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ORIGINAL ARTICLE

Age-Stratified Patterns of Suicide Methods in Bipolar Disorder: A Nationwide Cohort Study

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ABSTRACT

Objectives: Age-stratified suicide methods in bipolar disorder remain underexplored. This study compared method selection between suicide decedents with bipolar disorder and the general population.

Methods: We identified 47,488 individuals with bipolar disorder between 2003 and 2023 from Taiwan's nationwide health database and linked mortality records to ascertain suicide deaths. Using a decedent-only design, we compared the distribution of suicide methods between suicide decedents with bipolar disorder and those from the general population. Age-stratified (< 30, 30–49, 50–64, and ≥ 65 years) multivariable logistic regression analyses were performed with adjustment for sex, age at death, urbanization level, and employment status.

Results: Among 1452 suicide deaths over 478,729 person-years (incidence: 303.3 per 100,000), the most common methods were hanging (28.0%), charcoal burning and other gas poisoning (20.9%), jumping from a high place (18.0%), drug overdose (16.9%), and drowning (11.4%). Suicide decedents in the bipolar cohort had higher odds of drowning (adjusted odds ratio [aOR]: 1.70, 95% confidence interval [CI]: 1.44–2.00) and jumping from a high place (aOR: 1.31, 95% CI: 1.14–1.50) but lower odds of charcoal burning and other gas poisoning (aOR: 0.69, 95% CI: 0.60–0.79) and hanging (aOR: 0.87, 95% CI: 0.77–0.98) than did general-population decedents ($n = 81{,}159$). Age-stratified analyses showed charcoal burning concentrated in younger and middle-aged decedents, drowning consistently elevated across age strata, and jumping elevated in middle-aged and older decedents.

Conclusion: Individuals with bipolar disorder who die by suicide exhibit distinct, age-dependent patterns of suicide methods. Therefore, prevention strategies should be tailored to both age groups and methods.

1 | Introduction

Bipolar disorder is a severe, recurrent mood disorder associated with substantial functional impairment and premature mortality [1, 2]. Systematic reviews and meta-analyses have reported high rates of all-cause and cause-specific mortality in individuals with bipolar disorder—for example, increased mortality from unnatural causes such as suicide [3, 4]. Suicide remains a major global public health concern, and preventing access to specific methods is a key component of effective suicide prevention [5, 6].

Suicidal behavior and suicide mortality are core clinical concerns in bipolar disorder. Large-scale syntheses, including

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Key Points

- Significant Outcomes
  - Over 478,729 person-years, 1452 individuals with bipolar disorder died by suicide (303.3 per 100,000 person-years).
  - The bipolar cohort had higher odds of drowning and jumping but lower odds of charcoal burning and hanging than the general population.
  - Charcoal burning was lower in younger and middle-aged decedents; drowning elevated across all strata, and jumping elevated in middle-aged and older decedents.
- Limitations
  - The cohort was defined using psychiatric inpatients, which may limit generalizability to outpatients or untreated individuals.
  - Suicide method classification based on cause-of-death coding may be subject to misclassification, particularly in poisoning categories.
  - Axis I comorbidity and prior suicide attempts were unadjusted owing to undercoding and measurement asymmetry; residual confounding remains possible.

reports from the International Society for Bipolar Disorders Task Force and other systematic reviews, have reported increased risks of suicide attempts and suicide deaths among individuals with bipolar disorder and highlighted clinically meaningful heterogeneity across demographic and clinical subgroups [7–13]. In addition, sex differences have been noted in suicide outcomes in individuals with bipolar disorder, suggesting that sex-specific and life-course factors should be considered during the development of prevention strategies [14].

In addition to estimating suicide risk, understanding suicide methods is directly relevant to suicide prevention because methods vary in lethality, accessibility, and amenability to intervention [6, 15]. Method epidemiology provides an empirical basis for prioritizing feasible interventions in restriction of lethal means, one of the most evidence-supported approaches to population-level prevention [15]. A recent systematic review and meta-analysis found that individuals with bipolar disorder had more than three times higher odds of dying by jumping from a high place compared with those without a psychiatric diagnosis [16]. However, the evidence base for bipolar disorder remains sparse: only two to five studies contributed to any individual method-specific estimate, and no statistically significant differences were identified for overdose, drowning, or hanging in this diagnosis group [16]. Importantly, none of the included studies reported age-stratified analyses, and the available evidence was derived predominantly from North American and European settings, leaving East Asian method environments unrepresented in pooled estimates [16]. A decedent-only design has been used in comparable Taiwanese registry studies to examine method selection conditional on suicide death, and the present study extends this approach to bipolar disorder [17].

Age is a key determinant of suicide method choice. It influences how psychiatric illness determines method selection through differences in illness trajectories, treatment exposure, comorbidities, access to lethal means, and situational feasibility [2, 18–20]. Population-based register data have demonstrated that the relationship between age and method choice is nonlinear and differs by sex, with method distributions shifting substantially across the lifespan in ways that call for age-specific prevention strategies [21]. In bipolar disorder, age-stratified analyses have shown that suicide risk profiles, including the contributions of substance use disorders (SUDs), sleep disorders, and anxiety, differ meaningfully across life stages, but the corresponding patterns of method choice have not been examined [19]. Whether the method differences between individuals with bipolar disorder and suicide decedents in the general population are consistent across age groups, or whether they are concentrated in specific life stages, remains unknown. Addressing this gap has direct implications for the prioritization of age- and method-specific prevention strategies.

1.1 | Aims of the Study

In the present study, we analyzed nationwide linked health and mortality data from Taiwan to assess the age-stratified distribution of suicide methods among suicide decedents in a bipolar disorder cohort. In addition, we compared method choice between suicide decedents in the bipolar disorder cohort and those in the general population. Our findings can inform age- and method-specific prevention approaches.

2 | Methods

2.1 | Data Source

This population-based cohort study was conducted using nationwide administrative health data from Taiwan's National Health Insurance Research Database (NHIRD), which covers more than 99% of Taiwan's population [22]. The NHIRD has been extensively used as the basis for psychiatric epidemiological research [17, 23]. A validation study using structured chart review reported that the diagnostic codes for bipolar disorders as a broad category in the NHIRD demonstrated high positive predictive value (0.82) and sensitivity (0.84) [24]. Diagnostic validity was further enhanced in the present study by restricting inclusion to individuals with at least one psychiatric inpatient admission with a discharge diagnosis of bipolar disorder, as the accreditation standards of NHI-contracted hospitals mandate that diagnoses be made by board-certified psychiatrists [17]. Each included individual was linked to the National Mortality Database to ascertain dates and causes of death, including suicide deaths and the methods used. This study was approved by the Research Ethics Committee of Taipei City Hospital. The requirement for informed consent was waived owing to the retrospective study design and the use of anonymized data (TCHIRB-1137003-E-F).

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2.2 | Study Cohort

We identified individuals with discharge diagnoses of bipolar disorder (*International Classification of Diseases*, *Ninth Revision*, *Clinical Modification* [*ICD-9-CM*] 296.0–296.16, 296.4–296.81, 296.89, and 296.9; *International Classification of Diseases*, *Tenth Revision*, *Clinical Modification* [*ICD-10-CM*] F30 and F31) between January 1, 2002, and December 31, 2023. After applying a 1-year washout period (January 1, 2002, to December 31, 2002), we constructed the inpatient cohort for the period from 2003 to 2023. We excluded individuals with confirmed schizophrenia (*ICD-9-CM* code: 295; *ICD-10-CM* codes: F20 and F25) and those with missing information on sex or birth year. The final cohort comprised individuals who had at least one psychiatric admission alongside a discharge diagnosis of bipolar disorder between January 1, 2003, and December 31, 2023 ($N = 47{,}488$). A flowchart depicting cohort construction is presented in Figure S1. Follow-up began at cohort entry, defined as the date of the first psychiatric admission with a discharge diagnosis of bipolar disorder during the inclusion period, and continued until death or December 31, 2023, whichever occurred first. Linkage to the National Mortality Database until December 31, 2023 identified 12,525 deaths, including 1452 suicide deaths.

2.3 | Study Outcome and Suicide Method Classification

The primary outcome was suicide mortality, defined according to the underlying cause-of-death codes (ICD-9-CM codes E950–E959 and ICD-10-CM codes X60–X84). Information on combined suicide methods (e.g., overdose combined with jumping) was unavailable. Among suicide decedents, suicide methods were classified using external-cause codes. To ensure comparability with previous Taiwanese mortality coding practices, we classified methods on the basis of the *ICD-9-CM* codes E950–E958 (e.g., drug overdose [E950], charcoal burning and other gas poisoning [E952], hanging [E953], drowning [E954], cutting [E956], and jumping from a high place [E957]). Detailed code mappings and grouped categories are presented in Table S1.

2.4 | Comparison Group

For method-choice comparisons, we identified eligible suicide decedents in the general population from the National Mortality Database during the same study period. Analyses of suicide methods were restricted to suicide decedents (decedent-only design). For each method, we modeled suicide by that method versus all other suicide methods among decedents. Therefore, the odds ratios (ORs) reflect relative differences in method choice among suicide decedents rather than differences in method-specific suicide risk in the population at risk.

2.5 | Covariates

For cohort-level analyses, the following baseline covariates were used: sex, age at cohort entry (< 30, 30–49, 50–64, and ≥ 65 years), urbanization level, employment status during the year before baseline, and Axis I psychiatric comorbidities during the year before baseline (none, SUD, and non-SUD Axis I disorder). Urbanization level was classified into five categories on the basis of a Taiwan-specific urbanization stratification system. For decedent-only method-choice analyses, the regression models were adjusted for sex, age at death, urbanization level of residence at death, and employment status during the year before death. Axis I psychiatric comorbidities and prior suicide attempt history were treated as unadjusted in the main models; their handling is discussed in Section 4.6.

2.6 | Statistical Analysis

Overall and sex-stratified person-years of follow-up and crude incidence rates (per 100,000 person-years) were calculated for all-cause and cause-specific mortality (Table S2). Intergroup differences in cumulative incidence were assessed using the Wilcoxon (Gehan) statistic from life-table survival analysis.

The associations between baseline characteristics and suicide mortality were investigated using Cox proportional hazards models. Hazard ratios (HRs) and 95% CIs were calculated; adjusted HRs were derived from multivariable models adjusted for all covariates listed in Table 1.

Adjusted odds ratios (aORs) with corresponding 95% CIs were calculated from models adjusted for sex, age at death, urbanization level, and employment status. Age-stratified analyses were performed using age-at-death categories (< 30, 30–49, 50–64, and ≥ 65 years). To account for multiple comparisons, FDR control (Benjamini–Hochberg) was applied within each family of nine suicide methods separately: overall (Table 3) and per age stratum (Table S3), that is, five families, less stringent than one pooled family but consistent with separate reporting. An FDR-adjusted $p < 0.05$ was considered significant. As a sensitivity analysis, the decedent-only comparison for charcoal burning and other gas poisoning was repeated separately within the ICD-9 (2003–2015) and ICD-10 (2016–2023) coding periods, using the same covariate adjustment (Table S4).

Standardized mortality ratios (SMRs) were calculated as the ratio of observed to expected suicide deaths, with expected deaths derived by applying age- and sex-specific suicide rates from the general population to corresponding person-years in the bipolar disorder cohort. Overall SMRs and SMRs stratified by Axis I comorbidity status and suicide method are presented in the Table S5. For analyses other than the method-choice comparisons, a two-sided p value less than 0.05 was considered statistically significant.

3 | Results

3.1 | Cohort Characteristics and Suicide Deaths

The final cohort comprised 47,488 individuals with bipolar disorder, and 1452 suicide deaths were identified. In the adjusted Cox models (Table 1), sex was not associated with suicide mortality. Compared with the < 30-year group, the 30–49-year group had increased suicide mortality, and the ≥ 65-year group

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TABLE 1 | Baseline characteristics of and suicide mortality in the bipolar disorder cohort.

Characteristics	Bipolar disorder cohort $N=47,488$, n (%)	Suicide deaths $N=1452$, n (%)	Unadjusted hazard ratio	95% confidence interval	p	Adjusted hazard ratio	95% confidence interval	p
Sex								
Male	22,067 (46.5)	674 (46.4)	Reference			Reference		
Female	25,421 (53.5)	778 (53.6)	1.05	0.94–1.16	0.397	1.05	0.95–1.17	0.328
Age at cohort entry								
< 30	11,077 (23.3)	325 (22.4)	Reference			Reference		
30–49	16,588 (34.9)	681 (46.9)	1.35	1.18–1.54	< 0.001	1.29	1.13–1.48	< 0.001
50–64	11,195 (23.6)	344 (23.7)	1.05	0.90–1.22	0.525	1.00	0.86–1.16	0.992
≥ 65	8628 (18.2)	102 (7.0)	0.40	0.32–0.50	< 0.001	0.38	0.31–0.48	< 0.001
Urbanization level								
1	25,262 (53.2)	792 (54.6)	Reference			Reference		
2	9924 (21.6)	293 (20.2)	0.97	0.85–1.11	0.616	0.96	0.84–1.10	0.559
3	2602 (5.7)	72 (5.0)	0.92	0.72–1.17	0.479	0.97	0.76–1.24	0.812
4	3642 (7.9)	102 (7.0)	0.89	0.73–1.10	0.287	0.92	0.75–1.24	0.442
5	5398 (11.7)	193 (13.3)	1.02	0.87–1.19	0.803	1.02	0.75–1.13	0.807
Employment (within 1 year, closest to the baseline)								
Yes	20,059 (42.2)	570 (39.3)	Reference			Reference		
No	27,429 (57.8)	882 (60.7)	1.13	1.02–1.26	0.023	1.27	1.14–1.42	< 0.001
Comorbidity (within 1 year before the baseline)								
Without Axis I comorbidity	6130 (12.9)	110 (7.6)	Reference			Reference		
With SUD	4920 (10.4)	244 (16.8)	2.88	2.30–3.61	< 0.001	2.45	1.95–3.08	< 0.001
With non-SUD Axis I disorder	36,438 (76.7)	1098 (75.6)	1.84	1.51–2.24	< 0.001	1.84	1.51–2.24	< 0.001

Characteristics	Mean (SD)	Mean (SD)
Total contributed person-years	478,729	5554
Average contributed person-years, SD	10.08 (6.02)	3.82 (3.98)

Note: Urbanization was classified using a stratification system developed for Taiwan. The level of urbanization was classified as Level 1 (highly urbanized area), Level 2 (moderately urbanized area), Level 3 (township area), Level 4 (subrural area), or Level 5 (rural area).
Adjusted hazard ratios were estimated using a multivariable Cox proportional hazards model adjusted for all covariates listed in the table (sex, age at cohort entry, urbanization level, employment status during the year before baseline, and comorbidities during the year before baseline).
Abbreviation: SUD, substance use disorder.

had reduced suicide mortality. Unemployment was positively associated with suicide mortality. Individuals with SUD and those with non-SUD Axis I disorders had higher suicide mortality than did those without Axis I comorbidities.

Cumulative incidence of suicide mortality varied across the age groups (Wilcoxon [Gehan] statistic = 79.87; $p < 0.001$; Figure 1). The 30–49-year group exhibited the highest cumulative incidence of suicide mortality, followed by the 50–64- and < 30-year

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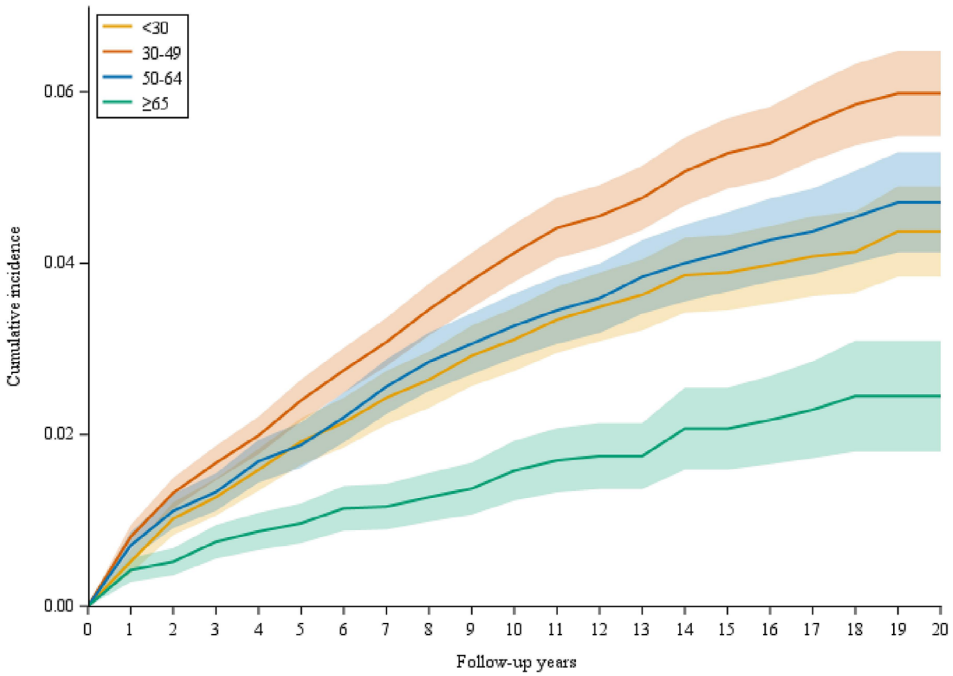

FIGURE 1 | Age-stratified cumulative incidence of suicide mortality in the bipolar disorder cohort, 2003–2023. Shaded bands represent 95% confidence intervals. Age groups were defined by age at cohort entry: < 30, 30–49, 50–64, and ≥ 65 years. Differences in cumulative incidence across age groups were tested using the Wilcoxon (Gehan) statistic from life-table survival analysis (test statistic = 79.87, $p < 0.001$).

groups. Incidence was the lowest in the ≥ 65-year group throughout the follow-up period.

3.2 | Distribution of Suicide Methods in the Bipolar Disorder Cohort

For the 1452 suicide deaths, the most frequent methods were hanging (407 deaths [28.0%]), charcoal burning and other gas poisoning (304 [20.9%]), jumping from a high place (262 [18.0%]), and drug overdose (245 [16.9%]). Drowning accounted for 165 deaths (11.4%).

In sex-stratified analyses (Table 2), the incidence of drowning was higher in women than in men (42.49 vs. 25.90 per 100,000 person-years; $p = 0.004$) and that of jumping from a high place was higher in women than in men (68.39 vs. 40.15 per 100,000 person-years; $p < 0.001$). Furthermore, the incidence of suicide involving firearms and explosives was higher in men than in women (8.63 vs. 1.21 per 100,000 person-years; $p = 0.001$).

3.3 | Differences in Method Selection Between Suicide Decedents in the Bipolar Cohort and Those in the General Population

In decedent-only analyses (Table 3), suicide decedents in the bipolar disorder cohort had higher odds of drowning (aOR: 1.70, 95% CI: 1.44–2.00; FDR-adjusted $p < 0.001$) and jumping from a high place (aOR: 1.31, 95% CI: 1.14–1.50; FDR-adjusted $p < 0.001$) but lower odds of charcoal burning and other gas poisoning (aOR: 0.69, 95% CI: 0.60–0.79; FDR-adjusted $p < 0.001$) and hanging (aOR: 0.87, 95% CI: 0.77–0.98; FDR-adjusted $p = 0.043$) than did those in the general population ($n = 81{,}159$). Drug overdose, although among the most common methods (16.9% of deaths), showed only a small, non-significant between-cohort difference before and after FDR correction (aOR: 1.15, 95% CI: 0.99–1.32; FDR-adjusted $p = 0.117$). Differences in the other remaining methods were likewise not statistically significant after FDR correction (Table 3). In a sensitivity analysis stratified by coding era, the lower odds of charcoal-burning and other gas poisoning suicide were nearly identical between the ICD-9 and ICD-10 periods (aOR = 0.69 for both; Table S4), confirming that this central finding was not driven by the ICD-9-to-ICD-10 coding transition.

3.4 | Age-Based Differences in Method Selection

Age-stratified decedent-only analyses (< 30, 30–49, 50–64, and ≥ 65 years) revealed heterogeneity in the association between bipolar disorder status and suicide method choice. To facilitate interpretation, age-stratified aORs for four key methods (charcoal burning and other gas poisoning, hanging, drowning, and jumping from a high place) are presented in Figure 2; complete results for all methods are presented in Table S3.

For charcoal burning and other gas poisoning, the odds were lower for younger decedents (< 30 years, aOR: 0.67, 95% CI: 0.49–0.91; FDR-adjusted $p = 0.040$) and middle-aged decedents (30–49 years, aOR: 0.63, 95% CI: 0.53–0.76; FDR-adjusted $p < 0.001$), with attenuation in older age strata (50–64 years, aOR: 0.84, 95% CI: 0.65–1.09; ≥ 65 years, aOR: 1.16, 95% CI: 0.54–2.49).

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TABLE 2 | Suicide methods among suicide decedents in the bipolar disorder cohort.

	Men ($N=22,067$) (PY = 231,616)		Women ($N=25,421$) (PY = 247,113)		Total ($N=47,488$) (PY = 478,729)		
Cause of death	**No. of deaths**	**Incidence[a]**	**No. of deaths**	**Incidence[a]**	**No. of deaths**	**Incidence[a]**	***p***
Total mortality	6975	3011.45	5550	2245.94	12,525	2616.30	< 0.001
Unnatural death	1152	497.37	1073	434.21	2225	464.77	0.004
Suicide	674	291.00	778	314.84	1452	303.30	0.378
Drug overdose	108	46.63	137	55.44	245	51.18	0.275
Gases in domestic use	1	0.43	0	0.00	1	0.21	—
Charcoal burning and other gas poisoning	155	66.92	149	60.30	304	63.50	0.231
Hanging	208	89.80	199	80.53	407	85.02	0.147
Drowning	60	25.90	105	42.49	165	34.47	0.004
Firearms and explosives	20	8.63	3	1.21	23	4.80	0.001
Cutting	16	6.91	8	3.24	24	5.01	0.069
Jumping from a high place	93	40.15	169	68.39	262	54.73	< 0.001
Others	13	5.61	8	3.24	21	4.39	0.186

Abbreviation: PY, person-year.
[a]Number per 100,000 person-years. Sex differences in cumulative incidence were examined using the Wilcoxon (Gehan) statistic from life-table survival analysis.

TABLE 3 | Suicide methods among suicide decedents in the bipolar disorder cohort and those in the general population.

	Bipolar cohort with suicides ($N=1452$)	General population with suicides ($N=81,159$)	aOR	95% CI	FDR-adjusted *p*
Drug overdose	245 (16.9)	13,388 (16.5)	1.15	0.99–1.32	0.117
Gases in domestic use	1 (0.1)	45 (0.1)	1.52	0.21–11.13	0.765
Charcoal burning and other gas poisoning	304 (20.9)	20,751 (25.6)	0.69	0.60–0.79	< 0.001
Hanging	407 (28.0)	27,672 (34.1)	0.87	0.77–0.98	0.043
Drowning	165 (11.4)	5271 (6.5)	1.70	1.44–2.00	< 0.001
Firearms and explosives	23 (1.6)	1068 (1.3)	1.38	0.91–2.10	0.200
Cutting	24 (1.7)	1796 (2.2)	0.84	0.56–1.27	0.534
Jumping from a high place	262 (18.0)	9805 (12.1)	1.31	1.14–1.50	< 0.001
Others	21 (1.5)	1363 (1.7)	0.92	0.60–1.43	0.715

Note: aORs were estimated using multivariable logistic regression models adjusted for sex, age at death, urbanization level, and employment status. For each method, the outcome was suicide by that method versus suicide by all other methods among decedents; therefore, aORs reflect relative method choice conditional on suicide death. *p* values were corrected for multiple comparisons across the nine suicide methods using the Benjamini–Hochberg false discovery rate (FDR) procedure. This overall comparison forms one family of nine tests; a separate family of nine tests was formed within each age stratum (Table S3), as described in Section 2.6.
Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; FDR, false discovery rate.

For hanging, the overall odds were slightly lower for suicide decedents in the bipolar disorder cohort than for those in the general population. In the age-stratified analyses, the difference reached statistical significance only in the 30–49-year group (aOR: 0.79, 95% CI: 0.65–0.95; FDR-adjusted $p = 0.020$), with similarly directed but non-significant estimates in the other age strata. For drowning, the odds were consistently elevated across all age strata (FDR-adjusted $p < 0.05$ for each).

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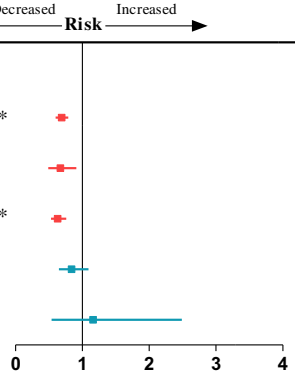
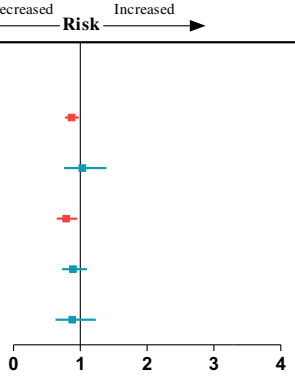
(a)

Age subgroups	Bipolar N(%)	General population N(%)	aOR (95% CI)
All	304 (20.9)	20751 (25.6)	0.69 (0.60-0.79)**
<30	56 (24.9)	3794 (36.6)	0.67 (0.49-0.91)*
30-49	171 (26.2)	11650 (38.3)	0.63 (0.53-0.76)**
50-64	70 (16.4)	4420 (21.3)	0.84 (0.65-1.09)
≥ 65	7 (4.7)	887 (4.5)	1.16 (0.54-2.49)



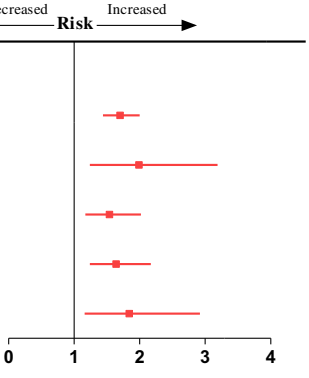
(b)

Age subgroups	Bipolar N(%)	General population N(%)	aOR(95% CI)
All	407 (28.0)	27672 (34.1)	0.87 (0.77-0.98)*
<30	60 (26.7)	2820 (27.2)	1.03 (0.76-1.39)
30-49	148 (22.7)	8646 (28.4)	0.79 (0.65-0.95)*
50-64	140 (32.9)	7728 (37.5)	0.89 (0.73-1.10)
≥ 65	59 (39.9)	8478 (43.4)	0.88 (0.63-1.23)



(c)

Age subgroups	Bipolar N(%)	General population N(%)	aOR (95% CI)
All	165 (11.4)	5271 (6.5)	1.70 (1.44-2.00)**
<30	20 (8.9)	436 (4.2)	1.99 (1.24-3.19)*
30-49	61 (9.3)	1581 (5.2)	1.54 (1.17-2.02)*
50-64	62 (14.6)	1566 (7.5)	1.64 (1.24-2.17)*
≥ 65	22 (14.9)	1688 (8.6)	1.84 (1.16-2.92)*



(d)

Age subgroups	Bipolar N(%)	General population N(%)	aOR (95% CI)
All	262 (18.0)	9805 (12.1)	1.31 (1.14-1.50)**
<30	62 (27.6)	2205 (21.3)	1.09 (0.81-1.48)
30-49	117 (17.9)	3449 (11.3)	1.39 (1.13-1.71)*
50-64	58 (13.6)	2029 (9.8)	1.14 (0.85-1.51)
≥ 65	25 (16.9)	2122 (10.9)	1.73 (1.11-2.70)*

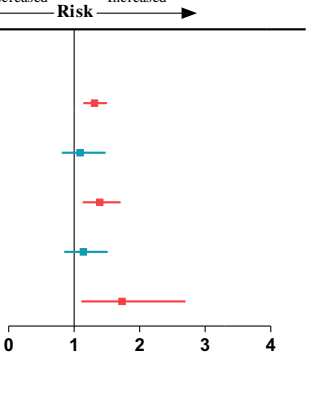


FIGURE 2 | Legend on next page.

For jumping from a high place, the odds were higher for decedents aged 30–49 years (aOR: 1.39, 95% CI: 1.13–1.71; FDR-adjusted $p = 0.004$) and ≥65 years (aOR: 1.73, 95% CI: 1.11–2.70; FDR-adjusted $p = 0.036$), whereas differences were weaker or not statistically significant in the <30 and 50–64 years strata.

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FIGURE 2 | Age-stratified aORs for four key suicide methods among suicide decedents in the bipolar disorder cohort versus those in the general population. Squares indicate aORs and horizontal lines indicate 95% CIs. aORs were estimated using multivariable logistic regression models adjusted for sex, age at death, urbanization level, and employment status. *p* values were corrected for multiple comparisons across the nine suicide methods within each age stratum using the Benjamini–Hochberg false discovery rate (FDR) procedure. *FDR-adjusted $p < 0.05$ and **FDR-adjusted $p < 0.001$. The age groups were as follows: <30, 30–49, 50–64, and ≥65 years. AOR, adjusted odds ratio; FDR, false discovery rate. (a) Charcoal burning and other gas poisoning. (b) Hanging. (c) Drowning. (d) Jumping from a high place.

Several estimates rest on sparse data and should be interpreted with caution, including gases in domestic use ($n = 1$; Table 3), charcoal burning and other gas poisoning in the ≥65-year stratum ($n = 7$), cutting in the 50–64-year stratum ($n = 4$), and firearms and explosives across multiple strata. For these cells, point estimates are unstable and confidence intervals are wide, and no stratum- or method-specific inferences were drawn.

4 | Discussion

4.1 | Main Findings

This study demonstrated that suicide methods differed between suicide decedents in the bipolar cohort and those in the general population, with variation across age strata, corroborating prior evidence that severe mental illness is associated with distinct method profiles and extending it with a life-course perspective directly relevant to prevention [6, 15–17, 25]. Because the method-choice analyses were restricted to suicide decedents, the aORs should be interpreted as differences in method distribution conditional on suicide death rather than method-specific suicide risk. Understanding method selection in bipolar disorder also requires attention to the clinical context in which suicidal crises unfold, including the psychological experience of intolerable mental pain and the role of long-term pharmacotherapy in modifying both suicide risk and method availability [26, 27].

4.2 | Differences in Suicide Methods in the Bipolar Cohort

In bipolar disorder, affective instability, impulsivity, and long-term pharmacotherapy may shape which methods are feasible at the time of a suicidal crisis, contributing to a method distribution that differs from the general population even after adjustment for sex, age, urbanization, and employment [7–9, 12, 13, 16, 20, 25].

4.3 | Age as an Effect Modifier

Age is not only a demographic characteristic but also a proxy for factors affecting suicide method choice, such as living arrangements and supervision, environmental exposure, and long-term treatment trajectories that influence access to medications [2, 18, 19]. The adoption of "diffusing" or "emerging" methods further depends on sociocultural context and cohort exposure, producing age-related differences in method choice within the same diagnosis [28, 29]. Consistent with this interpretation, cumulative incidence varied across age-at-entry strata (Figure 1); baseline age in this inpatient cohort likely reflects illness course, treatment pathways, and selection into hospitalization. Beyond mechanistic interpretation, age-stratified method epidemiology has direct implications for prioritizing means restriction interventions, which are among the most evidence-supported population-level suicide prevention strategies [15]. Because the dominant methods differ by life stage, the most appropriate prevention investment varies with the age composition of the target population, making age-stratified evidence a practical prioritization tool rather than a purely descriptive contribution.

4.4 | Sex Differences in the Bipolar Cohort

Sex-stratified incidence patterns (Table 2) suggest method-specific differences in the bipolar cohort: drowning and jumping were higher in women, whereas firearms and explosives were higher in men. Such sex differences have been consistently reported in bipolar disorder and severe mental illness and likely reflect cumulative differences in access to lethal means, environmental exposure, contextual triggers, and culturally patterned method availability rather than a single mechanism [14, 16].

4.5 | Common Suicide Methods

4.5.1 | Charcoal Burning and Other Gas Poisoning

Charcoal burning and other gas poisoning were less common among bipolar suicide decedents than in the general population, with FDR-corrected significance in the <30 and 30–49-year strata and attenuation in older strata. Charcoal burning is a high-lethality method whose East Asian diffusion has been amenable to community-level means restriction in Taiwan, but diffusion alone does not explain a between-cohort difference unless uptake or feasibility varies across subgroups [28–31]. The observed age pattern may therefore reflect between-subgroup differences in the local "method environment"—the uptake, substitution, and feasibility of the method. One possibility is that charcoal burning is a staged indoor method requiring several sequential steps and a sustained uninterrupted period, conditions that may be less compatible with acute impulsivity or short-latency crises; whether such crisis patterns are more prevalent in younger and middle-aged individuals with bipolar disorder warrants further investigation.

4.5.2 | Hanging

Hanging was among the most common suicide methods in the bipolar cohort, yet overall odds were modestly lower

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than in the general population; the FDR-corrected difference reached significance in the 30–49-year stratum and was similarly directed but non-significant in the other strata. This pattern is consistent with the broader observation that hanging is a common and highly lethal suicide method across many settings, including among individuals with severe mental illnesses. Population-level restriction of lethal means is difficult for this method because the required materials are widely available [16, 32]. The limited age variation may reflect opposing mechanisms, including physical capacity, residential context, and clinical trajectory, whose net effects warrant further investigation. Thus, prevention strategies should focus on early identification of acute affective crises and rapid clinical response. Environmental safety measures in high-risk settings may reduce opportunities for suicide by hanging [33].

4.5.3 | Drowning

Drowning was more common among suicide decedents in the bipolar cohort than in the general population, with FDR-corrected differences consistent across age groups. This finding suggests that the higher relative selection of drowning among bipolar disorder suicide decedents is not limited to a particular stage of life but is observed consistently across the lifespan. The consistently elevated odds across age groups are compatible with an explanation based on the interaction between acute affective dysregulation and environmental opportunity, though this hypothesis cannot be directly tested with the present data. These findings suggest that prevention should focus on situational risk management, including safety planning around water access during high-risk periods, supervision during acute episodes, and coordination with local environmental risk points rather than reliance on single age-specific interventions [33].

4.5.4 | Jumping From a High Place

Jumping from a high place was more common among bipolar suicide decedents than the general population, with FDR-corrected significance in the 30–49 and ≥65-year strata and the greatest elevation in later life. This pattern is consistent with meta-analytic evidence that jumping markedly differs between individuals with bipolar disorder and those without severe mental illness, suggesting that this method can distinguish severe mood disorders across settings [16]. The stronger association in later life may reflect age-based differences in feasibility: in the general population, physical frailty may limit access to high places, whereas older individuals with bipolar disorder who die by suicide may represent a subgroup with relatively preserved mobility or distinct residential exposure. These explanations are speculative, and future studies linking residential environment, functional status, and method-specific outcomes are needed to clarify mechanisms. Structural interventions at known hotspots are supported by strong evidence and represent the most direct method-specific prevention strategy; clinical care should additionally incorporate safety planning that considers proximity to high-risk locations and rapid response during acute crises [34].

4.5.5 | Drug Overdose

Drug overdose was among the most common suicide methods in the bipolar cohort, but overall odds did not differ significantly from the general population before or after correction. Unlike methods tied to specific environmental or treatment contexts, overdose is broadly accessible across populations, which may limit between-cohort differentiation. Moreover, the cohort's inpatient composition, entailing long-term pharmacotherapy and frequent healthcare contact, would bias overdose selection upward; this null finding should thus be interpreted cautiously, not as evidence of no association.

4.6 | Strengths and Limitations

The strengths of this study include nationwide coverage, linkage to mortality records, and decedent-only comparisons that directly evaluate method choice conditional on suicide death, consistent with previous registry-based approaches adopted in research on severe mental illness [17].

This study has several limitations. First, the cohort comprised psychiatric inpatients with bipolar disorder, thus representing a population with more severe illness, a higher comorbidity burden, and more intensive pharmacotherapy than outpatient or community-based populations. This selection may shape the observed method differences in predictable ways: more frequent inpatient contact and long-term pharmacotherapy increase exposure to medications, which may bias the relative selection of drug overdose upward beyond what is attributable to bipolar disorder alone. By contrast, methods with no plausible mechanistic link to inpatient treatment, such as jumping from a high place and drowning, are less susceptible to this source of bias, and the corresponding findings may generalize more reliably across the severity spectrum. Overall, the applicability of these findings to less severely ill or community-based populations with bipolar disorder should be interpreted with caution. Second, classification of suicide methods based on registry codes may be subject to misclassification, and such measurement error may vary across time periods and age groups [35].

Third, the method-choice models could not be adjusted for Axis I psychiatric comorbidity or prior suicide attempt history owing to differential ascertainment. By design, the bipolar cohort required prior psychiatric hospitalization, ensuring near-complete healthcare contact: 92.4% of bipolar-cohort suicide decedents had a recorded Axis I comorbidity in the year before death, versus approximately 45% of general-population decedents—who carried no such guarantee. This roughly twofold gap does not reflect true differences in underlying morbidity: a landmark Taiwanese psychological autopsy study [36] found that approximately 97% of suicide decedents had a diagnosable mental disorder, indicating the general-population registry figure substantially under-ascertains true comorbidity while the bipolar-cohort figure approximates it. Prior suicide attempt history is subject to the same mechanism and is further limited by severe undercoding: registry-coded attempts were recorded in only 3.03% of bipolar-cohort and 1.07% of general-population decedents—far below the approximately

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21% prevalence documented in the same autopsy study—indicating substantial under-capture in both cohorts [36]. The roughly 2.8-fold between-cohort gap thus reflects differential ascertainment rather than a true difference. For both variables, adjusting for an incompletely and differentially ascertained covariate risks introducing bias without eliminating confounding; we therefore excluded them from the main models.

Finally, because the analyses were restricted to suicide decedents, the aORs reflect differences in method choice conditional on suicide death rather than differences in method-specific suicide risk in the underlying population.

5 | Conclusion

In Taiwan, individuals with bipolar disorder who die by suicide exhibit distinct, age-dependent patterns of suicide methods compared with those noted among suicide decedents in the general population. Our findings suggest that method-informed and age-tailored suicide prevention strategies for individuals with bipolar disorder warrant further evaluation. For example, hotspot interventions for jumping from a high place and situational risk management for drowning may represent promising preventive approaches. Future studies should link prescribing trajectories, health-care contact patterns, and environmental exposure to method-specific outcomes to clarify underlying mechanisms and improve targeted prevention efforts.

Author Contributions

M.-C.C. and C.-J.K. conceived and designed the study. C.-J.K. acquired the data. S.-S.S. performed statistical analyses. P.-Y.C. and W.-Y.C. provided administrative and material support. M.-C.C. and C.-J.K. drafted the manuscript. C.-J.K. made critical revisions to the manuscript for important intellectual content. S.-Y.T. and C.-C.C. supervised the study. All authors have read and approved the submitted version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** Flowchart depicting cohort construction. **Table S1:** Medical codes used to define causes of death and suicide-related deaths in this study. **Table S2:** Crude incidence of cause-specific mortality in the bipolar disorder cohort. **Table S3:** Age-stratified comparison of suicide methods between suicide decedents in the bipolar disorder cohort and those in the general population. **Table S4:** Era-stratified comparison of charcoal burning and other gas poisoning between suicide decedents in the bipolar disorder cohort and those in the general population. **Table S5:** Observed and expected deaths and SMRs for suicide methods in the bipolar disorder cohort ($N = 47{,}488$; total deaths = 12,525; suicide deaths = 1452).

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