Introduction

The loss of a partner is considered to be one of the most stressful life events and is associated with a number of health-related consequences. In addition to declines in mental (Blanner Kristiansen et al., 2019; Onrust & Cuijpers, 2006; Singham et al., 2021) and physical health (Carey et al., 2014; Jones et al., 2010; Lee & Carr, 2007; Moon et al., 2014), the experience of widowhood has been linked to excess mortality risk (Holm et al., 2019; Moon et al., 2011; Shor et al., 2012). This phenomenon, commonly referred to as the widowhood effect, has been shown to be most detrimental shortly after a partner's death (Moon et al., 2011, 2014). The size of the widowhood effect varies across a range of individual characteristics, including gender, age, migration background, race, and SES (Caputo et al., 2021; Dabergott, 2022; Elwert & Christakis, 2006; Liu, Umberson, et al., 2020; Shor et al., 2012).

Despite the continuously growing number of non-heterosexual partnerships (Gates, 2012), the gender composition of a union has not been considered when exploring the widowhood effect. In general, previous research has shown that sexual minority people face significant disadvantages compared to straight people in various dimensions of health (Zeeman et al., 2019), including elevated overall mortality risk (Cochran et al., 2016; Frisch & Brønnum-Hansen, 2009). However, more research is needed on the vulnerability of the sexual minority people in the context of major stressful life events, such as widowhood, in comparison to the heterosexual population. The present study responds to calls for the necessity of identifying and evaluating existing health inequities, as a fundamental step towards achieving health equity (Braveman et al., 2018), a commitment that is outlined in the United Nations' Agenda 2030 (UN General Assembly, 2015). Therefore, the objective of this study is to evaluate the disparities in mortality risk following the loss of a partner between individuals who were in a same-sex union compared to those who were in a mixed-sex union.

Background

Previous research has offered several explanations for the relationship for excess mortality after a partner's death. First, it is the stress connected with the experience of partner loss that constitutes a health-threatening situation for the surviving partner (Ennis & Majid, 2020). Relatedly, the severity of health consequences following partner loss depends on the social support resources available to the individual (Holm et al., 2019). Finally, the loss of the beneficial effects a marriage provides for individuals' health contributes to increased mortality risk after the death of a partner (Halleröd, 2013; Lillard & Waite, 1995). It is likely that

experiences of stress during widowhood, social support resources, and the loss of marital health benefits differ between same-sex and mixed-sex partners.

Minority Stress during Widowhood

The transition into widowhood and the following period of bereavement are accompanied by grief, pain and other negative emotions (Shear, 2015). The experience of such emotional distress can lead to a number of adverse physical (Ennis & Majid, 2020; Fagundes et al., 2019; Slavich & Irwin, 2014), mental (Keyes et al., 2014; LeBlanc et al., 2019) and behavioral (Umberson et al., 2008) health consequences. Generally, stress during widowhood is a universal experience regardless of an individual's sexual orientation or the gender composition of a previous union (Bristowe et al., 2016). However, people who lost a partner of the same gender may face additional. For individuals in same-sex unions, the experience of losing a partner may be further influenced by exposure to specific minority stressors, as suggested by Meyer's minority stress theory (Meyer, 2003). The minority stress theory posits that individuals from socially marginalized groups experience distal (e.g., discriminatory policies and laws and stigma) and proximal (e.g., internalized stigma and concealment) stressors, contributing to negative mental and physical health outcomes (Frost & Meyer, 2023; Meyer, 2003). In times of bereavement these minority stressors may include the lack of acknowledgement of their former relationship and grieving experiences, as well as prevailing societal stigma and prejudices about the health of the sexual minority population.

Compared to losing a mixed-sex partner, the experience of losing a same-sex partner is not yet commonly understood nor socially expected (Patlamazoglou et al., 2018). If a same-sex union is closeted, not accepted or rejected in the social environment, the surviving partner may be excluded from discussion and decision-making, as well as grieving rituals surrounding the partners' death (Bristowe et al., 2016). The lack of recognition and social validation of the relationship, the loss and the griever can lead to a form of "disenfranchised grief" (Doka, 1989) creating additional stress among surviving same-sex partners (Piatczanyn et al., 2016).

Additionally, stress among surviving same-sex partners may be a consequence of exposure to prevalent societal stigma and prejudice about the sexual minority population and their health. Bereavement experiences, especially those of gay and bisexual men, are shaped by prevailing societal stigma associated with HIV/AIDS, which is often believed to be the cause of death among this group (Hornjatkevyc & Alderson, 2011). Regardless of the actual cause of death of

the partner, surviving same-sex partners describe the feeling of social pressure to reveal details about their partner's death, fearing impact on their support network or job loss otherwise (O'brien et al., 2002). Further societal stigma faced by sexual minority people is attributed to the persistent narrative that belonging to a sexual minority is related to unhappiness (Ferlatte et al., 2019). For example, individuals who lost their same-sex partner to suicide deal with stigma around mental health and suicidality among sexual minority populations and feel that they are reinforcing the prejudices against them (Ferlatte et al., 2019).

Limited Social Support for Surviving Same-Sex Partners

According to the stress-buffering theory, the deleterious health effects of stress can be reduced through social support (Cohen & Wills, 1985). In the context of widowhood, studies have demonstrated that the elevated mortality risk experienced by widowed individuals can be mitigated by social support (Holm et al., 2019). As a spouse's death also means losing the main source of long-standing companionship and social support, widowed individuals need to rely on alternative sources of social support. Although the unique form of social support individuals receive from their marital partner cannot be fully compensated for (Stroebe et al., 1996), the experience of support from family, friends or external support groups can weaken emotional pain and suffering after widowhood (Aoun et al., 2015; Holm et al., 2019). Widowed individuals with large networks of social support indeed have lower mortality risk than those who cannot rely on alternative sources of social support (Holt-Lunstad et al., 2015; Rico-Uribe et al., 2018).

Among surviving same-sex partners, elevated stress levels upon partner loss may be less likely to be compensated for through social support. Previous research suggests that people in same-sex unions cannot rely on support from their social environment to the same extent as people in mixed-sex unions. Due to family members' heterosexist attitudes, surviving same-sex partners are more likely to lose contact with their family and, thus, cannot rely on them as source of social support (Ferlatte et al., 2019; Ingham et al., 2017). Because same-sex couples are less likely to have children of their own, fewer surviving same-sex partners can rely on support from their offspring than mixed-sex partners (Gates et al., 2007). Additionally, people who have lost a same-sex partner lack appropriate professional support, such as bereavement support services, to express their pain and loss (Glackin & Higgins, 2008). Since professional support groups for surviving partners often reproduce heteronormative structures, people who lost their same-sex partner express the need to find safe spaces during the grieving process (Singham et al., 2021;

Valenti et al., 2021). Consequently, stress levels following the loss of a same-sex partner may be less likely to be alleviated by social support, given their smaller social networks. This may exacerbate inequalities in mortality risk associated with loss between surviving same-sex and mixed-sex partners.

More Equal Relationship Dynamics among Same-Sex Couples

Relationship dynamics in same-sex marriages differ from those in heteronormative marriages, which may lead to differential mortality risks during marriage and widowhood. Despite the declining significance of gender in determining social roles and in the division of labor between both partners, the relationship dynamics of many mixed-sex couples are rather static and conservative (Bianchi et al., 2000; Kleven et al., 2019). Studies suggest that although marriage confers benefits for both partners, the advantages men derive from marriage exceed those women receive (Liu, Umberson, et al., 2020; Manzoli et al., 2007). Women's health is primarily enhanced by their partners' provision of higher financial resources to the marriage, thereby improving their health through better nutrition, care in times of illness, and access to healthcare (Liu, Reczek, et al., 2020). Conversely, the health of men has been shown to benefit from women's effort in the household, including the preparation of meals and the monitoring of prescriptions (Halleröd, 2013; Umberson, 1992; Umberson et al., 2018). Furthermore, women positively influence their spouses' health behaviors through social control (Umberson, 1992). After a partner's death, the protective health effects of a marriage no longer exist, which leads to a deterioration in the surviving partner's health and an increased mortality risk (Brockmann & Klein, 2004). Whereas women are more affected by the loss of their partners' financial income and therefore face financial strains, men suffer from difficulties in taking on household tasks including the control and management of their own health. In short, gendered health effects during marriage driven by the gendered relationship dynamics in heteronormative marriages turn into a gendered widowhood effect (Dabergott, 2022), whereby, the greater marital health advantages of men translate into a greater deficit resulting in a greater widowhood effect for men (Moon et al., 2011; Shor et al., 2012). Whether such gender differences in the effect of widowhood on mortality can also be found Denmark, as a country with low levels of gender inequality (Dilli et al., 2019), has not been investigated yet. Denmark has progressed from a country with considerable gender disparities in the 1950s to one with high levels of gender equality in recent times, though some significant gender disparities still remain (Aboim, 2010; Dilli et al., 2019). Previous research in Denmark indicated that widowed

men had elevated mortality for most causes of death, while widowed women experienced increased mortality from cardiovascular diseases and psychiatric diseases/suicide (Sloth et al., 2025). Other studies showed that although women visited a doctor more often and used more prescription medications, including psychotropic drugs, than men, there was no gender-specific pattern in healthcare use post-widowhood (Oksuzyan et al., 2011; Santacroce et al., 2018). Research from Sweden, a country with comparable levels of gender equality (Aboim, 2010), demonstrated that gendered effects of widowhood on mortality varied across socio-economic status (Dabergott, 2022).

The relationship dynamics among same-sex couples may have different implications for their health during both marriage and widowhood. In recent years, scholars have argued that instead of viewing gender as static and binary, it should be understood as a dynamic and situational construct (Springer et al., 2012). Building on that, the gender-as-relational approach emphasizes that people in romantic relationships enact gender not individually but in relation to the gender of people they interact with (Reczek & Umberson, 2016; Thomeer et al., 2020). From this perspective, the social roles women and men take on within a marriage may vary depending on whether they are married to a woman or a man. For example, both women and men are more likely to control their partner's health behavior when they are married to a man than to a woman (Umberson et al., 2018). The division of labor within couples, such as contributing to financial and household resources, is also more equally distributed within same-sex couples than within mixed-sex couples (Van Der Vleuten et al., 2021). The higher equality among same-sex partners in terms of the division of labor, social support work, the reciprocal influence on health habits, and the social control in marriage compared to mixed-sex partners may contribute to a higher level of health concordance (Holway et al., 2018; Umberson et al., 2018).

The higher health concordance among same-sex couples can have two distinct implications for post-widowhood health declines. On one hand, the mortality risk after the partner's death may increase to a greater extent among surviving same-sex partners than mixed-sex partners. Given the higher health concordance among same-sex couples, surviving same-sex partners may be more likely to have the same health condition(s) that led to the partner's death. This would increase the mortality risk of the surviving partner.

On the other hand, less gendered relationship dynamics may also facilitate a more effective adaption to the new life situation without a partner's health-enhancing influence. As both partners in a same-sex marriage more equally contribute to both financial and household resources (Van Der Vleuten et al., 2021), this may result in reduced dependency on their partner.

Thus, less adjustment may be required after the partner's death among same-sex than mixed-sex partners. In the long term, this might lead to lower mortality risk among surviving same-sex partners than among mixed-sex partners.

Method

Study design

The current study utilizes Danish population register data (Jensen & Rasmussen, 2011; Pedersen, 2011; Petersson et al., 2011), i.e., the Central Person Register, the Integrated Database for Labor Market Research, the Population Education Register, and the Fertility Database. Denmark was the first country in the world to grant same-sex couples the right to legally register their partnership on 1st of October 1989, which marks the starting date of the current study. The end of the study period is 31th December 2022. Our study sample included 3,531,911 individuals aged 18 and over who were ever married or in a registered partnership, that did not end in dissolution. We excluded individuals who had missing information on employment and income (n = 52,706). Individuals entered the study when they married or registered their partnership or on 01.10.1989 in case of an earlier marriage. They were followed until the end of the study or the date of death, whichever came first.

Alternative study design

Due to legal restrictions that prohibited formal registration of same-sex partnerships in Denmark until October 1989, our study sample includes only same-sex partnerships that were registered in the period from 1989 to 2022. In contrast, the sample of the mixed-sex couples includes also earlier marriages, which may result in varying average durations of institutionalized unions between these two groups. Therefore, supplementary analyses included only mixed-sex couples with marriages starting on or after October 1989.

Measures

To examine differences in the widowhood effect by relationship type, the main variables of interest used in this study are widowhood status and relationship type. As an indicator of widowhood status, individuals are categorized into continuously married/ in a registered partnership, widowed for up to three years or widowed for three or more years after the date of

partner's death. Although widowhood has been found to have the greatest detrimental effect on health within the first six months after loss (Moon et al., 2011; Shor et al., 2012), we could not have smaller post-widowhood time intervals due to small numbers of deaths among surviving same-sex partners. Union type measures whether a person is in an institutionalized mixed-sex union with a partner of a different gender, or in an institutionalized same-sex union with a partner of the same gender as their own. In order to account for socioeconomic differences by union type, education, income and employment status were included as time-varying covariates. Education was categorized based on the Danish classification of education (DISCED-15) into low (Levels 0-2), medium (Level 3), high (Level 4-8) education. We used disposable family income, which is corrected for the number of people within the family. The income categories (low, medium and high) were derived from the yearly income distribution across the Danish population, split into tertiles. Employment status indicates whether a person is currently working for pay or not. Additionally, as time-constant covariates, gender (woman or man), parental status (at least one child or no child), birth cohort (before 1922, 1922-34, 1935-49, 1950-64, 1965-80, 1981-95 or after 1995) and a remarriage indicator (not remarried after widowhood or remarried after widowhood) have been incorporated into the models.

Statistical analyses

To examine the association between the main predictors, i.e., widowhood status, relationship type and their interaction, and the risk of death, we employed Cox proportional hazard models (Cox, 1972). The time scale was a function of age, with death due to any cause as the failure event. We estimated a total of four Cox regression models, each gradually adjusting for additional covariates. The first model included widowhood status, union type and gender. In the second model, we added an interaction term between widowhood status and union type to assess whether the effect of widowhood on mortality differed by union type. The third model further adjusted for sociodemographic characteristics, including income, education, employment status, parental status, and remarriage status. Finally, we additionally controlled for birth cohort in the fourth model. Hazard ratios (HRs) and 95% confidence intervals (CIs) are reported for all models. The proportional hazards assumption was assessed using Schoenfeld residuals after fitting each model. Based on the estimates of Model 4, survival curves for each comparison group were plotted to facilitate the understanding of the interaction between widowhood status and union type. Thereby the baseline survival function was estimated non-parametrically from the observed data. Survival curves for specific groups were

then calculated by applying the estimated hazard ratios to the baseline survival, yielding model-based survival estimates adjusted for covariates. The shown survival curves refer to estimates of men, who are employed, have medium income and education, have at least one child, are not remarried and are born between 1950 and 1964. All statistical analyses were conducted using the tidyverse (Wickham et al., 2019) and survival package (Therneau, 2024) in R, and the survminer R package (Kassambara et al., 2024) was used for the visualization of survival curves.

Results

Sample characteristics

Table 1 shows descriptive statistics by type of relationship. The study population comprised 3,515,465 individuals in mixed-sex unions and 16,446 in same-sex unions. Widowhood was more prevalent among individuals in mixed-sex unions, with approximately 18% experiencing the loss of a partner, compared to 7.1% among those in same-sex unions. This may be because people in same-sex unions were younger at the time of partner's death and at the start and the end of the study period. Persons in same-sex unions experienced loss of the partner at much younger ages than those in mixed-sex unions. Among widowed individuals, the proportion of those who died following the loss of their partner was 59.4% among individuals in same-sex unions and therefore lower compared to 34.7% among those in same-sex unions. Conversely, the proportion of remarried individuals was higher among surviving same-sex partners. Specifically, 15.2% of individuals who experienced same-sex partner loss remarried, whereas 4.1% of those who experienced mixed-sex partner loss remarried. The gender distribution was similar in same-sex unions and mixed-sex relationships. Individuals in same-sex unions were more likely to have high education and high income and were slightly more likely to be employed at study entry than their peers in mixed-sex unions. The share of people in same-sex unions who had at least one child was substantially lower compared to people in mixed-sex unions.

Table 1. Characteristics of the study population by relationship type

	Same-sex Relationship	Mixed-sex Relationship
Characteristic	**N = 16,446**	**N = 3,515,465**
	Mean (SD)	Mean (SD)
Age at first entry into the study	40.11 (11.36)	44.31 (14.93)
Age at last exit from the study	46.25 (12.66)	50.55 (16.85)
Age at widowhood	58.99 (14.49)	71.31 (11.82)
	%	%
Gender		
Women	48%	50%
Men	52%	50%
Education[b]		
Low education	19%	31%
Medium education	26%	32%
High education	49%	27%
Unknown/ Missing	5.4%	11%
Income[b]		
Low income	18%	32%
Medium income	39%	36%
High income	43%	32%
Employment status[b]		
Not working	22%	27%
Working	78%	73%
Parental status		
No child	74%	18%
At least one child	26%	82%
Birth cohort		
Before 1922	0.6%	8.5%
1922 - 1934	2.1%	13%
1935 - 1949	11%	22%
1950 - 1964	23%	22%
1965 - 1980	37%	21%
1981 - 1995	26%	12%
After 1995	1.2%	0.5%
Number of deaths, 1989-2022	1,733 (11%)	1,094,259 (31%)
Widowed, 1989-2022	1,168 (7.1%)	650,084 (18%)
Remarried after widowhood	177 (15.2% [a])	26,481 (4.1% [a])
Number of deaths 0-3 years post-widowhood	124 (10.6% [a])	86,869 (13.4% [a])
Number of deaths 3+ years post-widowhood	281 (24.1% [a])	299,430 (46.1% [a])

Note: [a]*Percentage of widowed individuals*
[b] *Education, income, employment at the study entry*

When we applied the alternative study design restricting the sample to marriages since 1989, our sample of mixed-sex unions was reduced to 1,636,313 individuals (see Supplementary Table A1). Both the proportion of widowed people (3.8%) and deceased individuals after widowhood (19.9%) among mixed-sex unions were now lower than in the population in same-sex relationships. Also, individuals in mixed-sex unions now entered and exited the study at younger ages than partners in same-sex unions, whereas the age at widowhood becomes more equal between both groups. Additionally, the sample restriction partially reduced the differences in education, income, employment between the two union types. The share of individuals belonging to earlier birth cohorts is now larger among those in mixed-sex unions.

The Widowhood Effect on Mortality by Relationship Type

Model 1 of Table 2 shows that by holding gender constant, individuals in same-sex unions had a 25% (HR = 1.25, CI = 1.19-1.31) higher mortality hazard compared to individuals in mixed-sex unions. Relative to individuals who were continuously married or in a registered partnership, widowed individuals had a 20 % (HR = 1.20, CI = 1.19-1.21) higher mortality hazard within the first three years after partner loss and 17% (HR = 1.17, CI = 1.17-1.18) three or more years post-widowhood. Additionally, women had a 34% (HR = 0.66, CI = 0.66-0.67) lower mortality hazard in comparison to men.

Model 2 additionally includes the interaction between widowhood status and union type. As in Model 1, Model 2 shows a higher hazard of death for women compared to men (HR = 0.66; CI = 0.66-0.67). It also indicates that married individuals in same-sex unions have a higher mortality hazard than those in mixed-sex unions (HR = 1.23; CI = 1.17-1.30). Among individuals in mixed-sex unions, the mortality hazard is higher among widowed individuals over short (HR = 1.20; CI = 1.19-1.21) and long durations (HR = 1.18; CI = 1.18-1.19) of widowhood than among married individuals. The interaction term suggests that the increase in mortality in the first three years of widowhood is higher among individuals in same-sex unions than among those in mixed-sex unions (HR = 1.31; CI = 1.09-1.57). In contrast, the increase in mortality hazard associated with widowhood after three or more years is similar among individuals in same-sex and mixed-sex unions (HR = 0.99; CI = 0.87-1.12).

Similar patterns are observed after adjusting for socioeconomic variables in Model 3, which also indicates that the mortality hazard decreased with income and education. Individuals who were employed, had at least one child and those who remarried following the loss of a partner have a lower mortality hazard relative to their peers who were unemployed, have no child and

Table 2. Mortality hazard ratios by relationship type

	Model 1		Model 2		Model 3		Model 4	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Relationship Type (ref: Mixed-sex Relationship)								
Same-sex Relationship	1.25***	1.19 - 1.31	1.23***	1.17 - 1.30	1.19***	1.13 - 1.26	1.32***	1.25 - 1.39
Widowhood status (ref: Married/ Registered partnership)								
Widowhood: 0-3 years	1.20***	1.19 - 1.21	1.20***	1.19 - 1.21	1.18***	1.17 - 1.19	1.17***	1.16 - 1.18
Widowhood: 3+ years	1.17***	1.17 - 1.18	1.17***	1.17 - 1.18	1.18***	1.18 - 1.19	1.19***	1.18 - 1.19
Relationship Type * Widowhood status								
Same-sex Relationship * Widowhood: 0-3 years			1.31**	1.09 - 1.57	1.28**	1.06 - 1.54	1.23*	1.03 - 1.48
Same-sex Relationship * Widowhood: 3+ years			0.99	0.87 - 1.12	0.99	0.87 - 1.13	0.97	0.85 - 1.10
Gender (ref: Men)								
Women	0.66***	0.66 - 0.67	0.66***	0.66 - 0.67	0.62***	0.62 - 0.62	0.62***	0.62 - 0.62
Income (ref: Low income)								
Medium income					0.91***	0.90 - 0.91	0.91***	0.91 - 0.92
High income					0.94***	0.93 - 0.94	0.93***	0.93 - 0.94
Education (ref: Low education)								
Medium education					0.89***	0.88 - 0.89	0.91***	0.91 - 0.92
High education					0.74***	0.74 - 0.75	0.78***	0.77 - 0.78
Unknown/ Missing					0.98***	0.98 - 0.99	0.85***	0.84 - 0.86
Employment Status (ref: Not working)								
Working					0.39***	0.39 - 0.39	0.39***	0.39 - 0.40
Parental status (ref: No child)								
At least one child					0.86***	0.86 - 0.87	0.89***	0.89 - 0.90
Remarried after widowhood (ref: Not remarried)								
Remarried					0.68***	0.66 - 0.70	0.70***	0.68 - 0.71
Birth cohort (ref: Before 1922)								

Table 2. Mortality hazard ratios by relationship type

	Model 1		Model 2		Model 3		Model 4	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
1922 - 1934							0.84***	0.84 - 0.85
1935 - 1949							0.69***	0.68 - 0.69
1950 - 1964							0.58***	0.57 - 0.58
1965 - 1980							0.32***	0.31 - 0.33
1981 - 1995							0.18***	0.17 - 0.20
After 1995							0.14***	0.07 - 0.27

Note: [a] HR: Hazard Ratio, CI – Confidence Interval

*p<.05; **p<.01; ***p<.001

did not remarry. All patterns remained the same in Model 4, which additionally adjusts for the birth cohort. It also demonstrates that the younger the cohort, the lower their mortality hazard.

Figure 1 provides a visualization of differences in survival probabilities over age by widowhood status and union type, which have been calculated based on Model 4. It illustrates that mixed-sex married individuals consistently have a survival advantage relative to their peers in same-sex unions regardless of widowhood status. Married individuals in mixed-sex unions have the highest survival probability across all groups followed by widowed individuals in mixed-sex relationships. Among individuals in same-sex unions, the highest probability of survival is observed among those who are married, whereas those who had recently lost a same-sex partner had the lowest probability of survival. For example, looking at individuals at the age of 70, married individuals in mixed-sex unions had an 87.5% probability of surviving, whereas recently or long-term widowed individuals both had a survival probability of approximately 85.3%. In same-sex unions, married individuals aged 70, had an 83.8% survival probability, whereas the survival probabilities are 77.5% for those who are widowed for 0-3 years and 81.6% for those who are widowed more than 3 years. Following, the percental reduction in survival probabilities within the first three years after partner loss is higher for individuals in same-sex unions than those in mixed-sex unions. Three or more years after partner loss, individuals in same-sex and mixed sex unions have similar percental survival probability decrease.

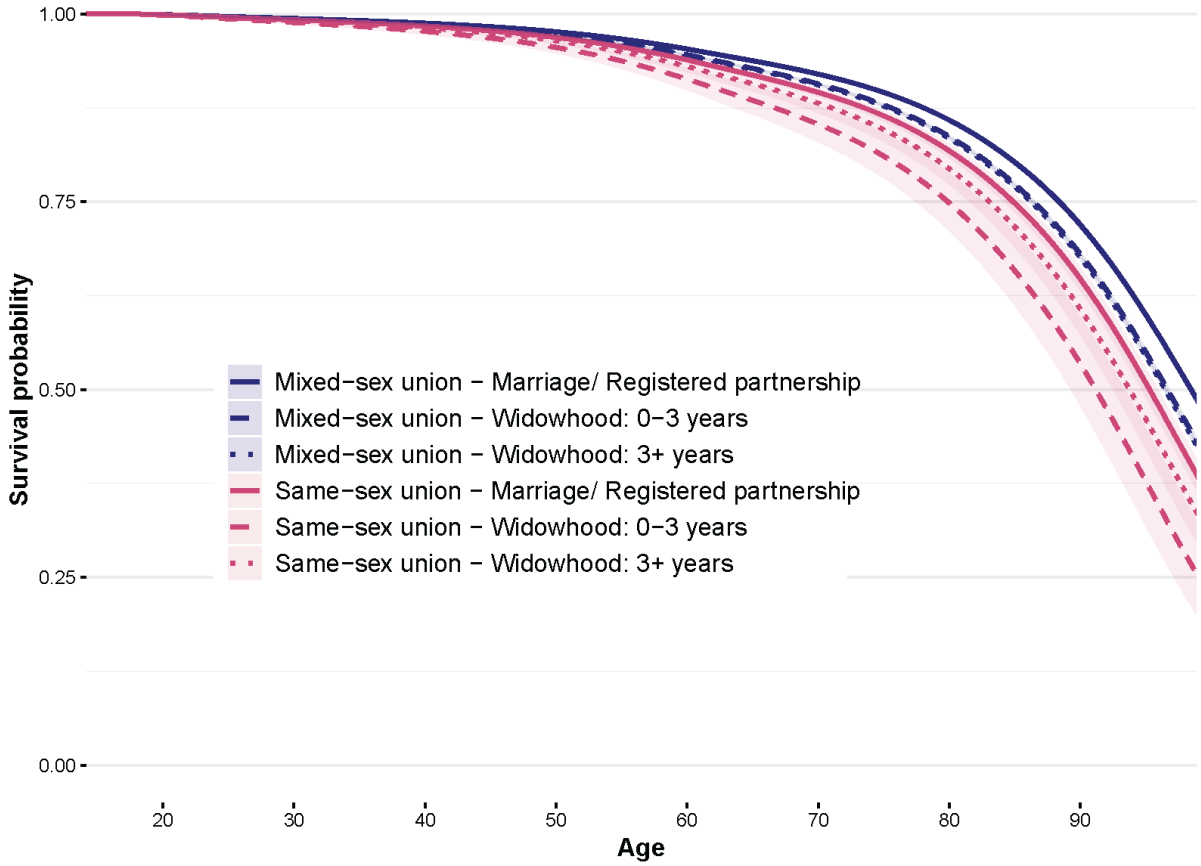

Figure 1. Age-specific probability of survival by widowhood status and union type in Denmark

Note: Model-based survival curves for estimates of men, who are employed, have medium income and education, have at least one child, are not remarried and are born between 1950 and 1964

Supplementary Analyses

The results of supplementary analyses can be found in Supplementary Table A2. Similar to the main analysis, in all models, individuals in same-sex unions and widowed individuals have higher mortality hazards relative to mixed-sex married individuals, respectively. However, in the restricted sample, the interaction terms between widowhood status and union type indicated that the increase in mortality hazard within the first three years of widowhood is slightly but not significantly higher (HR = 1.06, 95%, CI: 0.88-1.28), while it is significantly lower among individuals with 3 or more years of widowhood (HR = 0.74, 95%, CI: 0.65-0.84) among individuals in same-sex unions compared to those in mixed-sex marriages. The relationships between all covariates and mortality in the supplementary analyses are similar to those observed in the main analyses.

Discussion

The present study is to our knowledge the first to undertake a quantitative evaluation of the impact of same-sex partner loss on an individual's mortality risk. Our analyses reveal that individuals in same-sex relationships had a higher mortality hazard compared to those in mixed-sex relationships during marriage and widowhood. Our results suggest a higher widowhood effect among individuals who have lost a same-sex partner. We also show that, over longer durations of widowhood, the differences in mortality risk between individuals with same-sex and mixed-sex partners became similar to pre-loss differences.

Our results suggest a disproportionately stronger short-term widowhood effect among individuals who have lost a same-sex partner compared to those who have lost a mixed-sex partner. In other words, the already higher risk of death for people in same-sex unions increases to a greater extent than for people in mixed-sex unions within the initial three years following widowhood. This higher increase in mortality risk may be partly attributed to higher stress levels experienced by surviving same-sex partners in comparison to surviving mixed-sex partners. The stress associated with partner loss may be exacerbated by situational minority stressors during widowhood for individuals who have been in a same-sex relationship (Frost & Meyer, 2023; Meyer, 2003). Surviving same-sex partners' lack of social recognition of their previous union and their grieving experiences, compounded by societal stigma and prejudice against sexual minorities and their health, may exacerbate experienced stress. This stress related to the minority status of people who have lost a same-sex partner experience may lead to unequal mortality risks following widowhood. Given the smaller social support networks of people in same-sex unions (Ferlatte et al., 2019; Ingham et al., 2017), the elevated stress levels following partner loss are less likely to be mitigated by social support than among those in mixed-sex unions. Consequently, the negative health consequences associated with same-sex partner loss may persist and intensify, potentially leading to reinforced health inequalities between surviving same-sex and mixed-sex partners.

The higher health concordance among same-sex partners may also contribute to their greater increase in mortality risk following the loss of a same-sex partner. A higher health concordance of partners in same-sex unions results from less gendered relationship dynamics, including an equal share to the contribution to health-enhancing relationship (Holway et al., 2018; Umberson et al., 2018). In contrast, gendered relationship dynamics in mixed-sex couples lead to differences in each partner's contribution to shared resources by gender (Bianchi et al., 2000;

Kleven et al., 2019). In case of the partner's death, the higher health concordance of same-sex partners may increase the risk of death among surviving partners.

However, a higher excess mortality post-widowhood among individuals who were in a same-sex union appear to fade over time. The same mechanisms that contribute to higher health concordance among same-sex couples may facilitate more effective adaption to the new life situation without the partner and their health-enhancing effects. Whereas in same-sex unions, partners tend to contribute more equally to financial and household resources, social support, and the regulation of each other's health behaviors, in mixed-sex marriages each partners contribution is more likely to depend on their gender (Holway et al., 2018; Van Der Vleuten et al., 2021). Thus, surviving mixed-sex partners may suffer from the removal of partner's contribution to their daily life with adverse consequences for their health. Surviving same-sex partners, on the other hand, may be less reliant on the deceased partner's specific contributions, and consequently, they may experience an easier adaption to the new life circumstances after the partner's loss. As their health may be less dependent on the positive health contributions of the deceased partner, the increase in mortality risk due to the loss of marital health advantages may be reduced over time.

The supplementary analyses entailed the restriction of the sample of mixed-sex couples who married after 1 October 1989 to make them more comparable to same-sex couples in terms of institutionalized union duration. Although the interaction between short-term widowhood and relationship type was - in contrast to the main analyses - not significant, the analysis of the restricted sample showed a higher mortality risk in the first three years of widowhood for surviving same-sex than mixed-sex partners. The increase in mortality risk three or more years post-widowhood was significantly lower among surviving same-sex partners than mixed-sex partners. Given earlier findings that widowhood is more detrimental to health at younger ages (Shor et al., 2012), more similar ages at widowhood in the restricted sample of mixed-sex and same-sex unions may explain smaller differences in the effect of widowhood in our supplementary analyses. However, while the sample restriction may reduce differences in the duration of legally institutionalized relationships, it may introduce another bias related to the total relationship duration, including cohabitation prior to legal recognition. Selection into marriage after October 1989 may differ substantially between same- and mixed-sex couples. Many same-sex partners, who have lived as a couple for many years, may have formalized long-standing relationships only after legal pathways became available, whereas no legal restrictions were imposed on mixed-sex couples. The implications of these differing pathways

into marriage for health selection remain underexplored. Consequently, by restricting the mixed-sex sample to marriages formed after 1989 we still may not be able to create comparable groups with respect to the relationship duration and trajectories.

Besides the lack of clarity about differences in health selection mechanisms into marriage between same-sex couples and mixed-sex couples and their implications for the widowhood effect, our study has several other limitations. The current study includes only individuals who are part of institutionalized unions. The structure of the Danish register data does not allow us to extend our analyses to cohabitating partners or other partnership and household forms. Besides not reflecting the current trend in diversification of family forms, this may result in a selective sample of same-sex partnered individuals. Though socioeconomic differences between cohabiting and married couples were found to be smaller among same-sex than mixed-sex couples (Perry et al., 2025), socioeconomic characteristics determine the likelihood of individuals' disclosure sexual minority status and the resulting health consequences (McGarrity & Huebner, 2014). This is in line with earlier findings that married same-sex couples tend to have higher SES than their mixed-sex counterparts (McGarrity, 2014), which is also reflected in the characteristics of our study sample. Additionally, administrative data does not allow us to identify individuals based on self-reported gender identity and sexual orientation. Accessing the information in official registers can lead to misclassifications and does not capture the whole spectrum of gender identity and sexual orientation. Further, due to limited occurrence of death among same-sex partnered women we were not able to examine the relationship between widowhood and mortality separately for women and men. Moreover, this study did not test the mechanisms connecting the relationship between widowhood and mortality risk. Future research should aim to explore explanations for the disparities in mortality risk between same-sex and mixed-sex partnered individuals that were shown to increase in times of widowhood.

Although more research is needed, the present study is the first large-scale investigation of differences in the relationship between widowhood and mortality between individuals in same-sex and mixed-sex relationships. Our finding that persons in a same-sex relationship are at greater risk of dying shortly after losing a partner than their peers in mixed-sex relationships adds to research highlighting that minority groups may be especially vulnerable to the effects of major stressful life events. Our study also suggests that greater equality in same-sex unions may help them better adjust to the new life circumstances and may contribute to leveling out long-term health consequences of a partner's death.

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Appendix

Supplementary Table A1. Descriptive Statistics of the Restricted Study Population by Relationship Type in Percentage or Mean (SD)

	Same-sex relationship	Mixed-sex relationship
Characteristic	**N = 16,430**	**N=1,636,313**
Age at first entry into the study	40.10 (11.35)	35.77 (10.32)
Age at last exit from the study	46.23 (12.62)	44.27 (12.03)
Age at widowhood	58.97 (14.50)	58.87 (13.40)
Gender		
Women	48%	50%
Men	52%	50%
Education[b]		
Low education	19%	23%
Medium education	26%	33%
High education	50%	39%
Unknown/ Missing	5.4%	5.5%
Income[b] (tertiles)		
Low income	18%	24%
Medium income	39%	41%
High income	43%	35%
Employment status[b]		
Not working	22%	22%
Working	78%	78%
Parental status		
No child	74%	20%
At least one child	26%	80%
Birth cohort		
Before 1922	0.6%	0.1%
1922 - 1934	2.1%	0.7%
1935 - 1949	11%	5.5%
1950 - 1964	22%	22%
1965 - 1980	37%	45%
1981 - 1995	26%	26%
After 1995	1.2%	1.1%
Number of deaths, 1989-2022	1,728 (11%)	80,665 (4.9%)
Widowed, 1989-2022	1,164 (7.1%)	62,169 (3.8%)
Remarried after widowhood	176 (15.1% [a])	6,994 (11.2% [a])
Number of deaths 0-3 years post-widowhood	124 (10.6% [a])	3,238 (5.2% [a])
Number of deaths 3+ years post-widowhood	280 (24.1% [a])	9,125 (14.7% [a])

Note: [a]Percentage of widowed individuals
[b] Education, income, employment at the study entry

Supplementary Table A2. Mortality Hazard Ratios by Relationship Type

	Model 1		Model 2		Model 3		Model 4	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Relationship Type (ref: Mixed-sex Relationship)								
Same-sex Relationship	1.36***	1.30;1.43	1.43***	1.36;1.51	1.30***	1.23;1.37	1.27***	1.20;1.34
Widowhood status (ref: Married/ Registered partnership)								
Widowhood: 0-3 years	1.56***	1.51;1.62	1.56***	1.51; 1.62	1.37***	1.33;1.42	1.36***	1.31;1.41
Widowhood: 3+ years	1.57***	1.53;1.61	1.59***	1.55;1.63	1.44***	1.40;1.47	1.45***	1.41;1.49
Relationship Type * Widowhood status								
Same-sex Relationship * Widowhood: 0-3 years			1.06	0.88;1.28	1.13	0.93;1.36	1.11	0.92;1.34
Same-sex Relationship * Widowhood: 3+ years			0.74***	0.65;0.84	0.78***	0.68;0.88	0.78***	0.68;0.89
Gender (ref: Men)								
Women	0.68***	0.67;0.69	0.68***	0.67;0.69	0.62***	0.61;0.63	0.63***	0.62; 0.64
Income (ref: Low income)								
Medium income					0.85***	0.84;0.87	0.85***	0.84;0.87
High income					0.67***	0.66;0.69	0.69***	0.67;0.70
Education (ref: Low education)								
Medium education					0.85***	0.84;0.87	0.86***	0.85;0.88
High education					0.69***	0.68;0.71	0.71***	0.69;0.72
Unknown/ Missing					0.57***	0.55;0.58	0.53***	0.51;0.55
Employment Status (ref: Not working)								
Working					0.32***	0.32; 0.33	0.32***	0.32;0.33
Parental status (ref: No child)								
At least one child					0.80***	0.79; 0.82	0.81***	0.79;0.82
Remarried after Widowhood (ref: Not remarried)								
Rermarried					0.56***	0.52; 0.61	0.55***	0.51;0.59

Supplementary Table A2. Mortality Hazard Ratios by Relationship Type

	Model 1		Model 2		Model 3		Model 4	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Birth cohort (ref: Before 1922)								
1922 - 1934							0.70***	0.66;0.74
1935 - 1949							0.66***	0.62;0.70
1950 - 1964							0.57***	0.54;0.61
1965 - 1980							0.32***	0.30;0.35
1981 - 1995							0.18***	0.16;0.20
After 1995							0.12***	0.06;0.24

Note: *p<.05; **p<.01; ***p<.001

a - HR: Hazard Ratio, CI – Confidence Interval