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CLINICAL RESEARCH ARTICLE



Long-term physical and mental health effects of unresolved disaster-related bereavement: evidence from an 8-year propensity score-matched cohort study

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ABSTRACT

Background: Evidence on the long-term mental and physical health effects of disaster-related bereavement remains limited.

Objective: To compare long-term healthcare utilisation and disease incidence among individuals bereaved in the Sewol ferry disaster with matched controls.

Method: This retrospective cohort study used Korean National Health Insurance data to match 388 bereaved individuals with 1,552 controls. Healthcare utilisation and disease incidence were examined over three years pre-disaster and eight years post-disaster using difference-in-differences and Cox proportional hazards models.

Results: Psychiatric outpatient utilisation among the bereaved increased from 10% pre-disaster to 38% in year 1, stabilised around 20%, and rose again to 38% in year 8, whereas controls showed a gradual increase to 22%. Difference-in-differences analyses demonstrated significantly higher psychiatric outpatient visits in the bereaved group, with excess visits of 2.87 (95% CI 1.52–4.22) in years 1–3, 1.86 (0.51–3.21) in years 4–6, and 1.56 (0.21–2.91) in years 7–8. Psychiatric admissions also increased significantly across post-disaster periods. Physical outpatient visits showed delayed excess increases in years 4–6 and 7–8. Cox models indicated elevated risks for infectious, benign neoplastic, endocrine, mental, neurological, digestive, dermatological, and musculoskeletal disorders, as well as abnormal findings and injury.

Conclusions: Eight years after the disaster, bereaved individuals continued to exhibit persistent mental health problems and greater physical healthcare utilisation. These findings highlight the need for long-term, integrated support addressing both mental and physical health beyond the immediate aftermath of disasters.

Efectos a largo plazo en la salud física y mental del duelo no resuelto relacionado con desastres: evidencia de un estudio de cohorte emparejado mediante puntuación de propensión de 8 años

Antecedentes: La evidencia empírica sobre los efectos a largo plazo en la salud mental y física de las personas con un duelo relacionado con desastres sigue siendo limitada.

Objetivo: Este estudio comparó la utilización de servicios de salud a largo plazo y la incidencia de enfermedades entre las personas en duelo por el desastre del ferry Sewol y un grupo de controles emparejados.

Método: Este estudio de cohorte retrospectivo utilizó información de la base de datos del Seguro Nacional de Salud de Corea y emparejó a 388 personas en duelo con 1.552 controles. Durante tres años antes y ocho años después del desastre, la utilización de los servicios de salud y la incidencia de enfermedades se analizaron utilizando los modelos de diferencias en diferencias y modelos de Cox.

Resultados: Entre las personas en duelo, la utilización de los servicios ambulatorios psiquiátricos aumentó del 10% al 38% en el año 1, se estabilizó en aproximadamente el 20% y aumentó de nuevo al 38% en el año 8, mientras que aumentó de manera constante del 10% al 22% en los controles. Los análisis de diferencias en las diferencias mostraron que las personas en duelo tuvieron visitas ambulatorias psiquiátricas más altas que los controles,

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PALABRAS CLAVE

Duelo por desastre; salud mental; utilización de servicios de salud; estudio de cohortes; salud física

HIGHLIGHTS

- Using 8-year national insurance data, the bereaved in the Sewol ferry disaster were compared with matched controls.
- The bereaved showed persistently higher psychiatric and physical healthcare utilisation than the controls, and elevated risks were observed across multiple disease categories among the bereaved.
- These findings highlight the need for long-term, integrated physical and mental health support.

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con un exceso de 2,87 visitas (intervalo de confianza [IC] del 95% 1,52–4,22) en los años 1–3, persistiendo con 1,86 (0,51–3,21) en los años 4–6 y 1,56 (0,21–2,91) en los años 7–8. Las atenciones ambulatorias físicas aumentaron más tarde con un exceso en los años 4–6 y los años 7–8. Los modelos de Cox mostraron que las personas en duelo tenían mayores riesgos de enfermedades infecciosas, neoplasias benignas, endocrinas, mentales, neurológicas, digestivas, dermatológicas, musculoesqueléticas, hallazgos anormales y lesiones.

Conclusiones: Las personas en duelo continuaron experimentando un duelo no resuelto ocho años después del desastre, con problemas persistentes de salud mental y una mayor utilización de los servicios de salud física en comparación que los controles. Estos hallazgos subrayan la necesidad de un apoyo integral a largo plazo que aborde tanto los problemas de salud mental y física más allá de las secuelas inmediatas del desastre.

1. Background

Bereavement refers to the objective experience of losing a significant other, whereas grief denotes the subjective emotional, cognitive, and behavioural responses to that loss. Grief following bereavement is associated with an elevated risk of adverse health outcomes, including prolonged grief disorder, mood and anxiety disorders, post-traumatic stress disorder (PTSD), insomnia, substance misuse, and even major physical illnesses such as cardiovascular diseases, metabolic disorders, and cancer (Seiler et al., 2020; Stroebe et al., 2007). The findings discussed above are largely derived from the studies of individual bereavement such as losses due to natural causes or accidents. In contrast, collective loss resulting from disasters constitutes a qualitatively distinct psychosocial experience compared with individual bereavement and therefore warrants separate investigation of its impacts (Netherlands, 2006). From a long-term perspective, evaluating the mental health consequences among disaster-bereaved families is of critical importance for informing appropriate and effective disaster response. Historically, mental health responses to disaster-affected populations have tended to place disproportionate emphasis on early, acute-phase interventions, often at the expense of addressing long-term mental health problems that emerge over time (McFarlane & Van Hoof, 2015).

Epidemiological studies examining mental health outcomes more than six years after bereavement due to natural or human-made disasters have reported that a substantial proportion of bereaved individuals continue to experience significant mental health problems, including major depressive disorder (MDD), PTSD, prolonged grief disorder (PGD), somatic symptoms, and insomnia (Cozza et al., 2017; Cozza et al., 2019; Goenjian et al., 2009; Kristensen et al., 2015; Nordström et al., 2022; Thoresen et al., 2019). For example, a study of 454 family members bereaved by the September 11 terrorist attacks assessed mental health outcomes 14 years after the event and found that 21.3% of participants exhibited comorbid depressive, anxiety, and grief-related symptoms, while an additional 12.6% experienced these

symptoms in conjunction with PTSD. However, despite of their public health relevance, robust epidemiological studies assessing the causal impact of bereavement on mental and physical health remained limited. The aftermentioned studies have largely relied on cross-sectional surveys and self-reported mental health measures, introducing potential selection and recall biases that may have overestimated psychological distress (Bhandari & Wagner, 2006; Thorpe et al., 2015). In this context, comparisons with the general population are crucial for accurately estimating the long-term health burden associated with bereavement (Thorpe et al., 2015). Evidence regarding the long-term physical health consequences of collective loss following disasters is particularly scarce. By contrast, studies focusing on individual bereavement and assessing outcomes within three years after the loss have reported associations with adverse physical health outcomes, including cardiovascular diseases, metabolic disorders, and cancer (Olsen et al., 2005; Prigerson et al., 1997). Taking this evidence into consideration, we hypothesised that disaster-related collective bereavement would also have long-term adverse effects on physical health.

The sinking of Sewol ferry sinking in April 2014, which caused the deaths of 304 individuals – most of whom were high school students ($n = 250$) on a school trip – remains an unresolved national tragedy in South Korea. Despite multiple investigations, the causes of the ferry's sinking and the failure of have not been fully explained (Shin, 2024). Bereaved families have experienced institutional neglect that has limited accountability for those responsible, as well as public victim-blaming (Chae et al., 2018). In the immediate aftermath of the disaster, many families engaged in large-scale protests demanding transparency, particularly during the Park Geun-hye administration, which was criticised for obstructing the fact-finding efforts. Although a subsequent inquiry under the Moon Jae-in's administration achieved some progress, key questions remain unanswered. Public discourse framing the incident as a closed case, along with accusations that families were seeking compensation, has further

exacerbated psychological distress among the bereaved and impeded normal grief processes (Chung et al., 2022).

We hypothesised that family members who lost loved ones in the Sewol ferry disaster would experience long-term mental and physical health problems. To test this hypothesis, we compared healthcare utilisation patterns and the cumulative incidence of disease categories using a retrospective cohort design with propensity score-matched controls drawn from national health insurance data. These findings aim to inform future disaster response policies and the development of long-term support strategies for affected populations.

2. Methods

2.1. Participants

This study targeted the family members bereaved in the Sewol ferry disaster, which occurred on 16 April 2014. In 2023, we accessed a registry of bereaved families ($n = 797$) maintained by the Ministry of the Interior and Safety at the Ansan Trauma Center, with permission from the Ministry of Health and Welfare. The bereaved families' association is a representative organisation that conveys and coordinates bereaved families' perspectives in negotiations with the government and the operating company regarding post-accident matters. Prior to recruitment, we met with the executive committee of the bereaved families' association to explain the study's aims and procedures. Subsequently, Center staffs contacted all bereaved family members listed in the registry via mobile communication to request their consent to participate. Over a two-month recruitment period, 49.4% ($n = 394$) of 797 registered bereaved family members provided written informed consent following in-person explanations of the study's purpose, data linkage procedures (including access to healthcare utilisation records), potential risks and benefits, and future data use. All contacts were made exclusively by the Center staff for the purpose of obtaining consent for linkage with National Health Insurance data; no interviews or assessment related to psychological status were conducted. Compared the non-consent group ($n = 403$), the consent group agreed to participate in the study ($n = 394$) showed no sex differences, but included fewer individuals aged <40 years and a higher proportion of victims' parents (Supplementary Table 1). This study was approved by the Institutional Review Board (1041078-202208-HR-192).

2.2. Data sources and study design

We conducted a retrospective cohort study using PS matching to compare healthcare utilisation and disease incidence between bereaved individuals and

matched controls over an 11-year period: three years before the disaster (15 April 2011–15 April 2014) and eight years after the disaster (16 April 2014–16 April 2022). Data were obtained from the National Health Information Database (NHID) managed by the National Health Insurance Service (NHIS). South Korea operates a compulsory, single-payer National Health Insurance System covering the entire population, providing universal access to healthcare services with modest co-payments. The NHID includes comprehensive eligibility data (sex, age, household income, region, and insurance type), healthcare claims (consultations, diagnoses, and prescriptions), and health-screening records from 2002 to 2022, making it well suited for long-term epidemiological research.

Figure 1 presents a flow diagram of the participant selection process. Among 394 consenting individuals, 388 were successfully identified from the 2013 eligibility database using national registration numbers; six individuals were excluded due to unmatched records. A data extraction officer at the NHIS subsequently identified 38,800 individuals from the general population, matched 100:1 by age and sex and residing in different regions to minimise geographical confounding. From this pool, a final control group of 1,552 individuals was constructed using 1:4 propensity score (PS) matching based on sex, age, household income, insurance type, disability registration, urban or rural residence, and Charlson Comorbidity Index (CCI) in the baseline year (2013). The NHID records were linked using deidentified join keys.

To compare healthcare utilisation between the bereaved and the general population, the matched control group ($n = 1,552$) was used. To compare the cumulative incidence of disease categories defined by the Korean Classification of Diseases, 8th revision (KCD-8) – the Korean adaptation of the International Classification of Diseases, 10th revision (ICD-10) – individuals with any relevant diagnoses during the three-year pre-disaster period (15 April 2011–15 April 2014) were excluded from disease-specific analyses. Figure 1 displays the numbers of participants included and excluded for each of the 14 KCD-8 disease groups.

2.3. Propensity score matching

Propensity scores (PS) were estimated using logistic regression with bereavement status as the outcome and the covariates described above as predictors. A 1:4 nearest-neighbour matching algorithm without replacement was applied using a method adapted from the Coca-Perraillon SAS macro. Observations with missing covariate data or no suitable matches were excluded from the both groups. Matching quality was assessed using standardised mean differences (SMDs) for all covariates before and after matching;

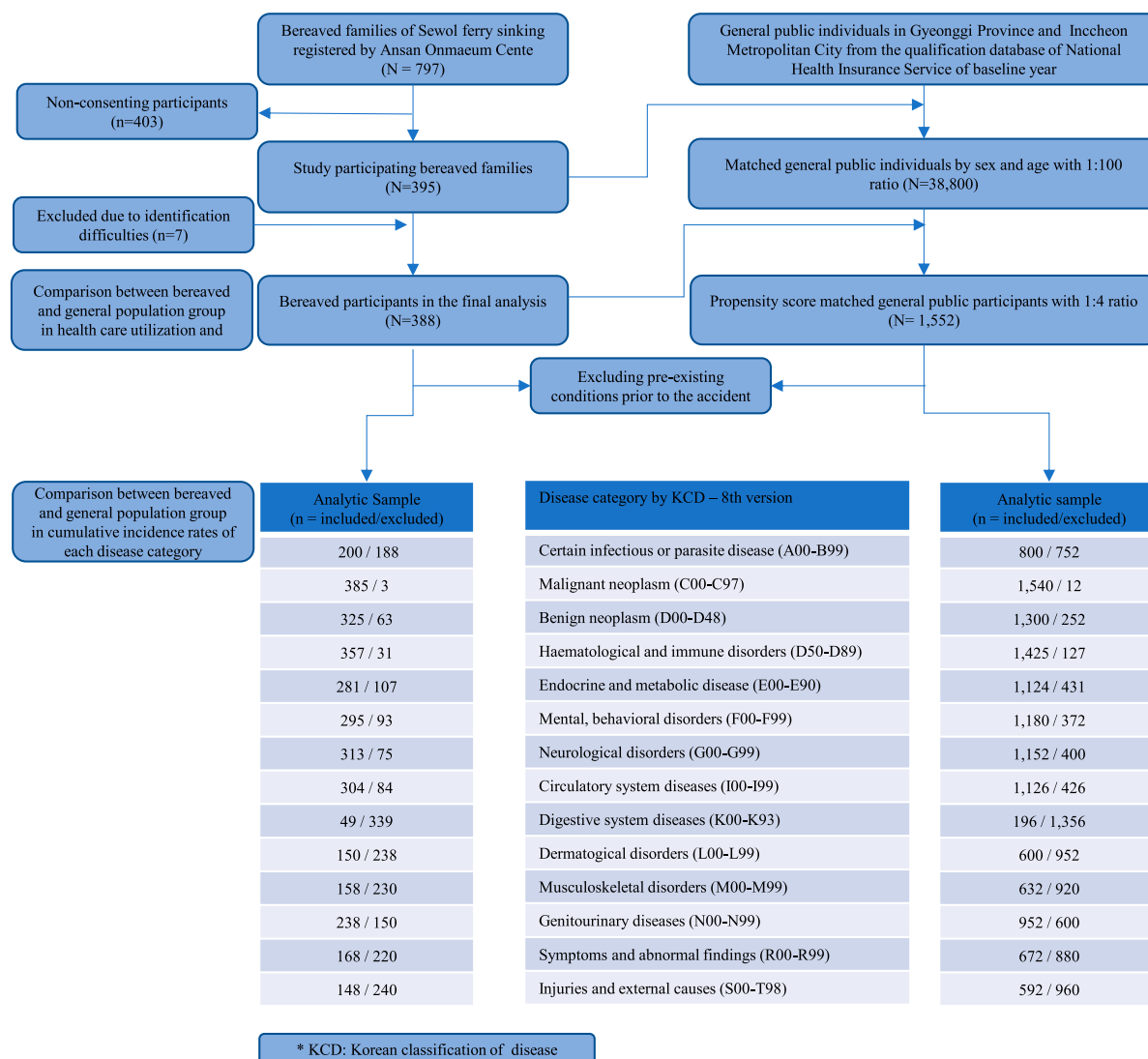


Figure 1. Flow diagram of study population selection and propensity score matching.

SMDs less than 0.1 were considered indicative of adequate balance (Table 1 and Supplementary Figure 1).

2.4. Study variables and outcomes

Baseline covariates included sex, age, household income level (five absolute levels based on monthly contributions to the National Health Insurance scheme), type of social health security and eligibility, disability status, residence (urban vs. rural), and CCI. Covariates were assessed at baseline (15 April 2013–15 April 2014) because time-varying factors such as income and disability status may themselves be consequences of bereavement. Adjusting for such post-exposure variables could introduce overadjustment bias, and both difference-in-difference (DiD) and Cox regression models assume predetermined covariates for causal inference.

The primary outcomes included healthcare utilisation and the cumulative incidence of disease categories based on the KCD-8. Health care utilisation was classified by care purpose (mental

vs. physical health) and service type (outpatient, inpatient, and emergency department care). Two utilisation metrics were examined: (1) the annual utilisation rate, defined as the proportion of individuals with at least one relevant healthcare encounter per year, and (2) the annual number of healthcare encounters per person, calculated as the total number of encounters divided by the total number of study participants. As was shown in Figure 1, disease categories included infectious or parasite diseases (A00–B99), malignant neoplasms (C00–C97), benign neoplasms (D00–D48), haematological and immune disorders (D50–D89), endocrine and metabolic diseases (E00–E90), mental and behavioural disorders (F00–F99, Z), neurological disorders (G00–G99), circulatory system diseases (I00–I99), digestive system diseases (K00–K93), dermatological disorders (L00–L99), musculoskeletal disorders (M00–M99), genitourinary diseases (N00–N99), symptoms and abnormal findings (R00–R99), and injuries (S00–T98).

Table 1. Changes in standardised mean differences of sociodemographic and clinical characteristics before and after propensity score matching among bereaved family members in the Sewol ferry disaster.

Variables	Category	Pre-matching				Post-matching			
		Bereaved group <i>n</i> (%) (<i>n</i> = 388)	General population group <i>N</i> (%) (<i>N</i> = 45,700)	<i>t</i> / <i>x</i> ²	SMD	Bereaved group <i>n</i> (%) (<i>n</i> = 388)	General population group <i>N</i> (%) (<i>N</i> = 1,552)	<i>t</i> / <i>x</i> ²	SMD
Sex	Male	177 (45.6)	20400 (44.6)	0.15	0.02	177 (45.6)	713 (45.9)	0.01	−0.01
	Female	211 (54.4)	25300 (55.4)			211 (54.4)	839 (54.1)		
Age	≤19	66 (17.0)	9500 (20.8)	−1.26	−0.06	66 (17.0)	278 (17.9)	−0.55	−0.03
	20–29	25 (6.4)	2700 (5.9)			25 (6.4)	93 (6.0)		
	30–39	19 (4.9)	2200 (4.8)			19 (4.9)	75 (4.8)		
	40–49	213 (54.9)	23700 (51.9)			213 (54.9)	254 (55.0)		
	50–59	49 (12.6)	5800 (12.7)			49 (12.6)	209 (13.5)		
	60–69	8 (2.1)	900 (2.0)			8 (2.1)	16 (1.0)		
	≥70	8 (2.1)	900 (2.0)			8 (2.1)	27 (1.7)		
Household income levels ^a	Level 1 (lowest)	18 (4.6)	886 (1.9)	6.70***	0.34	18 (4.6)	68 (4.4)	−0.68	−0.03
	Level 2	83 (21.4)	8031 (17.5)			83 (21.4)	359 (23.1)		
	Level 3	190 (49.0)	16427 (35.9)			190 (49.0)	751 (48.4)		
	Level 4	76 (19.6)	11778 (15.8)			76 (19.6)	279 (18.0)		
	Level 5 (highest)	21 (5.4)	8533 (18.7)			21 (5.4)	95 (6.1)		
Type of social health security and eligibility	Self-employed, Subscribers	55 (14.2)	7310 (16.0)	23.22***	−0.06	55 (14.2)	221 (14.2)	0.25	−0.01
	Self-employed, Dependents	72 (18.6)	8754 (19.2)			72 (18.6)	295 (19.0)		
	Employed, Subscribers	128 (33.0)	13361 (29.2)			128 (33.0)	511 (32.9)		
	Employed, Dependents	115 (29.6)	15391 (33.7)			115 (29.6)	457 (29.4)		
	Medical Aid, Category 1	7 (1.8)	485 (1.1)			7 (1.8)	23 (1.5)		
	Medical Aid, Category 2	11 (2.8)	399 (0.9)			11 (2.8)	45 (2.9)		
Disability Status	No	369 (95.1)	44214 (96.7)	3.30	−0.08	369 (95.1)	1503 (96.8)	2.78	−0.09
	Yes	19 (4.9)	1486 (3.3)			19 (4.9)	49 (3.2)		
Residence	Urban	376 (96.9)	39208 (85.8)	40.05***	0.32	376 (96.9)	1516 (97.7)	0.46***	−0.03
	Rural	11 (2.8)	6399 (14.0)			11 (2.8)	35 (2.3)		
CCI	0	195 (50.3)	24945 (54.6)	−2.51*	−0.12	195 (50.3)	796 (51.3)	−0.46	−0.02
	1	92 (23.7)	10678 (23.4)			92 (23.7)	363 (23.4)		
	2	59 (15.2)	6560 (14.3)			59 (15.2)	235 (15.1)		
	3	22 (5.7)	1956 (4.3)			22 (5.7)	82 (5.3)		
	6	20 (5.1)	1561 (3.4)			20 (5.1)	76 (4.9)		

****p* < .001, ***p* < .01, **p* < .05.^aHousehold income is categorised into five absolute levels based on monthly contributions to the National Health Insurance scheme.

SMD, standard mean difference; CCI, Charlson Comorbidity Index.

2.5. Statistical analysis

Healthcare utilisation indicators were calculated for the three-year pre-disaster and eight-year post-disaster periods to compare utilisation trajectories between families bereaved by the Sewol ferry disaster and matched general population controls. A difference-in-differences (DiD) approach was applied to estimate the long-term impact of bereavement on healthcare utilisation by comparing changes in average annual utilisation visits by service type before and after the disaster between groups. The 11-year study period was divided into four phases: a three-year pre-disaster, and three post-disaster periods (post-disaster I: years 1–3; post-disaster II: years 4–6; post-disaster III: years 7–8). DiD regression models were used to test the interaction effects of bereavement and time after adjusting for baseline. The plausibility of the parallel trends assumption was evaluated using graphical diagnostics based on pre-disaster data (event years −3 to −1), plotting observed mean healthcare utilisation

and fitted group-specific linear trends for bereaved families and the general population. Visual inspection indicated broadly similar pre-disaster trajectories across outcomes, with no systematic divergence in fitted trends, although minor level differences were observed (Supplementary Figures 2 and 3). Cumulative incidence differences across disease categories were analysed using Kaplan–Meier curves and Cox proportional hazards models, adjusting for sex, age, household income, social health security type, residential area, disability status, and CCI. Statistical significance was set at *p* < .05, and 95% confidence intervals (CI) were calculated.

3. Results

3.1. General characteristics of study participants

Baseline characteristics were well balanced between the bereaved and control groups following propensity

score matching (Table 1). Among the bereaved participants, more than half were in their 40s (54.9%), 23.7% belonged to the highest household income category, and the majority were employed (33.0%) or registered as dependents (29.6%). Most participants had no registered disability (95.1%) and resided in urban areas (96.9%). Women accounted for 62.1% of the bereaved group and men for 54.1%. Approximately half of the bereaved participants (50.3%) had a Charlson Comorbidity Index (CCI) score of zero at baseline.

3.2. Healthcare utilisation among bereaved vs. controls after the Sewol disaster

Physical healthcare utilisation was comparable between the bereaved and control groups during three years preceding the Sewol ferry disaster; disparities emerged and widened over the eight-year post-disaster period (Figure 2). For mental health services, annual outpatient utilisation rates in the bereaved group increased from approximately 10% pre-disaster to 38% in the first post-disaster year, subsequently stabilising between 20% and

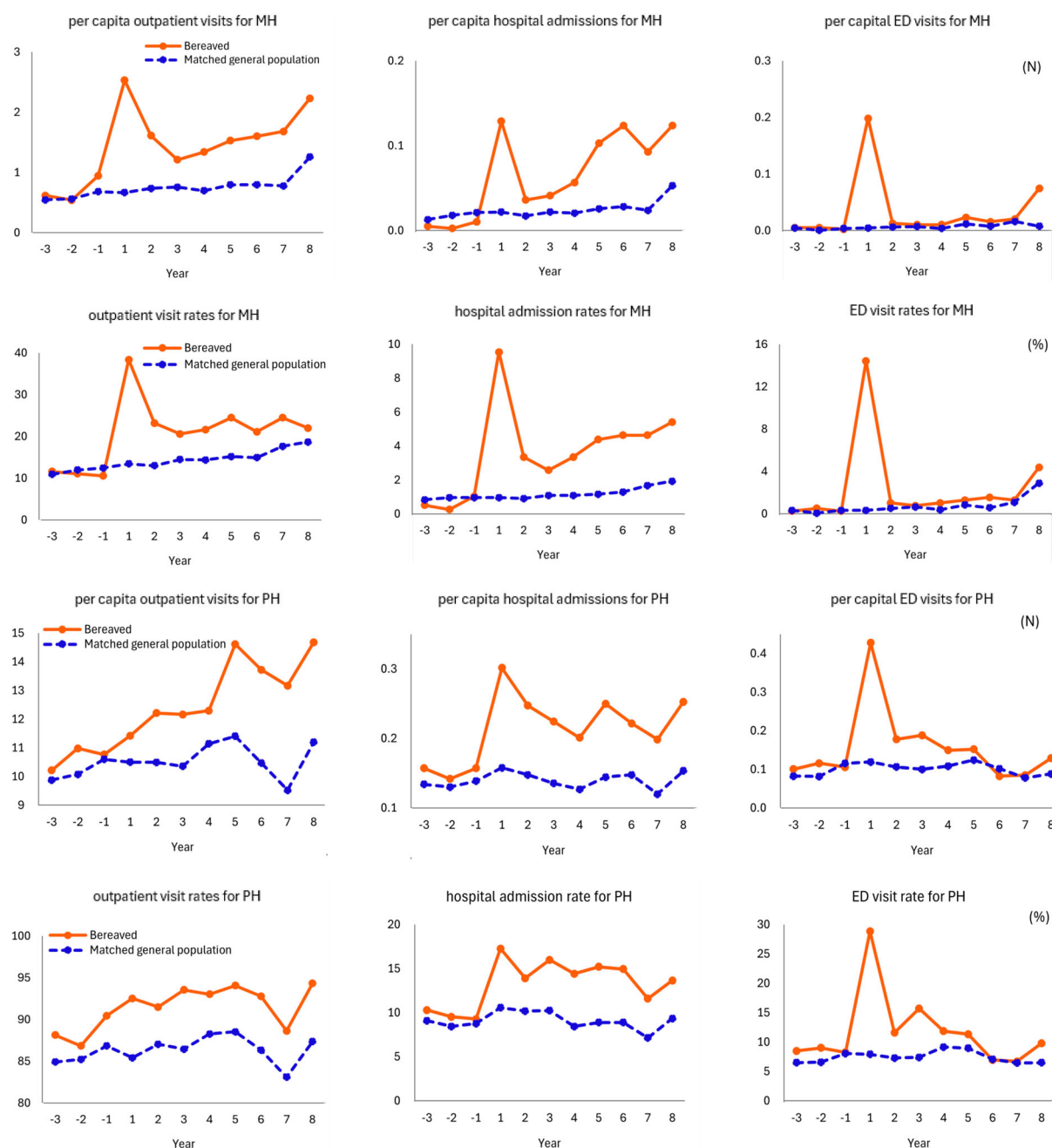


Figure 2. Annual trends of average counts and rates of healthcare utilisation by medical service type per person for physical and mental health in the bereaved group and matched general population 3 years before and 8 years after Sewol ferry sinking (PH, physical health; MH, mental health).

24% during years 2–7, before rising again to 38% in year 8. In contrast, the control group exhibited a gradual increase from 10% pre-disaster to 15% by year 7 and 22% by year 8. The annual number of psychiatric outpatient visits per person showed a similar pattern. Psychiatric inpatient annual utilisation rates in the bereaved group rose sharply from below 1% pre-disaster to approximately 9% in the first post-disaster year, followed by rapid decline and a secondary increase to approximately 5% by year 8. In contrast, the control group demonstrated only a modest increase to around 2% over the same period. The annual number of psychiatric inpatient visits per person mirrored these trends. For psychiatric emergency department services, annual utilisation rates among bereaved individuals surged to approximately 15% in the first post-disaster year, returned to near pre-disaster levels subsequently years, and then increased again to approximately 4% in year 8. The control group showed minimal change over time, except for a slight increase to approximately 3% in year 8. The annual number of psychiatric emergency visits per person mirrored the pattern of utilisation rates.

For physical health service, annual outpatient utilisation rates in the bereaved group increased from approximately 88% pre-disaster to approximately 93% in the first post-disaster year and remained stable thereafter, whereas the control group showed only a modest increase to approximately 86% (Figure 2). While the number of outpatient visits per person was similar between the groups before the disaster, divergence increased over time, reaching an excess of approximately three visits per person in the bereaved group by year 8. Inpatient service utilisation rates for physical health conditions increased to 17% in the bereaved group in the first post-disaster year and declined slightly to 14% by year 8, whereas in the control group remained stable at approximately 9%. The annual number of hospital admissions per person exhibited a similar trend. Emergency department annual utilisation rates for physical health condition

in the bereaved group increased sharply from approximately 9% pre-disaster to 28% in the first post-disaster year, then gradually declined to pre-disaster levels by year 6. No corresponding changes were observed in the control group, which remained stable at approximately 6%. Patterns in emergency department visits per person were consistent with utilisation rates.

3.3. Difference-in-differences regression of bereavement effects on healthcare utilisation

Table 2 shows the results of DiD regression model-assessed changes in the annual number of healthcare encounters per person for physical and mental health. Comparisons were made between the pre-disaster period (three years) and the post-disaster (eight years), which was subdivided into post-disaster period I (years 1–3), period II (years 4–6), and period III (years 7–8). For mental health services, baseline outpatient, inpatient, and emergency department utilisation measured by the annual number of healthcare encounters per person did not differ between groups prior to the disaster. Following the disaster, psychiatric outpatient visits per person increased significantly more among bereaved individuals than controls, with an excess of 2.87 visits per person per year in period I (95% confidence interval [CI], 1.52–4.22). Smaller but statistically significant excess increases persisted in periods II (1.86; 95% CI, 0.51–3.21) and III (1.56; 95% CI, 0.21–2.91). Hospital admissions for mental health conditions also increased significantly more in the bereaved group relative to controls, with excess admissions per person per year observed in the period I (0.17; 95% CI 0.03–0.31), period II (0.24; 95% CI, 0.10–0.38) and period III (0.17; 95% CI, 0.03–0.31). Emergency department visits for mental health conditions exhibited significant excess increase in the bereaved group relative to controls in period I (0.19; 95% CI, 0.04–0.32), but no significant excess increases were observed in subsequent periods.

Table 2. Difference-in-Differences of regression coefficients adjusting for covariates (sex, age, household income, social health security type, residential area, disability, and Charlson Comorbidity Index) for the effect of disaster-related bereavement on healthcare utilisation for physical and mental health 3 years before and 8 years after Sewol ferry sinking between the bereaved group and matched general population.

Type of healthcare utilisation (per person, per year)		Pre-accident period vs Post-accident period I Diff-in-Diff of regressions	Pre-accident period vs Post-accident period II Diff-in-Diff of regressions	Pre-accident period vs Post-accident period III Diff-in-Diff of regressions
Physical health problems	Average no- of outpatient visits	3.03	6.19	5.71
	95% Confidence Interval	–2.38 ~ 8.44	0.69 ~ 11.51	0.30 ~ 11.12
	Average no- of hospital admissions	0.27	0.20	0.12
	95% Confidence Interval	0.07 ~ 0.47	0.004 ~ 0.40	–0.08 ~ 0.32
	Average no- of emergency room visits	0.42	0.01	0.01
	95% Confidence Interval	0.28 ~ 0.56	–0.13 ~ 0.15	–0.13 ~ 0.15
Mental health problems	Average no- of outpatient visits	2.87	1.86	1.56
	95% Confidence Interval	1.52 ~ 4.22	0.51 ~ 3.21	0.21 ~ 2.91
	Average no- of hospital admissions	0.17	0.24	0.17
	95% Confidence Interval	0.03 ~ 0.31	0.10 ~ 0.38	0.03 ~ 0.31
	Average no- of emergency room visits	0.19	0.02	0.02
	95% Confidence Interval	0.15 ~ 0.23	–0.02 ~ 0.06	–0.02 ~ 0.06

Pre-accident period, 2011–2014; post-accident period I, 2014–2017; post-accident period II, 2017–2020; and post-accident period III, 2020–2022

For physical health services, baseline outpatient, inpatient, and emergency department utilisation measured by the annual number of healthcare encounters per person did not differ between groups prior to the disaster. No significant differences in outpatient visits were observed in period I (years 1–3), however, bereaved individuals experienced significantly greater increases in outpatient visits during period II (6.19 visits per person per year; 95% CI, 0.69–11.51) and period III (5.71; 95% CI, 0.30–11.12). Hospital admissions per person per year increased significantly greater in the bereaved group than controls in period I (0.27; 95% CI, 0.07–0.47) and period II (0.20; 95% CI, 0.004–0.4) though this difference was not sustained in period III. Emergency department visits for physical health conditions exhibited significant excess increase of 0.19 per person per year in period I (95% CI, 0.15–0.23), whereas no consistent greater increases were observed thereafter.

3.4. Cumulative incidence of disease groups by the KCD-8 disease categories during eight years of follow-up

Kaplan–Meier analyses with log-rank tests demonstrated significant differences in the eight-year cumulative incidence of multiple disease categories between bereaved individuals and controls (Figure 3). Compared with controls, bereaved individuals had higher cumulative incidences of Infectious or parasite diseases (75.0% vs. 65.6%; $\chi^2 = 8.38$, $p = .004$), benign neoplasm (38.2% vs. 28.6%, $\chi^2 = 14.71$, $p < .001$), endocrine and metabolic disorders (68.7% vs. 46.4%, $\chi^2 = 71.63$, $p < .001$), mental and behavioural disorders (75.6% vs. 54.3%, $\chi^2 = 122.12$, $p < .001$), neurological disorders (42.5% vs. 32.8%, $\chi^2 = 13.92$, $p < .001$), digestive system diseases (95.9% vs. 86.7%, $\chi^2 = 5.12$, $p = .024$), dermatological disorders (80.7% vs. 67.0%, $\chi^2 = 11.49$, $p < .001$), musculoskeletal disorders (84.8% vs. 77.7%, $\chi^2 = 6.62$, $p = .010$), symptoms and abnormal clinical findings (88.1% vs. 76.3%, $\chi^2 = 34.91$, $p < .001$), and injuries/external causes (81.1% vs. 71.8%, $\chi^2 = 9.23$, $p = .002$).

Differences in cumulative incidence were not statistically significant for haematological and immune disorders, circulatory system diseases, or genitourinary disorders. The cumulative incidence of malignant neoplas was higher among bereaved individuals (7.53% vs. 5.06%), but did not reach statistical significance ($\chi^2 = 3.54$, $p = .059$).

3.5. Hazard ratios of disease groups by the KCD-8 in bereaved vs. controls during 8-year follow-up

In cox proportional hazards models adjusted for baseline covariates, bereaved individuals exhibited significantly elevated risks for several disease categories

compared with controls (Figure 4). Increased risks were observed for infectious and parasitic diseases (adjusted hazard ratio [aHR] 1.32; 95% CI 1.10–1.58), benign neoplasms (aHR, 1.52; 95% CI 1.24–1.88), endocrine and metabolic disorders (aHR, 2.11; 95% CI 1.78–2.49), mental and behavioural disorders (aHR, 2.39; 95% CI 2.05–2.79), neurological disorders (aHR, 1.44; 95% CI 1.18–1.78), digestive system disorders (aHR, 1.46; 95% CI 1.03–2.05), dermatological diseases (aHR, 1.44; 95% CI 1.17–1.77), musculoskeletal disorders (aHR, 1.34; 95% CI 1.10–1.83), abnormal clinical findings (aHR, 1.70; 95% CI 1.41–2.08), and injury or external causes (aHR, 1.38; 95% CI 1.12–1.69). No statistically significant differences were observed for haematological and immune disorders, circulatory system diseases, and genitourinary disorders. Although the risk of malignant neoplasms was higher among bereaved individuals (aHR, 1.42; 95% CI, 0.92–2.18), this association did not reach statistical significance.

4. Discussion

In this nationwide matched cohort study of bereaved individuals following the Sewol ferry disaster, we observed marked and sustained increases in healthcare utilisation compared with controls. While both groups had comparable use before the disaster, psychiatric service utilisation rates in the bereaved group increased after the event and remained higher than the matched general population. Psychiatric outpatient visits in the bereaved group increased sharply in the first post-disaster year and remained consistently higher over the subsequent 8 years, with corresponding excess increases confirmed by the DiD regression. Mental health hospital admissions in the bereaved group also increased excessively during all the post-periods and emergency department visits for psychiatric problems showed a transient excess rise in the immediate aftermath. For physical health services, baseline utilisation was similar between the groups, but DiD regression revealed significant additional increases in outpatient visits in the medium and late post-disaster periods, as well as significant increase excessively in hospital admissions in the early and medium term. Emergency department visits for physical health problems also showed a significant short-term excess increase in the bereaved group. Cox proportional hazards models further demonstrated that the bereaved individuals had significantly elevated long-term risks across multiple disease categories, including mental and behavioural disorders; endocrine and metabolic conditions; neurological, digestive, dermatological, musculoskeletal, infectious, and benign neoplastic diseases; abnormal clinical findings; and injury or external causes. By contrast, no significant excess risks were found for circulatory,

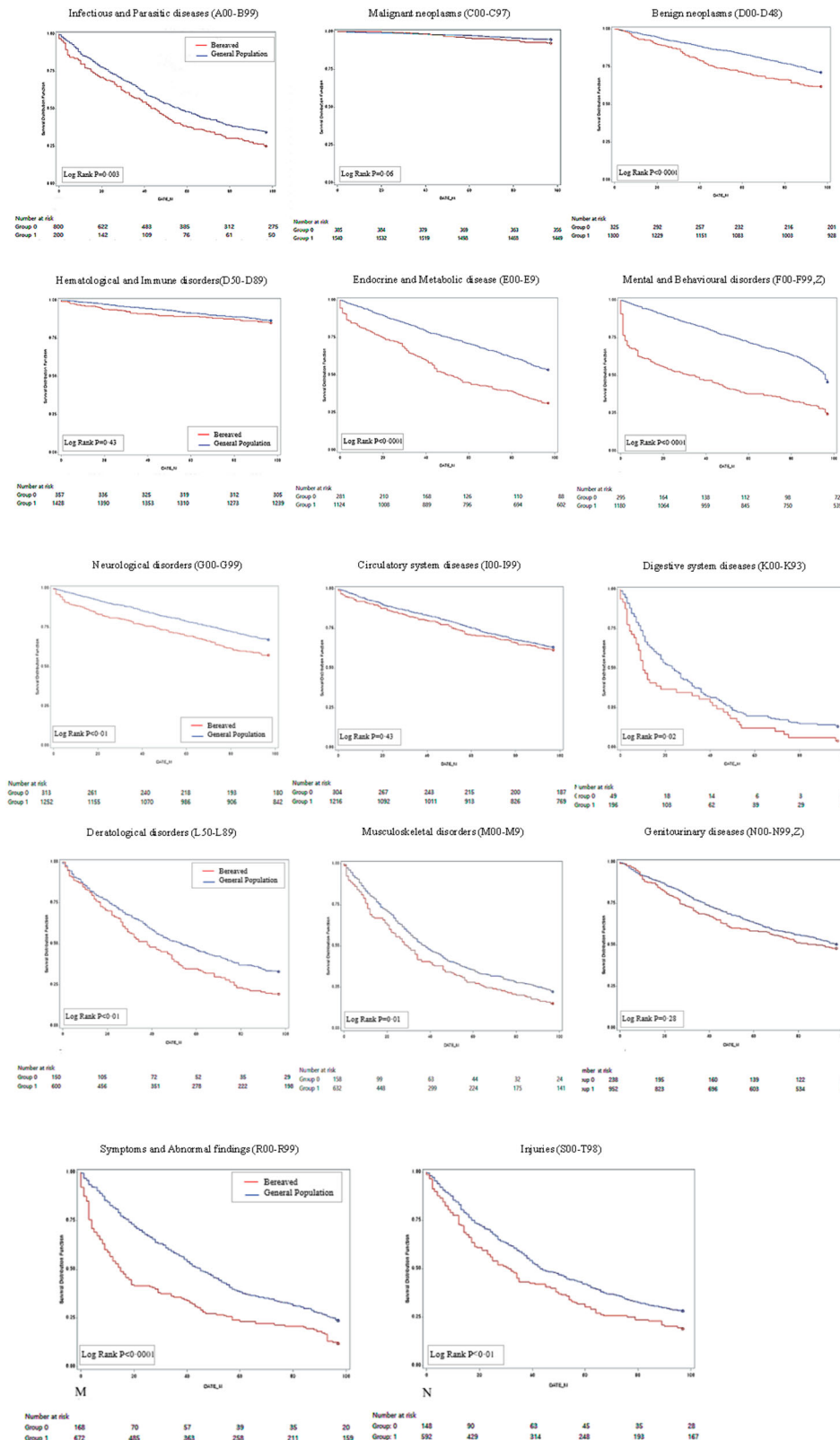


Figure 3. Differences in cumulative incidence rates of disease groups by the Korean Classification Disease 8th version between the bereaved group and matched general population, excluding participants with relevant pre-existing disease, using the Kaplan-Meier curve, during the 8-year follow-up period after Sewol ferry sinking.

haematologic/immune, or genitourinary disorders, and malignant neoplasms showed only a borderline non-significant increase.

In general, if individuals undergo a normative grieving process following bereavement, acute psychological and emotional distress is expected to peak in

early period after the loss and gradually stabilise over time (Schoo et al., 2025). However, among families bereaved by the Sewol ferry disaster, outpatient utilisation and hospitalisation rates for mental remained persistently high across middle and late post-disaster period as well as early phase. Moreover,

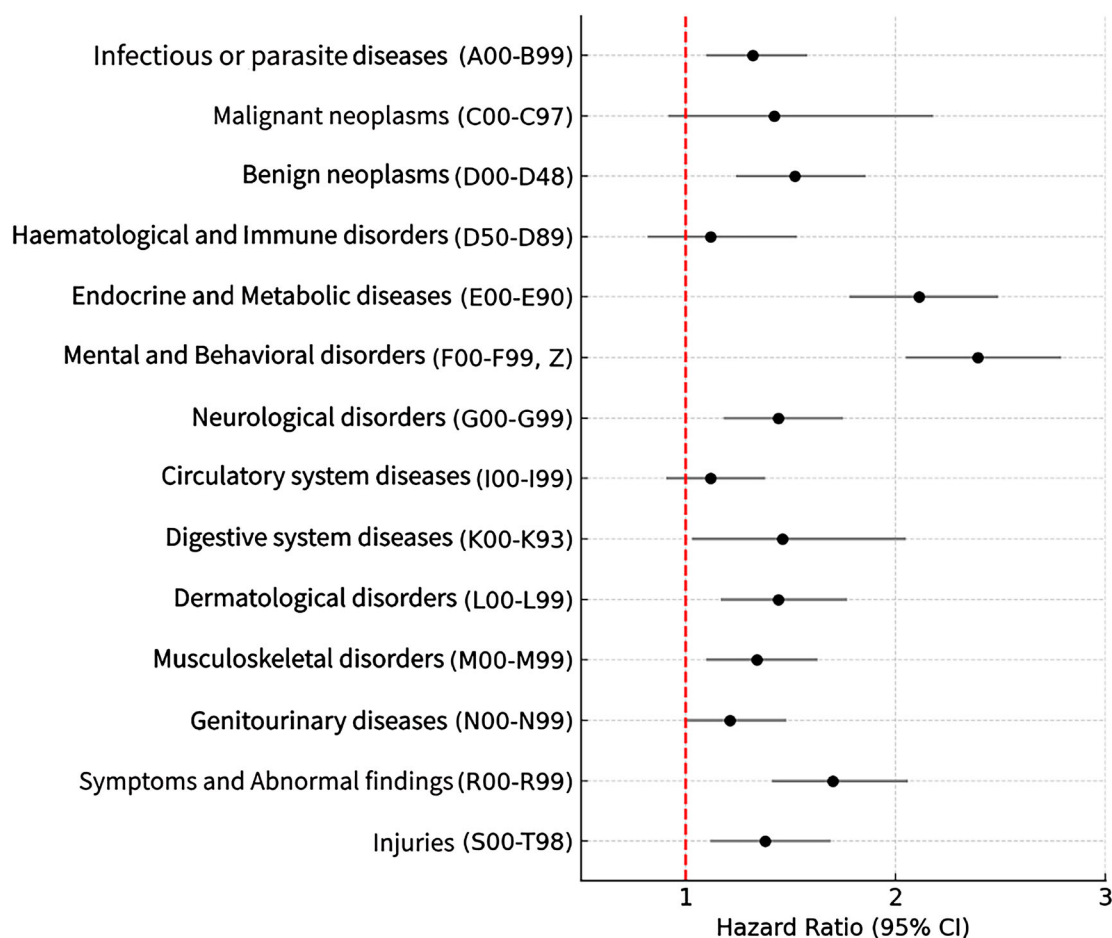


Figure 4. Hazard ratios for the bereaved vs. matched population group, excluding participants with relevant pre-existing disease, according to disease groups by the Korean Classification Diseases 8th version, during 8-year follow-up period after Sewol ferry sinking using Cox proportional hazard model.

in 2024, 10 years after the Sewol ferry disaster, according to a cross-sectional survey using a self-administered questionnaire for 289 bereaved family members, Prevalence rates were notably high: anxiety symptoms (48.4%), post-traumatic stress disorder (PTSD) symptoms (32.2%), depressive symptoms (68.5%), symptoms of complicated grief (62.7%), post-traumatic embitterment disorder (PTED; 47.4%), and high suicide risk (29.7%) (Ansan Trauma Center, 2024). These findings are consistent with prior longitudinal research on bereaved families of large-scale disasters, which indicate that 20–50% of individuals continue to suffer from psychological morbidity more than six years after the event (Kristensen et al., 2015; Nordström et al., 2022). The prolonged nature of these mental health challenges among disaster-bereaved families results from both sudden and traumatic characteristics of the deaths (Kristensen et al., 2012). The unexpected and violent nature of these deaths significantly increases the likelihood of developing complicated grief, particularly in cases involving the loss of a child (Xu et al., 2013). Of the 304 confirmed fatalities in the Sewol disaster, 250 were high school students from Danwon High School, who perished during a routine school trip. In this

regard, future studies should further examine long-term mental health outcomes by distinguishing between parents who lost high school-aged children during the school trip and other bereaved family members. Moreover, unlike isolated personal bereavement, disaster-related losses are frequently compounded by societal and structural barriers to recovery (Kohn & Levav, 1990). Generally, mistrust in governmental disaster response, public conspiracy theories, and victim-blaming narratives have been shown to further complicate the grieving process and hinder access to effective care (Netherlands, 2006). Despite the passage of a decade, bereaved families continue to demand accountability and full disclosure regarding the cause of the ferry's sinking and the subsequent rescue failures (Shin, 2024). Perceived inadequacies in legal proceedings and the lack of punitive measures against responsible actors contribute to ongoing distress (Chae et al., 2018). Furthermore, the politicisation of the disaster has led to public hostility, with some conservative factions opposing memorialisation efforts and verbally abusing the bereaved, thereby exacerbating psychological harm (Chung et al., 2022). Unlike individual bereavement, bereavement caused by man-made disasters such as

Sewol ferry disaster tends to result in more persistent mental health problems hindering normal grief process partly due to social factors such as lack of trust in government response and victim-blaming.

In this study, psychiatric outpatient consultations increased markedly in the early post-incident period, whereas visits for physical health concerns differed insignificantly from those of matched controls. In contrast, a prior disaster study demonstrated elevated primary-care attendance for physical problems at one year post-trauma (Dorn et al., 2006) and found that grief due to personal bereavement commonly increased outpatient physical-health use within the first year following loved ones' loss (Stroebe et al., 2007). However, some studies reported that individuals with personal bereavement such as the death of a spouse, who are most in the need of healthcare might not be obtaining such help (Prigerson et al., 2001). Notably, some Korean families bereaved by the Sewol ferry disaster declined all clinical and supportive interventions until the truth was fully revealed – attributing such rejection to a cultural belief that healing from the loss of a child is futile and may even intensify guilt (Choi & Cho, 2020).

Notably, for physical health services, the baseline healthcare utilisation counts were similar between groups, but DiD regression revealed significant additional increases in outpatient visits in the medium- and late post-disaster periods. Although more than three years had passed since the incident, ongoing conflict with the government over truth recovery and accountability together with the politicisation of the event and the ensuing blame and prejudice directed at the bereaved – continued to hinder their healing process (Chae et al., 2018; Lee et al., 2022). These sustained psychosocial stressors likely imposed chronic strain, compromised the efficacy of pharmacological and psychological interventions, entrenched mental health problems, and thereby intensified physical health morbidity (Choi & Cho, 2020). Moreover, it was reported that depressive symptoms are more frequently expressed through somatic complaints than through mood-related symptoms, in contrast to Western contexts (Jadhav & Weir, 2018). A substantial proportion of the bereaved families of the Sewol ferry disaster have experienced chronic depression over prolonged periods, which is in turn associated with a higher prevalence of long-term health care utilisation for physical conditions. Furthermore, prior research indicates that a considerable number of disaster-bereaved individuals continue to report somatic symptoms even long after the event (Nordström et al., 2024). Consistent with this literature, the present study found a higher prevalence of somatic symptoms in the bereaved group compared with the matched comparison group. Taken together, the elevated prevalence of somatic symptoms is likely

to have contributed to increased long-term utilisation of health care services for physical illnesses (Puri & Dimsdale, 2011).

In contrast, hospitalisations for physical illnesses increased sharply in the immediate aftermath of the disaster and remained significantly elevated through the mid-term period, whereas no significant excess increase was observed in the later period. In the early post-disaster phase, bereaved family members are known to experience acute stress responses, which may contribute to an increased risk of cardiovascular and other stress-related physical conditions (Bartrop et al., 2015; Prigerson et al., 1997). However, the finding that the bereaved families disaster continued to report substantial physical health problems even during the mid-term period, more than three years after the incident, suggests the influence of prolonged and cumulative psychosocial stress exposure as noted earlier.

This study reported an increased incidence of numerous physical illnesses, including infectious diseases, benign neoplasms, and metabolic disorders, over an extended period following bereavement due to a disaster. Prior studies on individual bereavement have documented associations with chronic diseases, such as cardiovascular diseases, cancer, infectious diseases, and diabetes (Bartrop et al., 2015; Levav et al., 2000; Lu et al., 2016; Olsen et al., 2005). Additionally, epidemiological research has shown that survivors or bereaved individuals exposed to traumatic events may develop up to 20 physical illnesses over time due to PTSD (Atwoli et al., 2015). Bereavement, whether resulting from an individual incident or large-scale disaster, appears to have long-term adverse effects on physical health. Several mechanisms may explain this association. First, persistent and chronic mental-health problems can trigger or exacerbate physical-health problems. Bereavement-related stress activates inflammatory responses and suppresses immune function, thereby contributing to long-term deterioration in physical health (Atwoli et al., 2015). Depression and PTSD may accelerate these biological mechanisms (Kapfhammer, 2018). Given that a substantial proportion of the bereaved in the Sewol ferry disaster ($n = 289$) were at risk of depression (38.4%), anxiety (21.1%), PTED (47.4%), and PTSD (32.2%) even 10 years after the incident, it is plausible that these mental health issues contributed to the onset or worsening of physical health conditions (Ansan Trauma Center, 2024). Some bereaved individuals, particularly following traumatic loss, experience unresolved grief that manifests as sleep disturbances, alcohol misuse, and social isolation – factors known to adversely affect long-term physical health (Donnelly et al., 2023; Stahl & Schulz, 2014). Among the Sewol disaster bereaved ($n = 289$), 70.6% reported sleep difficulties, 44.6% reported problematic alcohol use,

and 24.9% reported social isolation, even 10 years after the event (Ansan Trauma Center, 2024).

Our findings warrant cautious interpretation. First, no significant differences in cardiovascular, haematological, and genitourinary conditions were found between the bereaved and control groups over the entire follow-up period. However, when truncated to 3.3 years (40 weeks), all showed a significantly higher incidence in the bereaved group (eTable 3), suggesting short- to medium-term sensitivity to bereavement, which is consistent with a previous study (Prigerson et al., 1997). Second, cancer incidence was suggestive but not statistically significant. Given the evidence from Denmark, linking child loss to cancer in those over 16 years (Li et al., 2003), a longer follow-up may be needed. The elevated incidence of benign neoplasms in bereaved individuals supports this hypothesis. Third, increased diagnoses under KCD-8 codes R00–R99, covering symptoms, such as fatigue, pain, and dyspnoea, and reflecting persistent somatic complaints, were also reported a decade after the Utøya attack (Nordström et al., 2024). These symptoms often lead to greater healthcare utilisation (Puri & Dimsdale, 2011), which may have influenced the incidence estimates.

This study has some limitations. First, compensation for the Sewol ferry victims included medical support, which may have affected their healthcare utilisation. However, stigma (Heo et al., 2024) and burdensome certification processes (Lee, 2023) are likely to discourage its overuse. Second, individuals with pre-existing conditions were excluded to isolate new cases, potentially introducing a covariate imbalance. This was addressed by using covariate-adjusted Cox models and a 1:4 matching ratio. Third, patients with respiratory diseases were excluded due to their high baseline prevalence. Fourth, it was not possible to ascertain prior exposure to traumatic events including bereavement experiences among matched general population and subsequent chronic stressors after the Sewol disaster in both groups because it was not available in NHIS claims. Moreover residual covariates such as family history of mental or physical illness also were not measured for the same reason mentioned above. Despite the limitations, the strengths of this study include robust matching, a DiD design, and the use of objective healthcare data, supporting a rigorous assessment of the long-term health effects of bereavement.

5. Conclusion

Eight years post-disaster, many bereaved individuals continued to experience unresolved grief, with prolonged mental health problems and a persistently higher use of healthcare services for physical health than the general population. Moreover, our study

demonstrated that disaster bereavement was associated not only with diverse physical health problems, but also with enduring mental health problems. Unlike individual bereavement, bereavement following a disaster is shaped by social and political dynamics, such as conflicts over accountability and victim blaming, which can complicate or even disrupt normal grieving processes. Therefore, responses to disaster-related bereavement should not be limited to short-term mental healthcare in the immediate aftermath. Rather, they require a long-term perspective that recognises the enduring impact of disasters on both mental and physical health, ensuring that support systems are designed to accompany the bereaved over the years following disasters.

Author contributions

EJ Park and JW Han contributed to the study conception and design, data acquisition, data analysis, and drafting of the manuscript. MS Noh and SY Jeon were responsible for data management, statistical analysis, and interpretation of results. B Park and YJ Choi contributed to the study design, literature review, and data interpretation. HS Kim and HS Jung were involved in participant recruitment and clinical interpretation. KS Na provided clinical consultation and methodological support. WY Lee contributed to the study conception and design, supervision, data interpretation, and critical revision of the manuscript. All authors contributed to the final version of the manuscript, approved its submission, and agree to be accountable for all aspects of the work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available from the Korean National Health Insurance Service (NHIS). Restrictions apply to the availability of these data, which were used under license for the current study (NHIS approval number: NHIS-2023-1-087). Data are not publicly available but can be accessed upon reasonable request and with permission from the NHIS (<https://www.nhis.or.kr>).

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