a significantly increased risk of any psychiatric disorder when bereavement occurred from birth through age 18 (Table 2). Offspring's risk of depressive disorders and substance use disorders was significantly increased following bereavement from birth to 15 years, while risk of reactions to severe stress was significantly increased after bereavement from 5 to 15 years (Table 3). Furthermore, risk of anxiety disorders was significantly increased following bereavement from birth to 5 years and 15 to 18 years, while risk of childhood behavioral and emotional disorders was significantly increased after bereavement from birth to 10 years and 15 to 18 years. Risk of developmental disorders was only significantly increased following bereavement from 5 to 10 years.

Gender of bereaved offspring

No significant interaction between gender of the bereaved offspring and bereavement status was evident for any psychiatric disorder, indicating comparative associations between parental DBEC and developing a psychiatric disorder in daughters and sons (Table 2). This was also true for all the specific diagnoses investigated (data not shown). Tests for interactions between gender of the offspring and cause of death, gender of deceased, and age at bereavement for any psychiatric disorder resulted in a significant interaction between gender and age at bereavement (Table 2). Evidently, bereavement before age 10 was more detrimental to sons than daughters, while bereavement after age 10 was more detrimental to daughters than sons.

Comorbidity

In the present study, 1.2% (56) of bereaved offspring received multiple diagnoses, while 0.5% (3486) of

Table 1. Distribution of the study variable categories by the psychiatric disorders investigated

Variables	Bereaved at age 18	Any psychiatric disorder $N = 19{,}759$	Depressive disorders $N = 4079$	Reactions to stress $N = 3150$	Anxiety disorders $N = 2476$	Substance use disorders $N = 2222$	Developmental disorders $N = 1554$	Childhood disorders[a] $N = 4944$	Psychotic disorders $N = 477$	Bipolar disorder $N = 443$	Eating disorders $N = 626$	Personality disorders $N = 629$
Bereavement status												
No exposure to parental DBEC	650,754	19,406	4000	3100	2443	2163	1531	4860	466	433	623	613
Exposure to parental DBEC	4723	353	79	50	33	59	23	84	11	10	3	16
Cause of death												
No exposure to parental DBEC	650,754	19,406	4000	3100	2443	2163	1531	4860	466	433	623	613
Suicide	1922	167	38	21	22	27	11	35	8	6	2	9
Transport accidents	1331	71	13	12	6	14	5	13	1	2	0	2
Other accidents	1254	97	24	15	5	15	7	32	0	2	1	3
Other external causes	216	18	4	2	0	3	0	4	2	0	0	2
Gender of deceased												
No exposure to parental DBEC	650,754	19,406	4000	3100	2443	2163	1531	4860	466	433	623	613
Father	3794	273	61	42	28	49	21	61	7	7	3	13
Mother	867	73	16	8	5	8	1	21	3	3	0	3
Both parents	62	7	2	0	0	2	1	2	1	0	0	0
Age at bereavement												
No exposure to parental DBEC	650,754	19,406	4000	3100	2443	2163	1531	4860	466	433	623	613
4 years	1344	90	16	7	11	18	6	33	1	2	0	4
5–9 years	1339	117	22	24	8	12	11	33	5	2	0	5
10–14 years	1306	97	30	14	6	21	5	12	2	3	1	5
15–18 years	734	49	11	5	8	8	1	6	3	3	2	2

Both main and secondary diagnoses were considered when coding specific disorders.

Short for childhood behavioral and emotional disorders.

Table 2. Crude and adjusted HRs with 95% CIs for developing any psychiatric disorder associated with the variables under study, for all subjects and males and females separately

Variables[b]	Crude HR All subjects	Adjusted HR[a]			Gender interaction	
		All subjects	Female	Male	x^2	p
Bereavement status					0.00	1
Exposure to parental DBEC	2.02 (1.82–2.24)‡	2.19 (1.97–2.43)‡	2.17 (1.87–2.52)‡	2.19 (1.89–2.54)‡		
Cause of death					0.00	.997
Suicide	2.56 (2.20–2.98)‡	2.57 (2.21–2.99)‡	2.62 (2.11–3.25)‡	2.52 (2.03–3.12)‡		
Transport accidents	1.19 (0.94–1.50)	1.49 (1.18–1.89)†	1.51 (1.10–2.08)*	1.47 (1.04–2.07)*		
Other accidents	2.34 (1.91–2.85)‡	2.35 (1.93–2.87)‡	2.29 (1.71–3.07)‡	2.39 (1.82–3.13)‡		
Other external causes	2.12 (1.34–3.37)†	2.33 (1.47–3.70)‡	2.20 (1.10–4.41)*	2.43 (1.31–4.52)†		
Gender of deceased					0.00	.392
Father	1.89 (1.68–2.13)‡	2.10 (1.87–2.37)‡	2.04 (1.72–2.42)‡	2.15 (1.82–2.54)‡		
Mother	2.59 (2.05–3.25)‡	2.48 (1.97–3.12)‡	2.83 (2.05–3.89)‡	2.20 (1.58–3.06)‡		
Both parents	2.77 (1.32–5.81)†	3.21 (1.53–6.73)†	2.04 (0.66–6.32)	5.41 (2.03–14.42)†		
Age at bereavement					0.00	.036
4 years	1.91 (1.56–2.35)‡	2.09 (1.70–2.57)‡	1.90 (1.39–2.59)‡	2.26 (1.71–2.99)‡		
5–9 years	2.34 (1.95–2.81)‡	2.49 (2.07–2.98)‡	2.01 (1.50–2.70)‡	2.92 (2.31–3.68)‡		
10–14 years	1.93 (1.58–2.35)‡	2.09 (1.71–2.56)‡	2.46 (1.90–3.18)‡	1.71 (1.25–2.34)†		
15–18 years	1.78 (1.34–2.35)‡	1.96 (1.48–2.59)‡	2.38 (1.67–3.39)‡	1.49 (0.94–2.37)		

No exposure to parental DBEC as reference

[a] The HRs derived from these models were adjusted for ethnicity, year of birth and gender.

[b] The estimates for these variables were generated from separate models.

*$p < .05$, †$p < .01$, ‡$p < .001$.

Table 3. Adjusted HRs with 95% CIs for developing the most common specific disorders investigated, associated with the variables under study

Variables[b]	Adjusted HR[a]					
	Depressive disorders	Reactions to stress	Anxiety disorders	Substance use disorders	Developmental disorders	Childhood disorders[c]
Bereavement status						
Exposure to parental DBEC	2.09 (1.68–2.62)‡	1.90 (1.43–2.51)‡	1.45 (1.03–2.05)*	2.75 (2.13–3.57)‡	2.47 (1.63–3.73)‡	2.64 (2.13–3.28)‡
Cause of death						
Suicide	2.51 (1.82–3.46)‡	1.97 (1.28–3.02)†	2.40 (1.58–3.66)‡	3.17 (2.17–4.63)‡	2.71 (1.50–4.90)†	2.56 (1.84–3.57)‡
Transport accidents	1.15 (0.67–1.98)	1.55 (0.88–2.73)	0.89 (0.40–1.98)	2.18 (1.29–3.69)†	2.26 (0.94–5.44)	1.60 (0.93–2.76)
Other accidents	2.55 (1.71–3.80)‡	2.25 (1.35–3.73)†	0.87 (0.36–2.10)	2.82 (1.70–4.68)‡	2.61 (1.24–5.48)*	3.65 (2.58–5.17)‡
Other external causes	2.17 (0.81–5.78)	1.57 (0.39–6.30)	–	2.58 (0.83–8.02)	–	3.13 (1.17–8.34)*
Gender of deceased						
Father	2.00 (1.56–2.58)‡	1.98 (1.46–2.69)‡	1.53 (1.05–2.22)*	2.85 (2.14–3.78)‡	2.88 (1.87–4.42)‡	2.42 (1.88–3.12)‡
Mother	2.38 (1.46–3.89)†	1.68 (0.84–3.35)	1.23 (0.51–2.95)	2.03 (1.01–4.06)*	0.52 (0.07–3.70)	3.36 (2.19–5.16)‡
Both parents	3.52 (0.88–14.09)	–	–	7.48 (1.87–29.93)†	10.53 (1.48–74.84)*	5.78 (1.44–23.10)*
Age at bereavement						
4 years	1.72 (1.06–2.82)*	1.01 (0.48–2.12)	1.91 (1.06–3.46)*	3.49 (2.19–5.55)‡	1.84 (0.82–4.09)	3.15 (2.24–4.44)‡
5–9 years	2.11 (1.39–3.21)‡	3.17 (2.12–4.73)‡	1.24 (0.62–2.49)	2.02 (1.15–3.57)*	3.22 (1.78–5.82)‡	3.01 (2.14–4.24)‡
10–14 years	2.61 (1.83–3.74)‡	1.81 (1.07–3.06)*	0.89 (0.40–1.98)	3.32 (2.16–5.11)‡	2.32 (0.97–5.60)	1.55 (0.88–2.73)
15–18 years	1.67 (0.93–3.02)	1.20 (0.50–2.90)	2.10 (1.05–4.21)*	1.99 (0.99–3.98)	2.07 (0.29–14.71)	2.29 (1.03–5.10)*

No exposure to parental DBEC as reference.

Both main and secondary diagnoses were considered when coding specific disorders.

[a] The HRs derived from these models were adjusted for ethnicity, year of birth and gender.

[b] The estimates for these variables were generated from separate models.

[c] Short for childhood behavioral and emotional disorders.

*$p < .05$, †$p < .01$, ‡$p < .001$.

nonbereaved people received multiple diagnoses. Childhood behavioral and emotional disorders, and especially attention deficit hyperactivity disorder (ADHD), were the most common comorbid disorders: 41.5% (1469) of people receiving multiple diagnoses received at least one diagnosis of childhood behavioral and emotional disorder. These patients most often received these diagnoses together with a diagnosis of developmental disorder, or they received multiple diagnoses of childhood behavioral and emotional disorders. Other disorders that often co-occurred were depression and anxiety, depression and substance use disorder, multiple forms of anxiety, and multiple forms of substance use disorder.

Children and adolescents who had experienced parental DBEC had a significantly increased risk of psychiatric comorbidity compared to offspring who had not experienced such loss (HR: 1.97, 95%CI: 1.51–2.56).

Discussion

The present study found that children and adolescents who had lost a parent to external causes of death had a significantly increased risk of a wide range of psychiatric disorders and psychiatric comorbidity compared to people who had not experienced such loss. This increased risk was especially evident following parental suicide and accidents such as falls, poisoning, and drowning and impacted daughters and sons equally with respect to their later psychiatric morbidity. Offspring displayed an increased risk from loss throughout their childhood and adolescence, and after losing their mother and father.

Bereaved offspring in Norway have an increased risk of depressive disorders, substance use disorders, psychotic disorders, bipolar disorder, and personality disorders, all in accordance with previous Scandinavian register studies (Berg et al., 2016; Laursen et al., 2007; Wilcox et al., 2010). The present study is, however, the first large-scale population study to report an increased risk of childhood behavioral and emotional disorders, reactions to severe stress, anxiety disorders, developmental disorders, and psychiatric comorbidity. Symptoms of conduct disorder, a subcategory of childhood behavioral and emotional disorders, were reported to be more prevalent in offspring bereaved from all causes compared to nonbereaved peers in a previous US survey study (Kaplow, Saunders, Angold, & Costello, 2010). Another US survey study found a significantly increased risk of PTSD 9 months after parental suicide, but no significantly increased risk of anxiety disorders the first 9 or 21 months after parental suicide (Brent et al., 2009; Melhem et al., 2008). Likewise, a later US survey study also reported significantly higher prevalence of PTSD, but not anxiety disorders, for up to 7 years after the loss of a parent from all causes (Pham et al., 2018). This latter study also reported an increased incidence of functional impairment, such as impairment in school, partially mediated by the development of depression and negative life events. Methodological differences from the present study, including lower sample size and self-report, may account for the differences between the previous survey studies and the present register study.

The only disorder not found to be associated with an increased risk following parental DBEC in the present study was eating disorders, including anorexia nervosa, bulimia nervosa, and overeating. Since no previous study has investigated the impact of bereavement on these specific disorders, the lack of association is difficult to explain. A potential explanation may stem from the lower fertility in women with current or former eating disorders (Stewart, 1992), and a concomitant lower genetic transmission of this disorder to offspring. Note, however, that few people were diagnosed with eating disorders in our cohort, and the results may stem from a lack of statistical power.

Presumably, loss of a close family member can function as an underlying vulnerability factor, as well as provoke, aggravate, or alter the development of psychiatric disorders (Shear & Clayton, 2008). The increased risk of mental ill health following loss of a parent may be explained by both pre- and postbereavement factors, and there may exist a dose–response relationship between the number of pre- and postbereavement factors and the severity of psychosocial sequela (Andriessen, Draper, Dudley, & Mitchell, 2016). Factors preceding the loss that may increase risk of psychiatric disorders include low household resources and parental education (Fauth, Thompson, & Penny, 2009), parental psychiatric illness (Brent, Melhem, Masten, Porta, & Payne, 2012; Melhem et al., 2008), and a family environment characterized by discord and conflict. Such pre-bereavement factors may influence the risks of both parental death and offspring psychopathology and hence function as confounders in the present analyses. Additionally, the emotional closeness of the relationship with the deceased has been reported to influence the mental health of the bereaved following the loss (Andriessen et al., 2016). Previous studies have reported that the association between bereavement and psychosocial sequelae remains significantly increased, albeit reduced, following adjustment for such pre-bereavement factors (Melhem et al., 2008; Pham et al., 2018).

After the loss, postbereavement factors that may increase risk of mental ill health include sleep disturbances (Levenson, Nusslock, & Frank, 2013), lower stress resilience and coping skills (Kennedy et al., 2018; Hoeg et al., 2017), educational challenges (Burrell, Mehlum, & Qin, 2020a), a poor relationship with the remaining parent, and further family problems and lack of social support (Andriessen et al., 2016; Brent et al., 2012). Postbereavement factors function as mediators and contribute to the total effect of bereavement on psychopathology. In addition, there is probably a direct effect of bereavement on mental health due to the sudden nature of external deaths, bereaved offspring's lack of control and preparation, the accompanying shock and potential trauma, and the following rumination, grief, and counterfactual thinking. Combined, these pre- and postbereavement factors may create a negative spiral where one problem enhances another, which again fuels further challenges. The present study is, unfortunately, unable to investigate these specific risk factors.

A general finding throughout the specific diagnoses investigated was that the highest risks were associated with parental suicide and accidental deaths such as poisoning and falls, while deaths due to transport accidents were associated with a lower risk. These differences in risk of psychiatric disorders between different types of accidents have not been previously ascertained, but comparable differences have formerly been reported for bereaved offspring's risk of DSH hospitalization (Burrell et al., 2020b). Different risks of psychiatric disorders associated with different types of accidents may explain previous discrepant findings regarding potential differences between parental suicide and accidental deaths in general (Berg et al., 2016; Brent et al., 2009; Kuramoto et al., 2010; Melhem et al., 2008; Wilcox et al., 2010). An external validation of data from the Cause of Death Register reported that suicides are relatively seldom misclassified as accidental deaths in Norway (Tøllefsen et al., 2015), leaving misclassification as a fairly unlikely explanation for the present findings. A plausible explanation for the discrepancy between different types of accidents is, however, that the risk of psychiatric disorders is significantly higher in people who die from accidental poisonings and falls than in those who die from transport accidents (Crump, Sundquist, Winkleby, & Sundquist, 2013). Similarly, psychiatric disorders are more common in families where members have died by suicide (Melhem et al., 2008). As a result, offspring's family environment prior to the death of a parent to suicide or accidental poisoning or falls may have been problematic and marked by discord, insecurity and instability. Perhaps more importantly, genetic transmission of psychiatric disorders may be prevalent in children and adolescents bereaved by parental suicide and accidental poisonings and falls (Tidemalm et al., 2011). Such genetic transmission will, naturally, not apply to the low number of adoptive children in the present study.

Lack of differences in the risks of psychiatric disorders depending on the gender of the parent and offspring are in accordance with our earlier studies investigating bereaved offspring's risks of suicide (Burrell, Mehlum, & Qin, 2017), educational attainment (Burrell et al., 2020a), and DSH (Burrell et al., 2020b). This lack of gender differences may be a result of the relative gender equality in Norway today concerning child rearing responsibilities and economic and occupational functioning (Statistics Norway, 2012b; World Economic Forum, 2016). As a result, both parents may function as primary attachment figures, the remaining parent of both genders can be able to maintain household resources following the loss, and bereaved daughters and sons may have equal ability to seek social support and express their grief. Future studies can benefit from directly investigating the potential reasons behind the lack of gender differences, for example through interactions with parental socioeconomic status and occupation.

With regard to age at bereavement, previous studies investigating the association between parental death and offspring psychiatric disorders have both reported decreasing risks with increasing age (Berg et al., 2016; Laursen et al., 2007; Mortensen et al., 2003; Tsuchiya et al., 2005; Wilcox et al., 2010) and no systematic changes in associations with regard to age at bereavement (Appel et al., 2013; Wilcox et al., 2010), somewhat dependent on the type of psychiatric disorder investigated. Direct comparison with previous studies is, however, difficult given that many previous studies investigate all causes of death combined (Appel et al., 2013; Berg et al., 2016; Laursen et al., 2007; Mortensen et al., 2003) and different age classifications are used. The present results indicating an increased risk of psychiatric disorders following bereavement throughout childhood and adolescence and a lack of differences between different age groups are in line with our earlier studies on risks of suicide (Burrell et al., 2017), educational attainment (Burrell et al., 2020a), and DSH hospitalization (Burrell et al., 2020b). Notably, this lack of age differences may mask different processes from bereavement to psychiatric disorder, and we can hypothesize that postbereavement factors are more influential when bereavement occurs in early childhood, while pre-bereavement factors are more important when bereavement occurs in later adolescence. The authors are not aware of any present studies investigating the potentially different explanatory mechanisms associated with loss at different ages, and qualitative studies could effectively investigate the abovementioned hypothesis.

The primary strength of the present study is the investigation of disorders for which the scientific and therapeutic communities lack information, specifically anxiety disorders, developmental disorders, childhood behavioral and emotional disorders, eating disorders, and reactions to severe stress, as well as psychiatric comorbidity. Moreover, data in Norwegian registers cover the entire population, ensuring external validity, and are collected systematically and uniformly. The extent of national registers enables a large sample size, increasing statistical power when investigating rare events such as parental DBEC and psychiatric disorders. Furthermore, register studies are not affected by problems caused by sampling and attrition, or biases related to observations and self-report. Data in Norwegian registers hold high quality and are continuously monitored, corrected, and analyzed (Bakken et al., 2019; Pedersen & Ellingsen, 2015).

Present study results must be interpreted in light of limitations, most importantly limitations in data access and the ability to include important confounders and mediators such as the quality of the parent–child relationship, and parental socioeconomic status and psychiatric disorders. Data access also limits the information from the NPR to a relatively short time frame, and some members of the cohort have probably been in contact with specialist mental health services prior to the time period under investigation. These people will be censored, but will in reality possess the event in question. This limitation may lead to a type II error, potentially reducing our chances of significant findings. Additionally, we have only focused on the diagnosis at the first recorded contact in the patient register, which may also imply an underestimation of specific disorders. Moreover, people may suffer from mental illness without being in contact with mental health services, and the present results cannot automatically be generalized to them. A final limitation is a result of the study excluding all offspring without a registered link to parents, effectively excluding disproportionately many first generation immigrants given that their parents are not registered in Norway.

Conclusion

In conclusion, bereaved offspring have a higher risk of a range of psychiatric disorders compared to people who have not experienced such loss, especially following parental suicide and accidental poisonings and falls. The increased risk is evident for daughters and sons, after losing a mother and father and following loss throughout childhood and adolescence. Yet again, results indicate that parental death by external causes has vast and long-lasting effects on bereaved offspring.

Since all children and adolescents who have experienced parental death by external causes have an increased risk of psychiatric disorders, we advocate that all bereaved offspring should be offered supportive follow-up, both in primary healthcare and mental health services. Results from the present study indicate that children and adolescents bereaved by parental suicide and accidental poisonings and falls are especially vulnerable, and we would recommend a particularly proactive follow-up in mental health services for these groups. Follow-up in the form of individual counseling, support groups, and peer-to-peer support can indeed be beneficial in reducing psychopathology (Andriessen, Dudley, Draper, & Mitchell, 2017). Similarly important is to screen for a history of childhood parental bereavement in people suffering from mental illness to more effectively identify important targets for treatment. Future studies can aim to bridge the gap between population-based register studies and recommendations for postvention measures, for example through qualitative studies investigating bereaved offspring's own experience of loss and mental health, how they cope with the loss, and their need for postvention. Furthermore, future studies should aim to investigate the effectiveness of postvention measures, particularly for bereaved children and adolescents (Andriessen et al., 2019).

In addition to an increased awareness of bereavement-related challenges in mental health care, other groups working with children and adolescents, such as teachers, school nurses, and child welfare services should be targeted for increased awareness of bereavement-related sequelae in children and youth. These community gatekeepers are well placed to identify bereaved offspring who are struggling and guide them to seek further help. Most importantly, the extensive and long-lasting sequelae of parental bereavement call for a comprehensive and multilevel follow-up of this vulnerable group, hopefully halting the generational transfer of mental disorder and early mortality.

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Ethical information

The study was approved by the Regional Committee for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the registers.

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Short communication

Co-occurrence of psychosocial sequelae in bereaved offspring

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ABSTRACT

Background: : Previous studies have found that people who have lost a parent to external causes of death during childhood and adolescence have increased risks of psychosocial sequelae. However, we lack information on the potential co-occurrence of these problems. This study aims to investigate the co-occurrence of psychiatric disorders, deliberate self-harm (DSH) hospitalization, and high school non-completion in people who have lost a parent to external causes of death during childhood and adolescence compared to people who have not experienced such loss.

Methods: : The study cohort comprised 655 477 individuals born 1970-2012 with a link to both parents. Data on psychiatric disorders, DSH hospitalization, high school completion and parental death were retrieved from four longitudinal Norwegian registers. Chi-square tests of independence investigated potential differences in co-occurrence between bereaved and non-bereaved people.

Results: : Altogether, 4756 people had experienced the death of a parent due to external causes of death before their 18th birthday. These bereaved offspring had a significantly higher likelihood of having one, two and three adverse outcomes compared to people who had not experienced such loss. Specifically, bereaved offspring had a significantly higher co-occurrence of psychiatric disorders and high school non-completion, but not significantly higher co-occurrences of DSH hospitalization and high school non-completion or DSH hospitalization and psychiatric disorders.

Limitations: : Information concerning DSH hospitalization and psychiatric disorders was only available from 2008 onwards

Conclusions: : The significantly higher co-occurrence in bereaved offspring suggests that the relatively small group of people suffering from extensive sequelae should be particularly targeted for postvention measures.

1. Introduction

In the last few decades, studies based on national registers and self-reports have all reported extensive and long-lasting sequelae in children and adolescents who have experienced the death of a parent (Brent et al. 2009, Wilcox et al. 2010). Bereaved offspring have increased risks of psychiatric disorders, deliberate self-harm, low educational attainment, marital dissolution, and even suicide (Wilcox et al. 2010, Berg et al. 2014, Høeg et al. 2018). No previous study has, however, investigated the co-occurrence of several psychosocial sequelae in children and adolescents who have experienced the death of a parent. It is hence unknown whether the same bereaved offspring struggle with multiple problems, or if co-occurrence differs between bereaved offspring and their non-bereaved peers.

The present study aims to investigate the co-occurrence of psychiatric disorders, deliberate self-harm hospitalization, and high school non-completion in people who have lost a parent to external causes of death during childhood and adolescence compared to people who have not experienced such loss. External cause of death is a classification in the ICD coding system referring to deaths where the cause is external to the body, such as accidents, suicides and homicides.

2. Methods

We retrieved and merged information from four longitudinal Norwegian registers. The Central Population Register provided data on gender and a link to parents' personal identification numbers. We retrieved information on parental death from the Cause of Death Register, and Statistics Norway's Events Database provided information on education. The Norwegian Patient Register (NPR) provided information on hospital treated deliberate self-harm and psychiatric diagnoses, from somatic and psychiatric treatment respectively. The study was approved

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by the Regional Committee for Medical and Health Research Ethics (ref. 2013/1620/REK South East) and owners of the registers.

The present cohort consisted of a 25% random sample of all Norwegian residents born between 1970 and 2012 who had a link to both parents in the Central Population register, comprising 655 477 individuals.

The adverse outcomes investigated were high school non-completion, deliberate self-harm hospitalization and psychiatric disorders. *High school non-completion* was investigated between 1988 and 2012, while hospital treated deliberate self-harm (*DSH hospitalization*) was investigated between 2008 and 2012 and was broadly operationalized to detect probable cases of DSH. *Psychiatric disorders* (ICD-10: F00-F99) from patient's first direct contact with specialist mental health services were investigated between 2008 and 2012. See Burrell, Mehlum & Qin (2020a, 2020b; Burrell et al., 2020 unpublished results) for more information on high school non-completion, DSH hospitalization and psychiatric disorders, respectively. In order to directly compare the co-occurrence of different outcomes, we investigated high school non-completion, DSH hospitalization and psychiatric disorders after age 18.

The explanatory variable of interest is parental death by external causes before offspring turn 18 years, referred to as parental DBEC (ICD-8 and ICD-9 codes E800-E999, ICD-10 codes V01-Y89), investigated between 1970 and 2012.

Chi-square tests of independence (2-tailed) were used to investigate potential differences in co-occurrence between bereaved and non-bereaved people. The analyses were performed for all subjects, and separately for females and males and for cohort members who were between 18-30 years and 30-43 years in 2012, the end of the follow-up period. The analyses were conducted in SPSS Statistics, version 25 (IBM Corp. 2017).

3. Results

In the present cohort, 318 554 (48.6%) were female. Altogether, 4756 people had experienced the death of a parent due to external causes of death before their 18th birthday. Table 1 presents further information regarding sociodemographic data, bereavement-related factors and adverse outcomes.

Table 2 presents results from the chi-square tests of independence for all subjects, and for females, males, 18-30 year olds and 30-43 year olds separately. Regardless of the type of adverse outcome, 39.5% of bereaved offspring had one adverse outcome, 5.3% had two and 1.0% had all three outcomes. The corresponding percentages for non-bereaved people were 32.0%, 2.4% and 0.4%. Evidently, bereaved offspring had a significantly higher likelihood of having one, two and three adverse outcomes (table 2). These significant differences were evident in both females and males and for all ages. For further investigation, each specific combination of outcomes was individually investigated.

Compared to non-bereaved people, bereaved offspring had a significantly higher co-occurrence of psychiatric disorders and high school non-completion (table 2): In bereaved offspring, 66.2% with psychiatric disorders did not finish high school, while the corresponding co-occurrence in non-bereaved people was 55.9%. This difference was evident in females, males and people aged 18-30 years old, but not in people aged 30-43 years.

Furthermore, bereaved offspring had a moderate but not significantly higher co-occurrence of DSH hospitalization and high school non-completion compared to non-bereaved people (table 2): In bereaved offspring, 75.4% with DSH hospitalization did not finish high school vs 66.8% in non-bereaved people. This difference was not significant for females and males, or for people aged 18-30 and 30-43 years old.

Likewise, bereaved offspring did not have a significantly higher co-occurrence of DSH hospitalization and psychiatric disorders compared to non-bereaved people (table 2): In bereaved offspring, 83.6% with DSH hospitalization had a psychiatric disorder, while the co-occurrence in non-bereaved people was 76.8%. The difference was significant for people aged 18-30 years old, but non-significant for people aged 30-43 years, females, and males.

Table 1

Sociodemographic information, bereavement-related factors and adverse outcomes in the study cohort

	All subjects N = 655 477	**Female** N = 318 554	**Male** N = 336 923
Ethnicity			
Native Norwegians	529894 (80.8%)	257495 (80.8%)	272399 (80.8%)
First-generation immigrants	31297 (4.8%)	15135 (4.8%)	16162 (4.8%)
Norwegian-born to one or two foreign-born parents	81139 (12.4%)	39284 (12.3%)	41855 (12.4%)
Foreign-born to one or two Norwegian-born parents	13147 (2.0%)	6640 (2.1%)	6507 (1.9%)
Parental cause of death [a]			
No exposure to parental death by external causes	650721 (99.3%)	316269 (99.3%)	334452 (99.3%)
Suicide	1938 (0.3%)	920 (0.3%)	1018 (0.3%)
Transport accidents	1333 (0.2%)	676 (0.2%)	657 (0.2%)
Other accidents	1267 (0.2%)	593 (0.2%)	674 (0.2%)
Other external causes	218 (0.03%)	96 (0.03%)	122 (0.04%)
Gender of deceased parent			
No exposure to parental death by external causes	650721 (99.3%)	316269 (99.3%)	334452 (99.3%)
Father	3818 (0.6%)	1848 (0.6%)	1970 (0.6%)
Mother	876 (0.1%)	400 (0.1%)	476 (0.1%)
Both parents	62 (0.01%)	37 (0.01%)	25 (0.01%)
Offspring's age at bereavement			
Mean age	8.8	8.9	8.8
High school non-completion [b]	122571 (32.9%)	53641 (29.6%)	68930 (35.9%)
DSH hospitalization [b]	2845 (0.8%)	1512 (0.8%)	1333 (0.7%)
Mean age at DSH hospitalization	26.8	25.7	28.1
Psychiatric disorders [b]	17024 (4.6%)	8947 (4.9%)	8077 (4.2%)
Mean age at receiving a psychiatric diagnosis	26.7	26.6	26.9

[a] Parental cause of death was categorized according to the parent who died first

[b] Numbers, percentages and mean ages are based on cohort members above 18 years

4. Discussion

Being the first study to investigate psychosocial sequelae following parental death in combination, our results indicate that bereaved offspring have a significantly higher likelihood of developing not only one, but two and three co-occurring adverse outcomes compared to non-bereaved peers. This was particularly evident for the co-occurrence of psychiatric disorders and high school non-completion. The results did not find any gender differences, but indicated a slightly higher co-occurrence in the younger age group compared to the older age group. This difference may be due to a higher prevalence of adverse outcomes in young adults, or may be a result of data from the NPR only being available from 2008, rendering older cohort members with limited information on co-occurrence.

The present cohort study is unfortunately unable to determine the causal mechanisms involved in the development of multiple co-occurring psychosocial sequelae following bereavement. We argue that the psychosocial sequelae following bereavement, such as psychiatric disorders, low education, DSH, violent crime and relational difficulties (Wilcox et al. 2010, Berg et al. 2014, Høeg et al. 2018) develop in a negative spiral or developmental cascade (Masten and Cicchetti 2010), where one problem can lead to the development of another, which again fuels the initial problems as well as later symptomatology. In particular, we can postulate that educational challenges may increase the risk of

Table 2

Results from chi-square tests of independence for all subjects, females, males, 18-30 year olds and 30-43 year olds

Total				Female				Male				18-30 years				30-43 years			
DBEC	no DBEC	χ^2	p	DBEC	no DBEC	χ^2	p	DBEC	no DBEC	χ^2	p	DBEC	no DBEC	χ^2	p	DBEC	no DBEC	χ^2	p
1 problem in total																			
39,5 %	32,0 %	129,68	<0,001	34,9 %	29,2 %	40,39	<0,001	43,7 %	34,6 %	92,39	<0,001	45,9%	37,1%	90,09	<0,001	34,1%	27,2%	56,71	<0,001
2 problems in total																			
5,3 %	2,4 %	170,41	<0,001	5,1 %	2,4 %	70,68	<0,001	5,5 %	2,5 %	101,29	<0,001	7,2%	3,1%	138,75	<0,001	3,6%	1,8%	51,49	<0,001
3 problems in total																			
1,0 %	0,4 %	50,35	<0,001	1,3 %	0,4 %	42,24	<0,001	0,7 %	0,4 %	11,86	<0,001	1,6%	0,5%	63,81	<0,001	0,5%	0,3%	4,51	0,034
High school non-completion in patients with psychiatric disorders																			
66,2 %	55,9 %	13,32	<0,001	59,9%	49,9%	6,55	0,011	73,6%	62,5%	7,47	0,006	75,8%	64,2%	10,32	0,001	53,4%	45,7%	3,14	0,076
High school non-completion in DSH patients																			
75,4 %	66,8 %	2,01	0,156	77,1%	63,0%	2,96	0,085	73,1%	71,1%	0,05	0,823	82,5%	71,5%	2,34	0,126	61,9%	60,4%	0,02	0,888
Psychiatric disorders in DSH patients																			
83,6 %	76,8 %	3,56	0,059	88,6%	79,8%	3,69	0,055	76,9%	73,3%	0,44	0,507	82,5%	76,1%	4,17	0,041	85,7%	77,6%	0,22	0,639

psychiatric disorders, and additionally that psychiatric disorders can elevate the risk of poor school performance. As a result of these interactive causal mechanisms, bereaved offspring's increased risk of individual psychosocial sequelae may also entail an increased risk of co-occurrence of multiple sequelae.

The main limitation of the present study is that the NPR only records information from 2008 and onwards, so that people may have received treatment for DSH or psychiatric disorders before the study period. Furthermore, episodes of psychiatric disorder and DSH not leading to treatment in specialist health services have not been registered in the NPR, and we can for example expect that more than 85% of people who self-harm do not receive hospital treatment (Hawton et al. 2002). It is reasonable to assume that we have captured the most severe cases of self-ham and psychiatric disorder through our register based approach. As a result, frequencies and co-occurrences in the present study are probably unnaturally low, but we do not expect these estimates to be biased based on exposure category.

The significantly higher co-occurrence of psychosocial sequelae in bereaved offspring indicates a further liability for this already vulnerable group and suggests that the relatively small group of people suffering from extensive sequelae should be particularly targeted for postvention measures. However, identifying this group constitutes a challenge, and health care personnel and others in contact with bereaved people should investigate whether multiple problems are present. Clearly, a multifaceted approach to postvention is needed. Future studies should expand on the present findings by including more types of psychosocial sequelae, as well as study their interaction and development over time.

5. Author Statement

5.1. *Contributors*

All authors contributed to the study conception and outlined the study design. Qin prepared the data material, and Burrell performed the analyses. All authors interpreted the data results, and the article was written by Burrell. All authors revised the article and approved the finale manuscript.

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Declaration of Competing Interest

None

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