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# Overall and gender-specific associations between marital status and out-of-hospital coronary death during acute coronary events: a cross-sectional study based on data linkage in Beijing, China

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## ABSTRACT

**Objectives** To assess overall and gender-specific associations between marital status and out-of-hospital coronary death (OHCD) compared with patients surviving to hospital admission.

**Design** A cross-sectional study based on linkage of administrative health databases.

**Setting** Beijing, China.

**Participants** From 2007 to 2019, 378 883 patients with acute coronary event were identified in the Beijing Monitoring System for Cardiovascular Diseases, a validated city-wide registration system based on individual linkage of vital registration and hospital discharge data.

**Outcome measures** OHCD was defined as coronary death occurring before admission. Multilevel modified Poisson regression models were used to calculate the prevalence ratios (PR) and 95% CIs.

**Results** Among 378 883 acute coronary events, OHCD accounted for 33.8%, with a higher proportion in women compared with men (41.5% vs 28.7%, p<0.001). Not being married was associated with a higher proportion of OHCD in both genders, with a stronger association in women (PR 2.18, 95% CI 2.10 to 2.26) than in men (PR 1.97, 95% CI 1.91 to 2.02; p for interaction <0.001). The associations of OHCD with never being married (PR 1.98, 95% CI 1.88 to 2.08) and being divorced (PR 2.54, 95% CI 2.42 to 2.67) were stronger in men than in women (never married: PR 0.98, 95% CI 0.82 to 1.16; divorced: PR 1.47, 95% CI 1.34 to 1.61) (p for interaction <0.001 for both). Being widowed was associated with a higher proportion of OHCD in both genders, with a stronger association in women (PR 2.26, 95% CI 2.17 to 2.35) compared with men (PR 1.89, 95% CI 1.84 to 1.95) (p for interaction <0.001).

**Conclusions** Not being married was independently associated with a higher proportion of OHCD and the associations differed by gender. Our study may aid the development of gender-specific public health interventions in high-risk populations characterised by marital status to reduce OHCD burden.

## Strengths and limitations of this study

► This was the first study, to our knowledge, to examine the association between marital status and out-of-hospital coronary death (OHCD) in acute coronary events combining both fatal and non-fatal cases, which allowed a comparison between OHCD cases and those who survived to hospital admission.

► The large sample size based on city-level data linkage enabled us to examine gender-specific associations in depth through separate nonmarried subgroups with sufficient statistical power.

► Although we controlled for some factors associated with OHCD, this study did not adjust for some potential confounders, including stress, depression, lifestyle factors, comorbidities and medication use; as such, residual confounding could have impacted our findings.

## INTRODUCTION

Coronary heart disease (CHD) remains the leading cause of death worldwide, and accounted for 8.9 million deaths in 2017.[1] Despite advances in emergency transport systems and medical treatment, most coronary deaths occur before admission to hospital.[2–4] Therefore, identifying individuals at higher risk for out-of-hospital coronary death (OHCD) and implementing targeted prevention strategies will help reduce the burden of OHCD and overall CHD deaths.

Marriage may affect the development and prognosis of CHD through spouses encouraging each other to adopt healthy lifestyles, seek early medical attention, or comply with treatment regimens, or providing emotional support or financial security.[5–7] Previous meta-analyses and population studies reported that married people had lower CHD incidence and mortality and better prognosis after CHD

compared with those who were not married.[8–12] The association between marriage and the risk of out-of-hospital sudden cardiac arrest has also been reported in previous studies.[13 14] In addition, a study conducted between 1979 and 1989 using national longitudinal mortality data found that living alone or being unmarried was associated with OHCD compared with in-hospital coronary death.[15] However, these studies were conducted with a subgroup data set,[14] were not recent[13 15] or did not adjust for other factors[15] which have been reported to be associated with OHCD, such as emergency medical services and extreme environmental exposure.[16–18] Few contemporary studies with large sample sizes have explored the association between marital status and OHCD in acute coronary events, combining both fatal and non-fatal cases. Furthermore, gender differences have been observed in the association between marriage and cardiovascular risk.[10] However, gender differences in the association between marital status and OHCD have not been investigated.

We used data from the validated Beijing Cardiovascular Disease Surveillance System[19] to examine whether marital status was associated with the proportion of OHCD compared with patients surviving to hospital admission and whether such associations differed by gender.

## METHODS

### Data sources

All acute coronary events were identified in the Beijing Cardiovascular Disease Surveillance System which links routinely collected records from the Beijing Hospital Discharge Information System (HDIS) with the Beijing Vital Registration Monitoring System (VRMS), as previously described.[19] In detail, hospitalisation data were drawn from the Beijing HDIS managed by Beijing Municipal Health Big Data and Policy Research Center. The HDIS contains hospital discharge abstracts from electronic patient administrative systems submitted by all non-military hospitals in Beijing. Data on the cause of death for the same period were obtained from the Beijing VRMS managed by the Beijing Center for Disease Control and Prevention based on death certificates. Data from the HDIS and VRMS were linked through the personal identity number that is unique for all Chinese citizens. When identity numbers were missing in the system (1.7% of the total entries), we linked data using a combination of name, birth date, gender and address. The same in-hospital death identified in both the Beijing HDIS and the VRMS was considered a single case. After linking, patients' identity numbers were replaced by unique study numbers. Names and addresses were deidentified in all data files used for analysis.

### Study population

Acute coronary events included non-fatal acute myocardial infarction (AMI) cases and fatal CHD events. AMI cases were identified according to the principal discharge diagnosis using the International Classification of Diseases, 10th Revision (ICD-10) codes I21 or I22. Fatal CHD events, including those that died in or out of the hospital, were identified according to the underlying cause of death, using ICD-10 codes I20–I25. Patients who were discharged and then rehospitalised on the same day were considered a single continuous episode of care. In total, the system identified 430 609 acute coronary events among permanent residents in Beijing from 1 January 2007 to 3 December 2019. We excluded patients who were discharged alive with a total length of stay ≤1 day but without subsequent readmission on the same day (n=1418), where a diagnosis of AMI appeared to be unlikely. The first acute coronary event during the study period was used for each patient in the main analysis, with the last event used instead in a sensitivity analysis. After excluding individuals with incomplete demographic data or addresses (n=2654), 378 883 acute coronary events were included in the final analysis.

### Definition of OHCD

OHCD was defined as a death due to CHD (ICD-10 codes I20–I25) occurring before reaching hospital and without recorded admission on the day of death.[3] This included all coronary deaths that occurred at home, at work and other public places, and during transportation, based on the location of death in vital registration.

### Marital status and covariates

Marital status was recorded in four fixed categories: married, never married, divorced and widowed. The latter three categories were then combined into a non-married group. The covariates in the main analyses included year of event, average years of education (township level) and extreme ambient temperature on the day of the event. Covariates in the sensitivity analyses further included driving distance to the nearest percutaneous coronary intervention (PCI)-capable hospital, neighbourhood-level household income and $PM_{2.5}$ exposure level. The data sources and measurement methods are shown in online supplemental methods.

### Data quality and validation

Quality control and data validation are performed annually to compare the information obtained from the Beijing HDIS with that obtained from hospital charts by the Beijing Municipal Health Big Data and Policy Research Center. More than 95% of the data elements were correct, and the overall accordance for major discharge diagnosis was 98.2%.[20] In addition, ICD code-based diagnoses in the HDIS were validated using chart reviews. The positive and negative predictive values of ICD codes for AMI in the Beijing HDIS for the clinical diagnosis of AMI as defined by the Third Universal Definition of Myocardial Infarction were 87.9% and 97.0%, respectively.[21]

The Beijing VRMS coverage rate of the monitoring population was 100% during the study period. Information on the underlying cause of death in Beijing was available for more than 99% of all deaths.[20 22]

## Statistical analysis

Demographic and clinical characteristics were summarised as means and SDs or medians and IQR for continuous data, and counts and percentages for categorical data. Differences between subgroups were compared using $\chi^2$ or Fisher's exact tests for categorical variables and two-sample t-tests or Mann-Whitney tests for continuous variables (as appropriate).

According to the assigned latitudes and longitudes (online supplemental methods), all events were aggregated geographically and nested in the 310 townships in Beijing. A township is the smallest administrative unit in Beijing. The median permanent population of the 310 townships was 24 043 (range: 2351–131 975). The data had a two-level structure and the outcomes were common; therefore, we examined the overall and gender-specific associations between marital status and OHCD using multilevel modified Poisson regression models with robust variances to calculate crude and adjusted prevalence ratios (PR) and corresponding 95% CIs. First, we fit the null model (model 0) with no predictors, including only township-specific random effects. Then, we fit multilevel Poisson regression models that included marital status and other covariates in the null model in a stepwise manner. The initial model was unadjusted (model 1) and patients' age and gender were added in model 2. The final model (model 3) was further adjusted for year of event, average years of education (township level), and extreme ambient temperature on the day of the event (online supplemental methods). We used the median rate ratio (MRR) to measure the general contextual effect of townships in the multilevel Poisson regression analyses.[23] To assess the discriminatory accuracy of the multivariable model, we used receiver operating characteristic (ROC) curves and calculated the area under the curve (AUC). In addition, we performed a subgroup analysis to examine whether these associations differed by gender and tested the difference in the estimates with the Z-test.[24]

Five sensitivity analyses were conducted to determine the robustness of the results. First, we restricted the analyses to patients with AMI (ICD-10 codes I20 or I21); an OHCD case was defined as death from AMI occurring pre-admission. Second, we restricted the analyses to incident acute coronary events that had not been admitted for AMI within a minimum of 7 years before the event. To identify incident events, records from 2007 to 2013 were used as a wash-out period to exclude patients with a prior admission for AMI. Third, association analyses were performed when the last event instead of the first event was analysed for each patient with acute coronary event during the study period. Fourth, associations were examined after excluding patients aged over 80 years. Finally, for patients recruited between 2007 and 2012, we also adjusted for covariates, including driving distance to the nearest PCI-capable hospital, $PM_{2.5}$ exposure level and income, which have been associated with CHD prognosis in previous reports and data were available during that period.[16 17 19 25]

All statistical analyses were performed with Stata, V.14.2 (StataCorp). All tests were two sided and p values less than 0.05 were considered statistically significant.

## Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

## RESULTS

### Demographic characteristics of the study population

Between 2007 and 2019, 378 883 acute coronary events were identified in Beijing. The mean (SD) age was 71.8 (14.0) years and 39.8% were women. Overall, 74.4% (n=281 879) of the patients were married, 22.0% (n=83 230) were widowed, 2.0% (n=7707) were never married and 1.6% (n=6147) were divorced. Compared with married patients, widowed patients were older, whereas never married and divorced patients were younger. The divorced and widowed patients contained a higher proportion of women than the married patient group, and the never married patient group contained the lowest proportion of women. Never married and widowed patients had lower township-level average years of education than married patients, and divorced patients had the highest education level. Additionally, for 2.5% (154/6147) of divorced or widowed patients and 2.3% (179/7707) of never married patients, OHCD occurred on a day with extreme temperature, which was higher than the proportion in married patients (2.2% (6197/281 879)). During the study period, the proportions of married and never married patients declined from 77.1% to 72.5% and 2.5% to 1.8%, respectively, whereas the proportions of divorced and widowed patients increased from 1.1% to 2.0% and 19.3% to 23.7%, respectively (table 1). In addition, among patients who initially survived to reach hospital with an AMI, 43.4% (91 285/210 402) underwent PCI. The married patient group contained a higher proportion of PCI than unmarried patients (46.1% (87 040/188 967) vs 19.8% (4245/21 435), p<0.001). All of the differences in patient characteristics between these subgroups were significant (all p<0.001), with the exception of the proportion of extreme temperature.

### Association between marital status and OHCD

Among all acute coronary events, 55.5% (n=210 315) were fatal and 33.8% (n=128 114) were OHCD. The proportion of OHCD was 23.5% (15 546/66 153) in married patients and 63.8% (39 531/61 961) in those who were not married. The MRR values from the null model (model 0) and the final model (model 3) were 1.47 and 1.41, respectively. Overall, compared with being married, not being married was associated with a higher proportion of OHCD and this association remained robust after adjustment for covariates (PR 2.04, 95% CI 1.98 to 2.10). For the non-married subgroups, never married (PR 1.77, 95% CI 1.66 to 1.87), divorced (PR 2.08, 95% CI 1.97 to

**Table 1** Demographic characteristics for 378 883 acute coronary events between 2007 and 2019 in Beijing, stratified by marital status

| | | | Not married (n=97 004) | | |
|---|---|---|---|---|---|
| Characteristics* | Total (n=378 883) | Married (n=281 879) | Never married (n=7707) | Divorced (n=6147) | Widowed (n=83 230) |
| Age, years | 71.8 (14.0) | 68.8 (13.4) | 61.4 (16.9) | 67.6 (15.2) | 83.5 (7.9) |
| Age group, n (%) | | | | | |
| <60 years | 80 444 (21.2) | 73 977 (26.3) | 3425 (44.4) | 2141 (34.8) | 901 (1.1) |
| ≥60 years | 298 439 (78.8) | 207 822 (73.8) | 4282 (55.6) | 4006 (65.2) | 82 329 (98.9) |
| Women, n (%) | 150 943 (39.8) | 91 225 (32.4) | 1461 (19.0) | 2123 (34.5) | 56 134 (67.4) |
| Extreme temperature on the day of event†, n (%) | 8594 (2.3) | 6197 (2.2) | 179 (2.3) | 154 (2.5) | 2064 (2.5) |
| Average years of education at township level, years | 11.2 (1.6) | 11.3 (1.6) | 10.9 (1.7) | 11.6 (1.4) | 11.0 (1.6) |
| Year of event, n (%) | | | | | |
| 2007–2009 | 70 910 | 54 658 (77.1) | 1765 (2.5) | 808 (1.1) | 13 679 (19.3) |
| 2010–2012 | 82 028 | 62 350 (76.0) | 1741 (2.1) | 1131 (1.4) | 16 806 (20.5) |
| 2013–2015 | 90 069 | 66 243 (73.6) | 1809 (2.0) | 1482 (1.7) | 20 535 (22.8) |
| 2016–2019 | 135 876 | 98 548 (72.5) | 2392 (1.8) | 2726 (2.0) | 32 210 (23.7) |

*Values are mean (SD) for age and township-level average years of education and counts (percentages) for other characteristics.
†Extreme ambient temperature on the day of event included extreme cold and extreme hot temperature, which were defined as the first and 99th centiles of temperature distribution in Beijing during the study period, respectively.

2.20) and widowed (PR 2.07, 95% CI 2.00 to 2.14) were associated with a higher proportion of OHCD (table 2). The discriminatory accuracy of the final multivariable model was evaluated by ROC curves and the AUC was 0.77 (95% CI 0.75 to 0.80).

### Gender-specific associations between marital status and OHCD

The proportion of OHCD among acute coronary events was higher in women than in men (41.5% (62 596/150 943) vs 28.7% (65 518/227 940), p<0.001) (figure 1).

Overall, compared with being married, not being married was associated with a higher proportion of OHCD for both genders after adjustment for covariates, with a more pronounced association in women (men: PR 1.97, 95% CI 1.91 to 2.02; women: PR 2.18, 95% CI 2.10 to 2.26; p for interaction <0.001). Never married and divorced men both had higher proportions of OHCD compared with married men (never married: PR 1.98, 95% CI 1.88 to 2.08; divorced: PR 2.54, 95% CI 2.42 to 2.67), with these associations stronger than those for never married (PR

**Table 2** Associations between marital status and out-of-hospital coronary death in acute coronary events between 2007 and 2019 in Beijing

| | OHCD events, N (%*) | Prevalence ratio (95% CI) | | |
|---|---|---|---|---|
| Characteristics | | Model 1 | Model 2 | Model 3 |
| Marital status | | | | |
| Married | 66 153 (23.5) | 1.00 | 1.00 | 1.00 |
| Not married | 61 961 (63.8) | 2.56 (2.49 to 2.63) | 2.03 (1.97 to 2.09) | 2.04 (1.98 to 2.10) |
| Marital status | | | | |
| Married | 66 153 (23.5) | 1.00 | 1.00 | 1.00 |
| Never married | 3036 (39.4) | 1.59 (1.50 to 1.69) | 1.78 (1.67 to 1.89) | 1.77 (1.66 to 1.87) |
| Divorced | 2744 (44.6) | 1.98 (1.88 to 2.08) | 2.03 (1.92 to 2.15) | 2.08 (1.97 to 2.20) |
| Widowed | 56 181 (67.5) | 2.69 (2.61 to 2.77) | 2.06 (1.99 to 2.13) | 2.07 (2.00 to 2.14) |

Model 1 was not adjusted, model 2 was adjusted for age and gender, model 3 was adjusted for age, gender, year of event, average years of education at the township level, and extreme temperature on the day of event (yes or no).
*Proportion of OHCD among acute coronary events by marital status group.
OHCD, out-of-hospital coronary death.
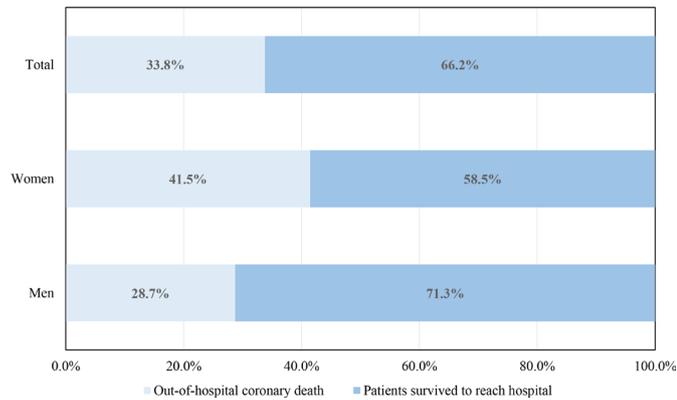
**Figure 1** Proportion of out-of-hospital coronary deaths in acute coronary events between 2007 and 2019 in Beijing.

0.98, 95% CI 0.82 to 1.16) and divorced (PR 1.47, 95% CI 1.34 to 1.61) women (both p for interaction <0.001). Being widowed was significantly associated with a higher proportion of OHCD for both genders, and the association was significantly stronger in women (PR 2.26, 95% CI 2.17 to 2.35) than men (PR 1.89, 95% CI 1.84 to 1.95; p for interaction <0.001) (table 3).

**Sensitivity analyses**
We performed five sensitivity analyses to check our main findings. Similar results for overall and gender-specific associations were found in all analyses (figure 2 for sensitivity analysis 1–4, online supplemental table S1 for sensitivity analysis 5).

**DISCUSSION**
To our knowledge, this is the first study to evaluate overall and gender-specific associations between marital status and OHCD in acute coronary events. Compared with being married, not being married was associated with a higher proportion of OHCD in both genders, with this

association stronger among women. For non-married subgroups, never married and divorced men exhibited stronger associations with OHCD than never married and divorced women, while widowed women had a stronger association with OHCD than widowed men.

**Comparison with previous studies and interpretation**
Traditional risk factors for CHD are well established, and the evolving role of non-traditional risk factors (eg, socioeconomic and psychosocial factors) is increasingly recognised.[26] The merits of marriage have been observed in numerous studies investigating CHD incidence, mortality and prognosis.[8 9] However, previous studies on marital status related to OHCD are scarce. The Chinese Longitudinal Healthy Longevity Survey reported that marital status was not associated with place of death among older people in China, but that analysis was not stratified by cause of death.[27] Additionally, the US National Longitudinal Mortality Study (1979–1989) found that persons living alone/unmarried were 1.60 times more likely to suffer OHCD than married people, independent of demographic and socioeconomic characteristics.[15] Our contemporary city-wide analysis of fatal and non-fatal coronary events extended previous findings regarding poor cardiovascular outcomes in nonmarried individuals[8 9 15] and demonstrated an association between not being married and a higher proportion of OHCD.
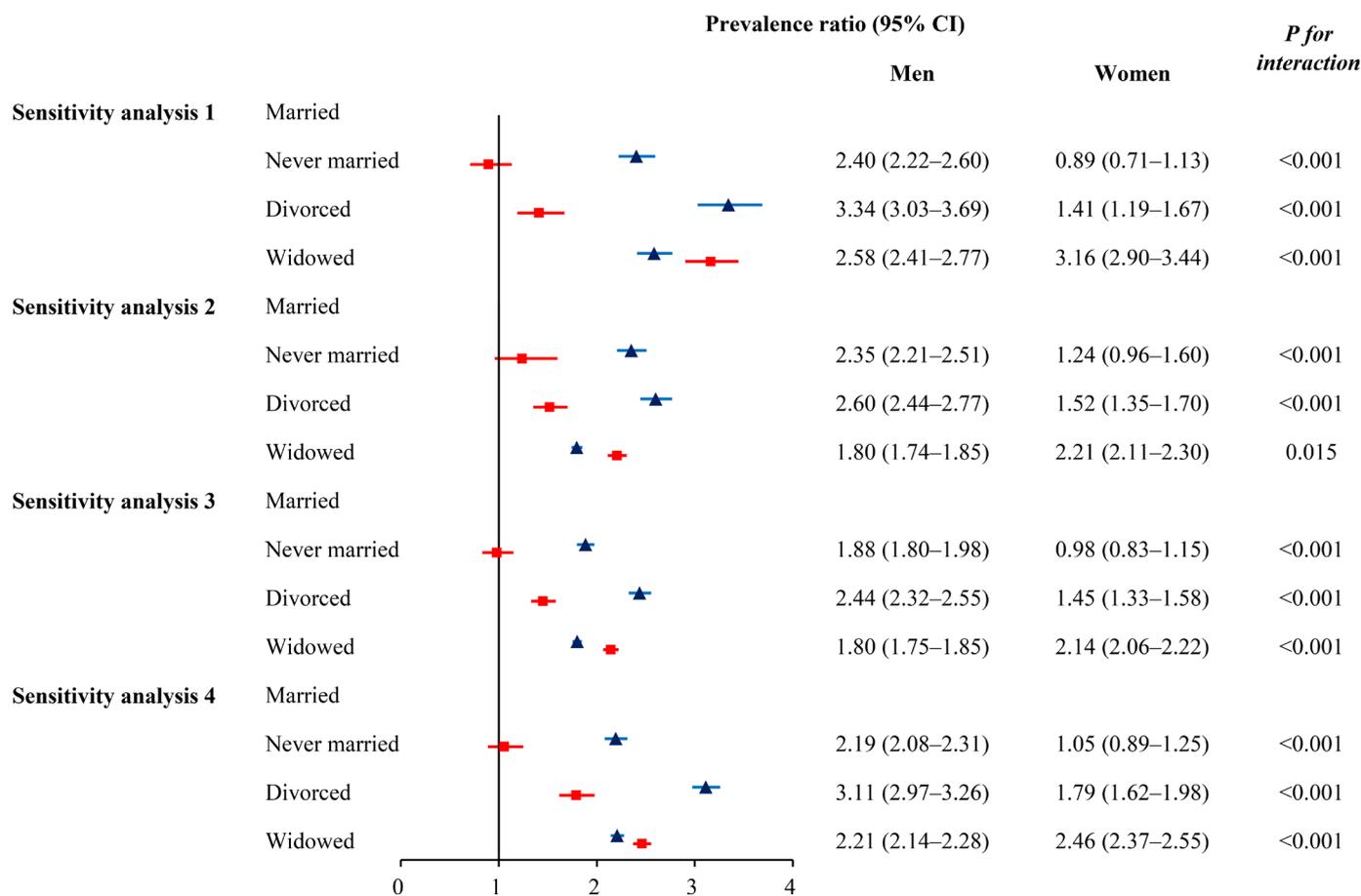
The effect of marriage on OHCD observed in this study primarily occurred via two pathways: psychosocial factors, such as social support, and neo-materialist interpretation, such as financial security. Previous studies suggested that married people were more likely to have healthier lifestyles and better adherence to treatment that promoted cardiovascular health compared with those who were not married.[6 7 28] Furthermore, a lack of social support from spouses along with emotional and financial stress may worsen cardiovascular risk factors

**Table 3** Gender-specific associations between marital status and out-of-hospital coronary death in acute coronary events between 2007 and 2019 in Beijing

| Characteristics | Men | | Women | | P for interaction |
|---|---|---|---|---|---|
| | Events, n (%*) | Prevalence ratio (95% CI)† | Events, n (%*) | Prevalence ratio (95% CI)† | |
| Marital status | | | | | |
| Married | 42 618 (22.4) | 1.00 | 23 535 (25.8) | 1.00 | |
| Not married | 22 900 (61.3) | 1.97 (1.91 to 2.02) | 39 061 (65.4) | 2.18 (2.10 to 2.26) | <0.001 |
| Marital status | | | | | |
| Married | 42 618 (22.4) | 1.00 | 23 535 (25.8) | 1.00 | |
| Never married | 2705 (43.3) | 1.98 (1.88 to 2.08) | 331 (22.7) | 0.98 (0.82 to 1.16) | <0.001 |
| Divorced | 1991 (49.5) | 2.54 (2.42 to 2.67) | 753 (35.5) | 1.47 (1.34 to 1.61) | <0.001 |
| Widowed | 18 204 (67.2) | 1.89 (1.84 to 1.95) | 37 977 (67.7) | 2.26 (2.17 to 2.35) | <0.001 |

*Proportion of OHCD among all acute coronary events by marital status group.
†Model was adjusted for age, year, average years of education at the township level and extreme temperature on the day of event (yes or no).
OHCD, out-of-hospital coronary death.

| | | **Prevalence ratio (95% CI)** | | *P for interaction* |
| | | **Men** | **Women** | |
| **Sensitivity analysis 1** | Married | | | |
| | Never married | 2.40 (2.22–2.60) | 0.89 (0.71–1.13) | <0.001 |
| | Divorced | 3.34 (3.03–3.69) | 1.41 (1.19–1.67) | <0.001 |
| | Widowed | 2.58 (2.41–2.77) | 3.16 (2.90–3.44) | <0.001 |
| **Sensitivity analysis 2** | Married | | | |
| | Never married | 2.35 (2.21–2.51) | 1.24 (0.96–1.60) | <0.001 |
| | Divorced | 2.60 (2.44–2.77) | 1.52 (1.35–1.70) | <0.001 |
| | Widowed | 1.80 (1.74–1.85) | 2.21 (2.11–2.30) | 0.015 |
| **Sensitivity analysis 3** | Married | | | |
| | Never married | 1.88 (1.80–1.98) | 0.98 (0.83–1.15) | <0.001 |
| | Divorced | 2.44 (2.32–2.55) | 1.45 (1.33–1.58) | <0.001 |
| | Widowed | 1.80 (1.75–1.85) | 2.14 (2.06–2.22) | <0.001 |
| **Sensitivity analysis 4** | Married | | | |
| | Never married | 2.19 (2.08–2.31) | 1.05 (0.89–1.25) | <0.001 |
| | Divorced | 3.11 (2.97–3.26) | 1.79 (1.62–1.98) | <0.001 |
| | Widowed | 2.21 (2.14–2.28) | 2.46 (2.37–2.55) | <0.001 |

**Figure 2** Sensitivity analyses for gender-specific associations between marital status and out-of-hospital coronary death. The model was adjusted for age, year of event, average years of education at township level, and extreme temperature on the day of event (yes or no). Forest plot with triangle in dark blue colour=men. Forest plot with square in red colour=women. Sensitivity analysis 1, gender-specific associations between marital status and out-of-hospital coronary death in patients with acute myocardial infarction between 2007 and 2019 in Beijing. Aensitivity analysis 2, gender-specific associations between marital status and out-of-hospital coronary death in incident acute coronary events between 2014 and 2019 in Beijing. Sensitivity analysis 3, gender-specific associations between marital status and out-of-hospital coronary death when the last event instead of the first event was used for each patient between 2007 and 2019 in Beijing. Sensitivity analysis 4, gender-specific associations between marital status and out-of-hospital coronary death excluding patients aged over 80 years between 2007 and 2019 in Beijing.

such as hypertension, hyperlipidaemia and diabetes,[29] thereby potentially contributing to disease severity.[30] In addition, early recognition of symptoms may play a role in the improved outcomes seen in married individuals, as studies have found longer delays in seeking medical care in non-married individuals.[31]

Our study found significant gender differences in the associations between specific marital status and OHCD. The association between OHCD and marital status appeared to be stronger in never married and divorced men than women, whereas this association was stronger in widowed women than widowed men. Previous studies reported that never married or divorced women tended to have high education levels and have highly qualified occupations, with these characteristics associated with a lower risk for OHCD.[2] In contrast, men may experience a more dramatic decline in supportive social ties than women after divorce,[32] which provides a plausible explanation for our finding of a stronger association of OHCD

with divorce in men. The determinants of gender-specific associations among widowed patients were unclear. However, a possible explanation is that widowed women in our study tended to be older than widowed men and may, therefore, have had an increased burden of risk factors and comorbidities. These observations merit further investigation and replication.

**Strengths and limitations of this study**

This study had several strengths. First, this was the first study to examine the association between marital status and OHCD among acute coronary events combining both fatal and non-fatal cases, which allowed a comparison between OHCD cases and those who survived to hospital admission. Second, the use of data from a city-level registry system minimised selection bias. The system combined the validated Beijing HDIS, as mentioned above, and VRMS which has been widely used in many large-scale studies and other similar

research exploring factors associated with OHCD.[18 33 34] The VRMS in Beijing was established to cover the whole city population in 1975, and is the highest quality in China. Third, the large sample size in our study enabled us to examine gender-specific associations in depth through separate nonmarried subgroups with sufficient statistical power.

Our study also had several limitations that should be considered. First, we were not able to adjust for confounders, including stress, depression, lifestyle factors (eg, smoking and drinking alcohol), comorbidities and medication use because the registry system lacked this information. Although we controlled for some factors associated with OHCD in previous reports (eg, education level, extreme ambient temperature, driving distance to the nearest PCI-capable hospital, $PM_{2.5}$ exposure level and income),[2 15–18] we acknowledge that there remains potential residual confounding. Second, our study did not consider cohabitation/living with someone. This could potentially lead to misclassification and dilution bias, because some individuals classed as unmarried could be protected due to cohabiting with someone. Third, the measure of education was based on township-level data, which risks some imprecision. Fourth, there are 15 military hospitals that are not covered by our monitoring system. Although the number of acute coronary events in Beijing was underestimated, the absence of such data should have little effect on the association between marital status and OHCD.

## Implications of the results

The present findings may have important implications for public health. Despite advances in emergency transport systems and medical treatment, most coronary deaths occur before admission to hospital. To develop targeted prevention strategies, knowledge about the risk factors for OHCD is needed; however, this information is scarce, particularly in China.[35] Although daily practice tends to focus on established biological risk factors (ie, dyslipidaemia, diabetes mellitus and hypertension), psychosocial parameters have been reported to impact both the occurrence and prognosis of CHD. Although marital status is not amenable to medical intervention or treatment, understanding the impact of this factor can help healthcare providers and policy-makers identify individuals at high risk for OHCD. Subsequently, targeted public health efforts and social support can be designed for high-risk populations, including mental health counselling, and assistance with medication adherence and seeking timely medical care. Furthermore, the findings of gender-specific associations in our study indicate differences in the underlying determinants of the effect of marriage on OHCD, and further investigation may help develop effective gender-specific prevention measures. Implementing these interventions could help reduce the burden of OHCD and have substantial public health benefits.

## CONCLUSIONS

Our study suggests that marital status is independently associated with OHCD for both men and women in acute coronary events, with gender-based differences in this association. Further investigation is needed to identify the underlying determinants of gender differences in the association between marital status and OHCD. Consideration of gender-based differences in the development and implementation of public health interventions targeting high-risk populations characterised by marital status may be helpful to reduce the burden of OHCD.

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