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Epidemiological features of suicidal ideation among the elderly in China based meta-analysis

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Abstract

Background Studies on the prevalence of suicidal ideation (SI) and its associated factors among the elderly in China show considerable variability. This meta-analysis aims to clarify the epidemiological features of SI in this population.

Methods We systematically searched English and Chinese databases for relevant literature up to September 15, 2022. The extracted data facilitated the calculation of prevalence and odds ratios (ORs) for factors associated with SI among China's elderly.

Results We analyzed 31 cross-sectional studies, comprising a total of 79,861 participants from over 20 provinces and municipalities. The pooled prevalence of SI was found to be 11.47% [95% confidence interval (CI): 7.82–15.71%]. Significant variations in prevalence were influenced by residence, physical health (including chronic diseases and daily living capabilities), mental health (depressive symptoms and life satisfaction), economic status, and time-specific assessment tools. Notably, the prevalence from 2011–2020 (15.59%, 95% CI: 9.08–23.44%) was almost double that of 2001–2010 (7.85%, 95% CI: 5.08–11.16%). The SI prevalence in the eastern region (8.06%, 95% CI 5.59–10.94%) was significantly lower than in the central and western regions (16.97%, 95% CI 12.04–22.53%). Fourteen factors exhibited a significant pooled OR greater than 1 ($p < 0.05$), and two factors had ORs less than 1 ($p < 0.05$), indicating notable association with SI among the elderly.

Conclusion SI among China's elderly showed relatively high prevalence and considerable heterogeneity across different characteristics and associated factors. This underscores the need for targeted intervention strategies and standardized temporal assessments of SI to effectively address suicide risk in this population.

Keywords Suicidal ideation, Prevalence, Associated factor, Elderly, Meta-analysis

Introduction

Suicide consistently poses a significant global health and societal issue, resulting in over 700,000 fatalities annually [1]. Older adults, due to the elevated burden of chronic health conditions and potential for increased social isolation, are considered a higher-risk demographic for suicide compared to other age groups [2, 3]. The multifaceted nature of suicide encompasses a spectrum of behaviors, including suicidal ideation (SI), suicide attempts, and completed suicides [4, 5]. SI, referring to thoughts about taking one's own life, is the third most significant predictor of future suicide deaths, following prior psychiatric hospitalization and suicide attempts [5–7]. Serious SI represents the submerged portion of the suicidality iceberg and could be considered a misery index of global suffering [8, 9]. The SI of the elderly has largely been overlooked, leading to many potential suicide risks going unidentified and unaddressed in a timely manner, which

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imposes significant burdens on families and society [8, 9]. The World Health Organization highlights that addressing SI could reduce suffering across populations and enhance overall quality of life [10]. China, home to the world's largest elderly population, faces significant challenges concerning geriatric suicide. Understanding the epidemiological characteristics of SI within the elderly population in China could aid in identifying potential high-risk groups for suicide and offer valuable insights for the prevention of geriatric suicide-related behaviors.

China has not yet conducted a nationwide epidemiological survey on suicide-related behaviors led by the government. To provide basic policy references, prior research has investigated the epidemiological attributes (prevalence and associated factors) of SI among the elderly population in China from a localized standpoint. However, there were notable variances across elderly individuals with distinct characteristics. For instance, a study conducted in rural Shandong in 2017 showed the prevalence of SI among Chinese seniors was 7.7% [11], significantly different from the 17.8% prevalence reported by a separate survey conducted in Hunan nursing homes [12]. These discrepancies could be attributed to differences in sample characteristics, sampling methodologies, measurement instruments, and temporal snapshots across various studies. To address this issue, Dong et al. performed the first meta-analysis of SI prevalence across the Chinese elderly population in 2014, calculating a pooled prevalence of 11.5% based on 11 studies [13]. Regrettably, the study did not disclose the transformation techniques used in recalculating the SI prevalence from the original 11 studies, potentially introducing bias into the findings [14]. Considering that the prevalence does not always conform to a standard binomial distribution, the original prevalence should be restructured and variance stabilized using logit or double arcsine transformations when the prevalence is particularly low or high [14, 15]. Additionally, there have been insufficient meta-analytic studies on the factors associated with SI among China's senior demographic. The global perception of the overall status of SI among China's elderly population is also affected by linguistic and cultural barriers.

Therefore, this meta-analysis primarily serves three purposes. First, we aim to update the prevalence of SI among the elderly Chinese population and compare the results obtained using three common transformation methods in meta-analysis. Second, we seek to explore the detailed characteristics relating to the prevalence distribution of SI through subgroup analysis. Lastly, we pool together the factors associated with SI among Chinese elderly to identify significant, preventable factors that could be addressed beforehand.

Method

Search strategy

This original research protocol was registered at PROSPERO International Prospective Register of Systematic Reviews (Registration number: CRD42023463124). It was also guided by the PRISMA 2020 statement for systematic reviews [16]. Parallel systematic electronic searches were conducted across seven English databases: PubMed, Embase, Web of Science (WOS), ProQuest, the Cochrane Library, Ovid, and PsycINFO, and three Chinese databases: China National Knowledge Infrastructure (CNKI), Wan Fang, and Chongqing VIP database. The search terms applied were: ("suicidal ideation" OR "suicid*" OR "suicidal thought" OR "suicide thoughts" OR "suicidal thinking" OR "suicidality") AND ("elderly" OR "old people" OR "aged" OR "old adults") AND ("China" OR "Chinese" OR "Hong Kong, China" OR "Taiwan, China" OR "Macau, China") within the article titles, abstracts, and keywords. Additionally, further studies were sourced from the reference lists of the included studies. The search concluded on September 15, 2022.

Inclusion and exclusion criteria

The criteria for including studies in this research were as follows: (1) The participants in the study were individuals aged 60 years and above. (2) The study clearly specified the tool used for measuring SI and the corresponding data collection time points. The tools used should be self-reported items, questionnaires, or scales, accompanied by explanations of their reliability and validity or other justification. (3) The prevalence of SI in the study was expressly stated, providing both the number of individuals surveyed and those who tested positive, or presenting the associated factors' odds ratios (ORs) along with the 95% confidence interval (CI). (4) The research was conducted in China, encompassing Mainland China, Hong Kong S.A.R., China, Macau S.A.R., China, and Taiwan, China. (5) The study employed a cross-sectional survey methodology. (6) The language of the selected studies was either English or Chinese. (7) The selected studies should come from rigorously peer-reviewed journal articles or academic papers.

Exclusion criteria included the following conditions: (1) Studies involving hospitalized patients or samples currently receiving suicide interventions or other mental health interventions. (2) Studies involving Chinese residents living overseas. (3) Studies with missing or non-disclosed critical information related to the survey. (4) Duplicate publications, conference abstracts, reviews, and protocols.

Study selection

Two investigators (WY and SBB) independently assessed the titles and abstracts of potential studies, using the established inclusion and exclusion criteria for reference retrieval and identification of additional publications. Any disagreements that arose were resolved through consultation with a third reviewer (ZYH) to ensure consensus. Figure 1 presents a PRISMA flowchart that outlines the process for study selection and exclusion.

Data extraction

Data from eligible studies were independently extracted by two investigators (WY and SBB) using a standardized Excel template. Extracted information included the first author's name, year of survey and publication, study

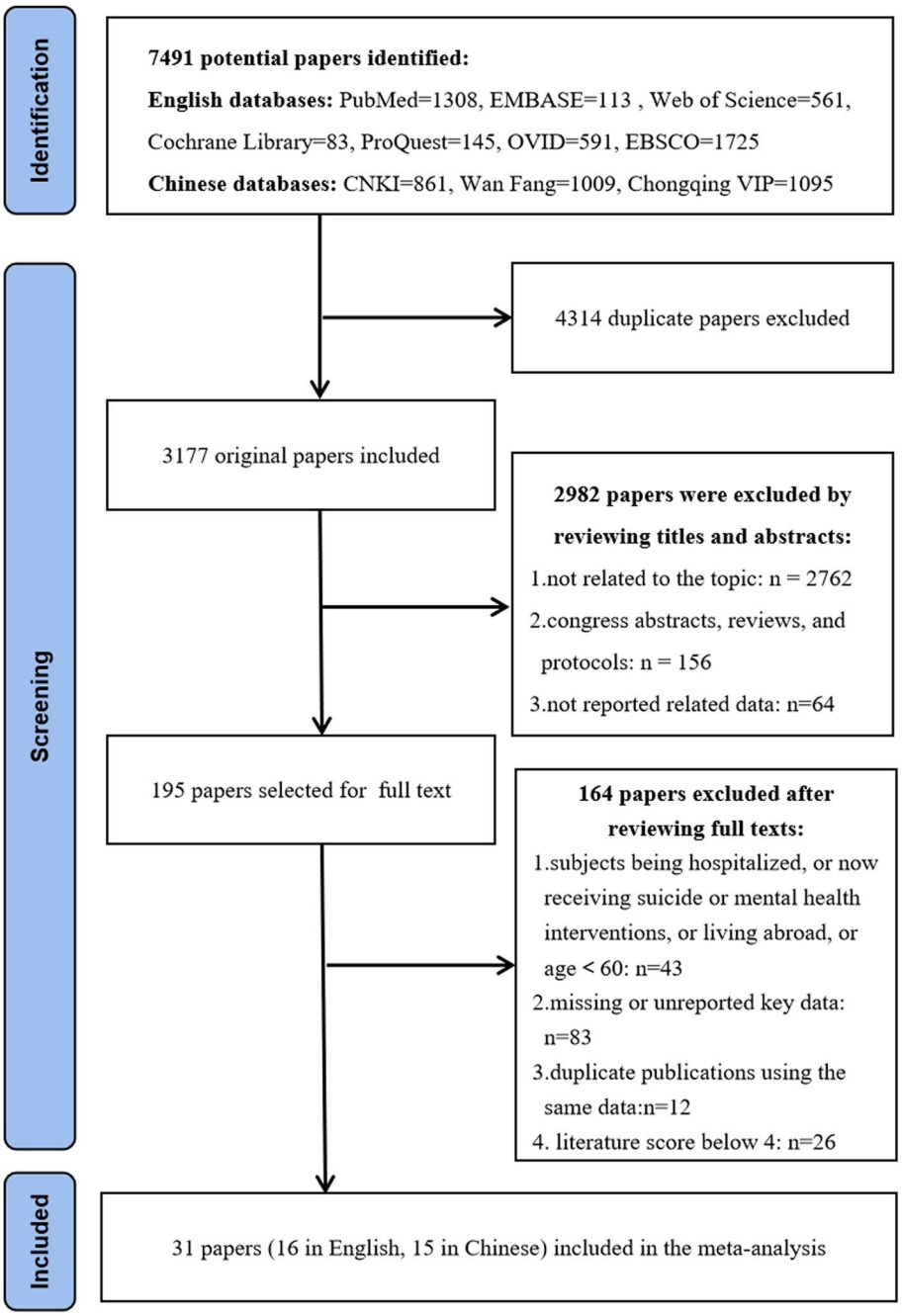

Fig. 1 PRISMA flow chart of the selection process

design, survey location, sampling method, participant age and residence, tools used for measuring SI, along with their corresponding time points, number of survey participants, number of respondents reporting SI, and the number of identified associated factors with SI. Any discrepancies encountered were resolved by consulting a third researcher (CC). In the event of missing or unextractable data, the reviewers endeavored to contact the corresponding author. In cases where multiple articles were confirmed to originate from the same survey, only the most comprehensive article was retained and extracted.

Quality assessment

The evaluation of the literature involved was primarily guided by the criteria established by Loney et al. [17], which was widely used for quality assessment in epidemiological research [18–21]. Eight specific parameters were utilized to determine the literature's bias risk: (1) proper study design and methodology corresponding to the research inquiry; (2) the unbiased selection of sample subjects; (3) sufficient sample size exceeding 300 subjects; (4) standard measures of health outcomes; (5) unbiased assessors conducting outcome measurements; (6) satisfactory response rate from subjects (>70%) and appropriate description of non-respondents; (7) detailed provision of prevalence estimates, including CIs and subgroup specifics where necessary; (8) thorough description of study subjects and the research setting [17]. The aggregated score could vary from 0 to 8, with higher scores reflecting lower bias risks. Two independent reviewers (WY and SBB) undertook the quality assessment, and any disputes were resolved in consultation with a third reviewer (ZPL).

Statistical analysis

Statistical analyses were executed using STATA, version 15.1 (Stata Corporation, College Station, Texas, USA). Both the pooled prevalence of SI, inclusive of 95% CIs, as well as the pooled ORs of associated factors (also including 95% CIs), were calculated using the Dersimonian–Laird method-based random effects model [22]. The Freeman-Tukey double arcsine transformation method was used to correct the raw distribution for calculating the pooled prevalence [14, 15]. A comparison of this prevalence was made to outcomes acquired through Direct and Logit Transformed methods [14]. Subgroup analyses were conducted to compare prevalence characteristics concerning demographics, physical condition, mental condition, economic condition, temporal and spatial distribution, and tools with time points. The Q test and the I^2 index were used to test and quantify heterogeneity, respectively [23]. A random-effects model for meta-analysis replaced the fixed-effects model in situations where I^2 was equal to or exceeded 50% and the p-value of the Q test was less than 0.1 [23]. Forest plots were used to present results graphically.

Additionally, the risk of bias in the included studies was assessed using the criteria of Loney et al., which focused on eight key domains such as selected sample, sampling frame, measurement, sample size, assessors, response rate, CI or subgroup analysis, and subject description [17]. The potential risk of bias was visualized through bias risk plots. A visual funnel plot was used to assess potential publication bias before applying Egger's and Begg's tests to determine the bias degree in the plot [24, 25].

Lastly, to ensure the robustness of our results, we conducted the following sensitivity analyses: First, we sequentially removed studies to assess the impact of each included study on the pooled prevalence of SI and the pooled ORs of associated factors with SI [21]. Second, given that small sample sizes or few data points in certain categories may lead to sparse events and increase the probability of the occurrence of monotone likelihood [26–28], we first adjust the effect estimates for each included study using Firth's logistic regression, which is a method used to handle data sparsity or complete separation issues by introducing penalty terms to reduce estimation bias [29]. Subsequently, we incorporated the corrected effect estimates into the aforementioned standard meta-analysis and compared the results before and after the correction.

Results

Search results

An initial literature search yielded 7,491 potentially relevant studies. Following the removal of duplicates, 3,177 studies remained. A screening of titles and abstracts led to the exclusion of 2,982 studies, leaving 195 for comprehensive full-text review. The primary reasons for exclusion are detailed in Fig. 1. Finally, 31 articles [30–60] met the inclusion criteria and were selected for further systematic review and meta-analysis.

Characteristics of the included studies

Table 1 provides a summary of the characteristics of the included studies. Out of the 31 studies, 16 were sourced from English databases, and 15 from Chinese databases, published between the years 2003 and 2022. The sample sizes of these studies varied from 63 to 18,683, with a cumulative total of 79,861 participants. A number of associated factors ranging from 0 to 14 were successfully extracted from the original studies. The studies collectively spanned across more than 20 provinces and cities in Mainland China, Hong Kong S.A.R., China and

Table 1 Basic description of 31 included Literature

First Author (Survey Year)	Publish Year	Study Design[a]	Location[b]	Sampling Method	Age (Years)	Residence[c]	Tool[d]	Time Point[e]	Survey Numbe	SI Number[f]	Factor Number[g]	Quality Score[h]
Yip(1999–2000)	2003	CRS	Hongkong(NA[i])	Random sampling	60–98	U	H	H	917	50	1	8
Yen(2001)	2005	CRS	Taiwan(NA)	Multi-stage Stratified Sampling	65–74	U + R	D	B	897	147	8	8
Chan(2002–2003)	2011	CRS	Taiwan(NA)	Three-stage Systematic Random Sampling	≥ 65	U + R	G	B	3596	218	7	8
Ma(2003)	2009	CRS	Beijing(E)	Stratified Multi-stage Systematic Sampling	≥ 65	U + R	A	H	1159	25	0	7
Su(2004–2005)	2012	CRS	Heilongjiang(C)	Cluster Sampling	≥ 60	NA	D	A	221	29	1	4
Qing(2006)	2007	CRS	Hunan(C)	Stratified Cluster Random Sampling	≥ 60	R	E	F	912	181	2	8
Li(2006a)	2011	CRS	Nationwide(NA)	Stratified Multi-stage Proportional Probability Sampling	≥ 60	U + R	A	G	1969	93	4	8
Li(2006b)	2016	CRS	Nationwide(NA)	Stratified Multi-stage Random Sampling	60–103	U + R	A	F	15,957	160	1	8
Chiu(2006)	2012	CRS	Sichuan(W)	Multi-stage Cluster Stratified Random Sampling	≥ 65	R	A	F	87	9	0	6
Li(2009)	2011	CRS	Hunan(C)	Stratified Cluster Random Sampling	60–97	R	A	F	1040	224	1	8
Xu(2009–2011)	2016	CRS	Hunan(C)	Multi-stage Cluster Sampling	≥ 60	R	A	F	1879	273	7	8
Cheng(2010)	2013	CRS	Hubei(C)	Multi-stage Cluster Random Sampling	60–93	R	D	F	2025	144	9	8
Liu(2010)	2014	CRS	Beijing(E)	Stratified Multi-stage Proportional Probability Sampling	≥ 60	U + R	A	F	3662	94	3	8
Zhang(2010–2011)	2014	CRS	Hunan(C)	Multi-stage Cluster Random Sampling	60–84	R	A	F	839	47	9	8
Wei(2010)	2018	CRS	Nationwide(NA)	Stratified Multi-stage Random Sampling	60–103	U + R	A	E	18,683	518	8	8
Ge(2011–2012)	2017	CRS	Shandong(E)	Three-stage Cluster Sampling	≥ 60	U + R	A	H	3313	139	10	8
Qi(2012)	2013	CRS	Hubei(C)	Cluster Sampling	60–99	U	D	F	63	8	4	5
Li(2013)	2015	CRS	Hunan(C)	Stratified Cluster Random Sampling	60–89	R	C	F	988	257	4	8
Hu(2014–2015)	2020	CRS	Anhui(C)	Cluster Sampling	60–94	R	B	C	695	164	10	6
Wu(2015–2016)	2018	CRS	Shanghai(E)	Stratified Systematic Random Sampling	64–96	U	B	C	501	28	0	4
Zhang(2015)	2018	CRS	Shandong(E)	Convenient Sampling	60–94	R	F	B	205	40	4	4
Yu(2017)	2019	CRS	Shandong(E)	Multi-stage Stratified Sampling	≥ 60	U + R	A	F	7070	499	14	8
Sun(2017–2018)	2019	CRS	Zhejiang(E)	Cluster Sampling	≥ 60	U	B	C	215	32	9	4

Table 1 (continued)

First Author (Survey Year)	Publish Year	Study Design[a]	Location[b]	Sampling Method	Age (Years)	Residence[c]	Tool[d]	Time Point[e]	Survey Numbe	SI Number[f]	Factor Number[g]	Quality Score[h]
Dong(2017)	2018	CRS	Jiangxi(C)	Random Sampling + Convenient Sampling	60–76	U	C	F	490	94	4	6
Yang(2018)	2020	CRS	Nationwide(NA)	Convenient Sampling	≥ 60	U + R	D	A	4622	2061	0	5
Chen(2018)	2021	CRS	Hunan(C)	Multi-stage Cluster Random Sampling	62–89	R	A	F	1002	353	8	8
Zhang(2018–2019)	2021	CRS	Shandong(E)	Two-stage Cluster Sampling	≥ 60	U	B	C	538	80	4	7
Zhao(2019)	2021	CRS	Shandong(E)	Three-stage Stratified Cluster Random Sampling	≥ 60	R	A	H	2549	258	6	8
Jing(2019)	2021	CRS	Shandong(E)	Three-stage Stratified Sampling	≥ 60	R	A	H	3242	343	0	8
Yi(2019–2020)	2022	CRS	Sichuan(W)	Convenient Sampling	60–85	R	A	F	233	45	3	5
Liang(2020)	2022	CRS	Nationwide(NA)	Convenient Sampling	≥ 60	NA	A	D	292	10	0	4

[a] *CRS* Cross-sectional Study; [b]According to the regional classification standards set by the National Development and Reform Commission of China, mainland China's provinces and municipalities are respectively categorized into eastern (E), central (C), and western regions (W); [c]*U* Urban, *R* Rural; [d]8 measuring tools in total: A:1-Item From US National Comorbidity Survey; B:Beck Scale for Suicide Ideation; C:Self-rating Idea Of Suicide Scale; D:Self-designed Questionnaire; E:1-Item From Beck Scale for Suicide Ideation; F:1-Item From Beck Depression Inventory; G:1-Item From Taiwan Depression Questionnaire; H:6-Item Geriatric Mental State Examination-Version A; [e]8 time points in total, A = for the moment, B = past 1 week; C = past 1 week or worst period; D = past 2 weeks; E = past 1 month; F = past 12 months; G = past 5 years; H = past lifetime; [f]SI Number = the number of people with suicidal ideation; [g]Factor Number = the number of factors associated with suicidal ideation calculated in this research; [h]Literature Quality Score ranging from 0 to 8 points is rated according to guidelines proposed by Loney et al.; [i]*NA* Not applicable

Taiwan, China, covering a period of over 20 years from 1999 to 2020. The studies used various tools to measure SI—with 8 distinct types of instruments employed. The item from the US National Comorbidity Survey was the most commonly used tool. A range of time points (eight variations) were considered, with the "past 12 months" being the most frequently used reference. This resulted in a total of 14 distinct tool-time groups.

Quality assessment

Of the 31 studies analyzed (Supplemental Table 1), 18 achieved a score of eight points, 2 attained seven points, 3 secured six points, another 3 received five points, and the remaining 5 garnered four points, all in accordance with Loney's criteria.

Prevalence of SI

The observed prevalence of SI among elderly individuals in China varied in 31 studies, ranging from 1.00% to 44.59%. Using a random-effects model, the pooled prevalence of SI among this demographic was estimated at 11.47% (95% CI 7.82–15.71%, $I^2 = 99.65\%$, $p < 0.001$), as depicted in Fig. 2. For comparative purposes, when applying the direct methodology without any transformation, the estimated prevalence was 12.84% (95% CI 10.78–14.89%, $I^2 = 99.5\%$, $p < 0.001$). When using the logit transformed method, the estimated prevalence was 9.45% (95% CI 6.39–13.95%, $I^2 = 99.6\%$, $p < 0.001$), as shown in Fig. 3.

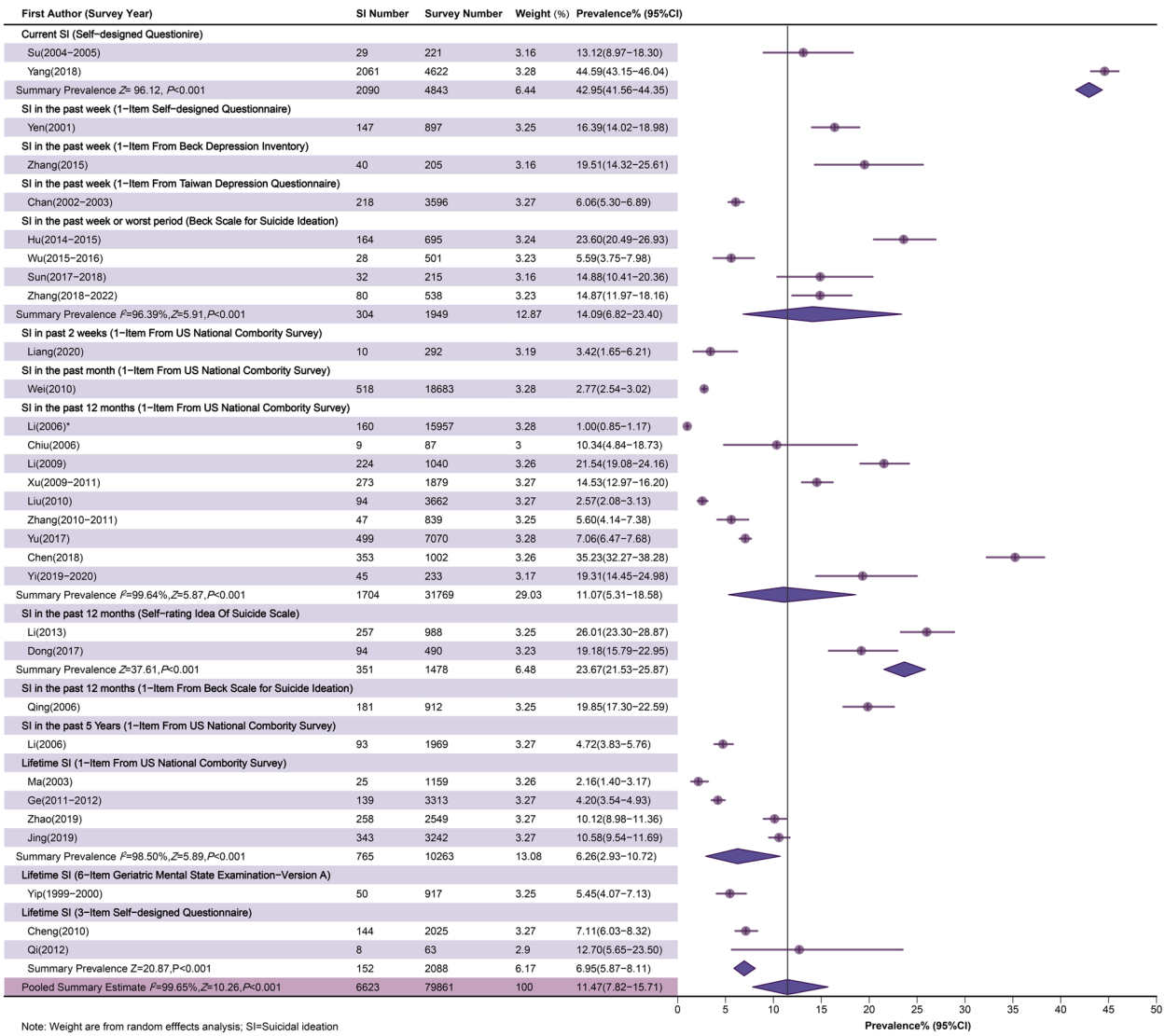

Fig. 2 Forest plot illustrating the prevalence of suicidal ideation (SI) among the elderly population in China

Subgroup analysis on the prevalence of SI

Subgroup analyses were conducted across six categories: (1) Basic demographics demonstrated that rural seniors had a significantly higher prevalence of SI (11.00%, 95% CI 7.01–15.74%) compared to urban seniors (5.30%, 95% CI 2.87–8.40%). Higher rates were also observed in females, older individuals, the unmarried, and illiterate groups, although these differences were not statistically significant. (2) Physical health conditions revealed a significantly higher prevalence of SI among seniors with chronic diseases, activities of daily living (ADL) disability, and poorer physical health. (3) Mental health conditions revealed a markedly higher prevalence of SI among the seniors with depressive symptoms and reduced life satisfaction. (4) Living and economic conditions showed that the prevalence of SI was significantly higher among seniors with a poorer economic status (15.41%, 95% CI 8.55–23.81%) compared to those who felt economically secure (3.38%, 95% CI 1.56–5.81%). (5) Temporal and spatial distribution of the surveys showed a startlingly significant difference in SI prevalence among seniors between 2001–2010 (7.85%, 95% CI 5.08–11.16%) and 2011–2020 (15.59%, 95% CI 9.08–23.44%). The SI prevalence among the seniors in the eastern region (8.06%, 95% CI 5.59–10.94%) was significantly lower than that in the central and western regions (16.97%, 95% CI 12.04–22.53%). However, no significant differences in SI prevalence were found between the seniors of mainland China, Hong Kong S.A.R., China, and Taiwan, China. (6) The use of different measuring tools at various time points also revealed significant differences in the prevalence of SI. SI prevalence measured at time points ≤ 1 year (13.10%, 95% CI 8.38–18.68%) was significantly more than that measured at time points > 1 year (5.86%, 95%CI 3.44–8.86%). Detailed information on the subgroup analysis, excluding tools with time points, is provided in Table 2. The forest plot for the pooled prevalence of SI among Chinese seniors using different measuring tools and time points is shown in Fig. 2. All subgroup analyses were conducted using a random-effects model due to an $I^2 > 50\%$.

Effect sizes of associated factors with SI

This study incorporated a total of 18 distinct factors associated with SI, which were categorized into four primary domains, each corresponding to the subgroups mentioned above. A minimum of three studies were incorporated for each factor, six factors encompassed ten or more studies, and twelve factors included between three and nine studies. The factors with ORs exceeding 1, in which the CI did not incorporate the value of 1, are as

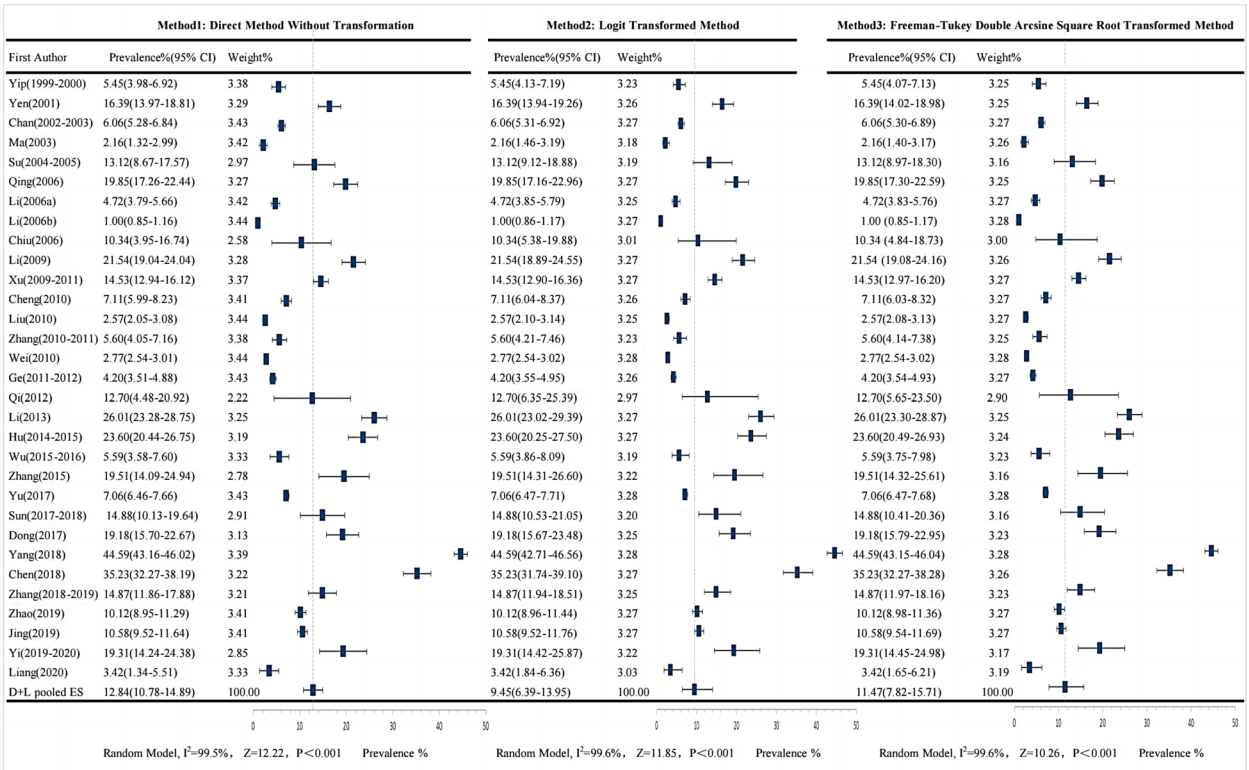

Fig. 3 Comparison of the pooled prevalence of suicidal ideation (SI) in elderly Chinese population using three different calculation methods

Table 2 Subgroup analysis of the prevalence of suicidal ideation among the elderly in China

Subgroup	Research Number	Survey Number	SI Number	I^2	Model	Pooled Prevalence % (95% CI)	$\chi 2$	*P*
1. Basic Demographic								
Gender								
Male	20	24,061	1433	98.46%	RE	11.20(7.88–15.00)	0.71	0.3994
Female	20	26,780	2194	98.61%	RE	13.45(9.92–17.42)		
Age(years)								
60–69	14	12,286	960	97.03%	RE	10.39(7.04–14.26)	1.27	0.5296
70–79	14	8429	773	97.86%	RE	12.96(8.03–18.83)		
≥ 80	13	2574	353	97.11%	RE	15.11(7.52–24.64)		
Residence								
Urban	6	22,479	510	98.55%	RE	5.30(2.87–8.40)	4.98	0.0257
Rural	13	32,181	2078	99.29%	RE	11.00(7.01–15.74)		
Marriage								
In	16	31,415	1857	98.69%	RE	8.81(5.86–12.25)	3.02	0.0821
Out	16	14,410	1249	98.09%	RE	13.89(9.61–18.81)		
Educated level								
Illiteracy	13	14,618	1424	98.38%	RE	15.11(10.52–20.36)	1.77	0.1830
Primary school and above	16	27,897	1579	98.85%	RE	10.77(7.13–15.05)		
2. Physical Condition								
Chronic disease								
Yes	11	28,106	2101	99.28%	RE	13.79(8.69–19.83)	4.75	0.0294
No	11	10,906	447	97.57%	RE	6.70(3.68–10.49)		
Multimorbidity								
Yes	6	2464	512	98.60%	RE	25.47(11.50–42.61)	2.92	0.0872
No	6	4408	318	97.56%	RE	11.37(5.24–19.42)		
ADL disability								
Yes	6	2535	729	98.11%	RE	29.36(16.68–43.90)	12.84	< .001
No	6	10,978	746	94.48%	RE	7.91(5.65–10.52)		
Sleep quality(self-rated)								
Poor	3	1536	230	NA	RE	21.75(7.37–40.72)	2.20	0.1378
Good	3	1558	108	NA	RE	9.09(3.09–17.69)		
Health status(self-rated)								
Poor	5	6777	728	98.23%	RE	19.48(11.10–29.50)	12.86	< .001
Good	5	10,108	257	96.73%	RE	4.25(1.86–7.47)		
3. Mental Condition								
Depressive symptoms								
Yes	8	944	462	92.27%	RE	41.78(29.86–54.19)	44.50	< .001
No	8	4834	291	91.53%	RE	5.97(3.66–8.78)		
Feeling pressure(self-rated)								
Yes	3	4470	633	NA	RE	14.27(12.68–15.93)	2.81	0.0937
No	3	3138	96	NA	RE	6.91(1.55–15.40)		
Life satisfaction(self-rated)								
High	3	8642	459	NA	RE	7.15(3.62–11.75)	25.71	< .001
Low	3	388	141	NA	RE	35.36(24.41–47.12)		
Religious belief								
Yes	7	7531	550	97.12%	RE	10.18(5.95–15.35)	0.00	0.9841
No	7	24,409	1146	98.83%	RE	10.22(5.96–15.44)		
4. Living and Economic condition								
Living style								
Alone	11	6352	823	98.35%	RE	15.57(8.91–23.63)	0.79	0.374

Table 2 (continued)

Subgroup	Research Number	Survey Number	SI Number	I^2	Model	Pooled Prevalence % (95% CI)	$\chi 2$	*P*
With others	11	16,150	1451	98.04%	RE	11.91(8.25–16.13)		
Living place								
Community	26	78,333	6438	99.70%	RE	11.25(7.32–15.88)	0.19	0.6663
Nursing Home	5	1528	185	89.79%	RE	12.64(7.53–18.79)		
Left behind								
Yes	6	6308	750	99.03%	RE	10.53(3.61–20.40)	0.37	0.5441
No	4	12,195	1162	97.32%	RE	7.77(3.85–12.90)		
Employment								
Yes	3	1240	66	NA	RE	5.73(2.51–10.11)	1.33	0.2487
No	3	1240	66	NA	RE	10.50(4.18–19.22)		
Economic status(self-rated)								
Poor	6	9849	710	98.76%	RE	15.41(8.55–23.81)	12.07	< .001
Good	6	16,953	317	95.60%	RE	3.38(1.56–5.81)		
5. Temporal and spatial distribution								
Survey period								
2001–2010	14	52,926	2162	99.29%	RE	7.85(5.08–11.16)	4.39	0.0361
2011–2020	16	25,726	4401	99.58%	RE	15.59(9.08–23.44)		
Geographical region								
Main Land	28	74,451	6208	99.68%	RE	11.79(7.77–16.50)	0.68	0.4104
Hongkong & Taiwan	3	79,861	6623	NA	RE	8.73(3.86–15.31)		
Policy-defined regions								
Eastern region	10	22,454	1538	97.94%	RE	8.06(5.59–10.94)	9.95	0.0016
Central and Western regions	13	10,464	1828	98.76%	RE	16.97(12.04–22.53)		

SI Number The number of samples with suicidal ideation, *RE* Random effects analysis model, *CI* Confidence interval, *NA* Not applicable, Out of marriage includes single, divorced and widowed options, *ADL disability* Activities of daily living disability

follows: (1) Demographics: rural residence (OR = 1.81, 95% CI 1.26–2.61), illiteracy (OR = 1.71, 95% CI 1.44–2.01), advanced age (OR = 1.55, 95% CI 1.12–2.14), and female (OR = 1.31, 95% CI 1.08–1.58); (2) Physical health: poor health (OR = 5.87, 95% CI 4.20–8.20), ADL disability(OR = 4.61, 95% CI 3.31–6.41), poor sleep quality(OR = 3.04, 95% CI 1.18–7.84), multimorbidity (OR = 2.78, 95% CI 1.71–4.51), and chronic diseases (OR = 2.36, 95% CI 1.87–2.98); (3) Mental health: depressive symptoms (OR = 13.39, 95% CI 9.01–19.88), mental disorders (OR = 11.22, 95% CI 5.90–21.33), low life satisfaction (OR = 8.37, 95% CI 4.55–15.41); (4) Economic condition: poor financial situation (OR = 4.05, 95% CI 2.59–6.34). Each of these factors displayed a statistically significant correlation with the onset of SI. Conversely, factors associated with ORs less than 1, where the CI did not include the value of 1, indicated that marriage (OR = 0.64, 95% CI 0.55–0.74) and employment (OR = 0.54, 95% CI 0.41–0.72) were statistically correlated with a decrease in SI among the elderly in China. A random-effects model was used to calculate the pooled ORs for all factors except employment. Detailed information concerning associated factors is shown in Table 3.

Bias risk, publication bias, and sensitivity analysis

The bias risk plot shows a low overall risk of bias in the included studies, as shown in Fig. 4. The prevalence of SI among the elderly was analyzed for publication bias, with a visual inspection of the funnel plot indicating slight asymmetry, as demonstrated in Fig. 5. Supporting evidence suggesting no publication bias in this prevalence study was provided by the outcomes of both the Begg's (z = 1.63, $p = 0.103$) and Egger's tests (t = 1.98, $p = 0.058$). In examining the ORs of associated factors with SI among the elderly, neither the Begg's nor Egger's tests indicated publication bias for 14 out of the 16 factors, with both showing $p > 0.05$. However, potential bias was noted for depressive symptoms (Begg's test: z = -2.25, $p = 0.024$; Egger's test: t = -2.76, $p = 0.040$) and religious belief (Egger's test: t = -2.58, $p = 0.049$). Detailed results are presented in Table 3.

The results of the sensitivity analysis showed that the exclusion of any specific study did not cause significant changes in the pooled prevalence of SI or the OR values of factors associated with SI, supporting the robustness of our meta-analysis (Supplemental Figs. 1 and 2). Similarly, while some pooled OR values of SI-associated

Table 3 Analysis of the associated factors with suicidal ideation among the elderly in China

Associated Factor	Research Number	Pooled Effect Estimate				Heterogeneity Test			Begg's Test		Egger's Test	
		Model	Pooled OR	95% CI	*P*	Cochran's Q	*P*	I^2	*Z*	*P*	*t*	*P*
1. Basic demographic												
Living in rural area (vs urban)	4	RE	1.81	(1.26 ~ 2.61)	0.001	21.33	< .001	85.9%	0.00	1.000	0.19	0.868
Illiteracy (vs primary and above)	13	RE	1.71	(1.44 ~ 2.01)	< .001	42.14	< .001	71.5%	-0.49	0.625	-0.83	0.424
Advanced age(vs 60–79 years)	12	RE	1.55	(1.12 ~ 2.14)	0.008	45.93	< .001	76.1%	-0.41	0.681	-0.84	0.418
Female (vs male)	20	RE	1.31	(1.08 ~ 1.58)	0.006	113.39	< .001	83.2%	-1.10	0.270	-0.47	0.641
In marriage(vs out)	16	RE	0.64	(0.55 ~ 0.74)	< .001	39.10	< .001	61.6%	0.36	0.719	0.50	0.625
2. Physical condition												
Poor health status (vs good)	5	RE	5.87	(4.20 ~ 8.20)	< .001	11.78	0.019	66.0%	-0.98	0.327	-1.45	0.243
ADL disability (vs no)	6	RE	4.61	(3.31 ~ 6.41)	< .001	25.53	< .001	80.4%	0.56	0.573	0.92	0.407
Poor sleep quality (vs good)	3	RE	3.04	(1.18 ~ 7.84)	0.021	10.62	0.005	81.2%	-0.52	0.602	-0.33	0.796
Multimorbidity (vs no)	6	RE	2.78	(1.71 ~ 4.51)	< .001	36.15	< .001	86.2%	-0.19	0.851	-0.96	0.392
Chronic disease (vs no)	11	RE	2.36	(1.87 ~ 2.98)	< .001	38.12	< .001	73.8%	-1.01	0.312	-0.66	0.525
3. Mental condition												
Depressive symptoms (vs no)	7	RE	13.39	(9.01 ~ 19.88)	< .001	18.57	0.005	67.7%	-2.25	0.024	-2.76	0.040
Mental disorders (vs no)	3	RE	11.22	(5.90 ~ 21.33)	< .001	8.14	0.017	75.4%	-0.52	0.602	-0.08	0.949
Low life satisfaction (vs high)	3	RE	8.37	(4.55 ~ 15.41)	< .001	10.59	0.005	81.1%	-1.57	0.117	-2.15	0.277
Feeling pressure (vs no)	3	RE	2.52	(0.88 ~ 7.21)	0.084	28.63	< .001	93.0%	-0.52	0.602	-3.17	0.194
Religious belief (vs no)	7	RE	1.03	(0.75 ~ 1.42)	0.846	19.78	0.003	69.7%	-1.65	0.099	-2.58	0.049
4. Living and economic condition												
Poor economic status (vs good)	6	RE	4.05	(2.59 ~ 6.34)	< .001	32.70	< .001	84.7%	0.94	0.348	0.32	0.764
Living alone (vs with others)	10	RE	1.30	(0.98 ~ 1.72)	0.067	48.14	< .001	81.3%	0.27	0.788	0.16	0.877
Employment (vs no)	3	FE	0.54	(0.41 ~ 0.72)	< .001	0.80	0.671	0.00%	-0.52	0.602	-1.56	0.363

RE Random effects analysis model, *FE* Fixed effects analysis model, *OR* Odds ratio, *CI* Confidence interval, *ADL disability* Activities of daily living disability

factors corrected by Firth's logistic regression showed slight decreases compared to the uncorrected values, the overall differences were minimal, indicating that the impact of sparse effects and monotone likelihood on this study is relatively minor (Supplemental Table 2).

Discussion

This article provides the first comprehensive systematic review concerning epidemiological features of SI among the elderly in China. To the best of our knowledge, this is also the first meta-analysis to evaluate the ORs of factors correlated with SI in this demographic. Building on the study conducted by Dong et al. [13], our work significantly enhances and supplements the understanding of SI prevalence among the Chinese geriatric population by employing a more accurate methodology. Our meta-analysis reveals a pooled prevalence of SI in China's elderly population at 11.47% (95% CI 7.82–15.71%), deduced from a total of 79,861 participants across 31 cross-sectional studies. We also identified sixteen statistically significant factors associated with SI in this group. As the aging process continues to deepen, this study could provide certain reference for constructing SI prevention strategies tailored for China's elderly population. Additionally, our findings also underscore the necessity of conducting nationwide epidemiological surveys on mental health among older adults in the future.

Cultural backgrounds and economic statuses can influence the prevalence of SI among the elderly around the world [13]. This study reveals that the prevalence of SI among the elderly in China is reasonably high in comparison to the global older population. For example, a nationwide cross-sectional survey in South Korea, that included 58,590 older individuals, exhibited a 15.72% prevalence of SI [61]; On the other hand, in a developing country like Mexico, a cross-sectional survey among individuals aged 65 and above identified a 13.5% lifetime prevalence of SI [62]. Contrastingly, a national survey incorporating 5,191 older Black American citizens found a meager 6.1% lifetime prevalence [63]. Several factors may account for the high prevalence of SI among China's elderly. First, rapid urbanization has partially eroded traditional Chinese familial ties, potentially escalating feelings of loneliness and depression, especially among the left-behind elderly, which could contribute to higher SI prevalence. Moreover, while China has a large aging population, mental

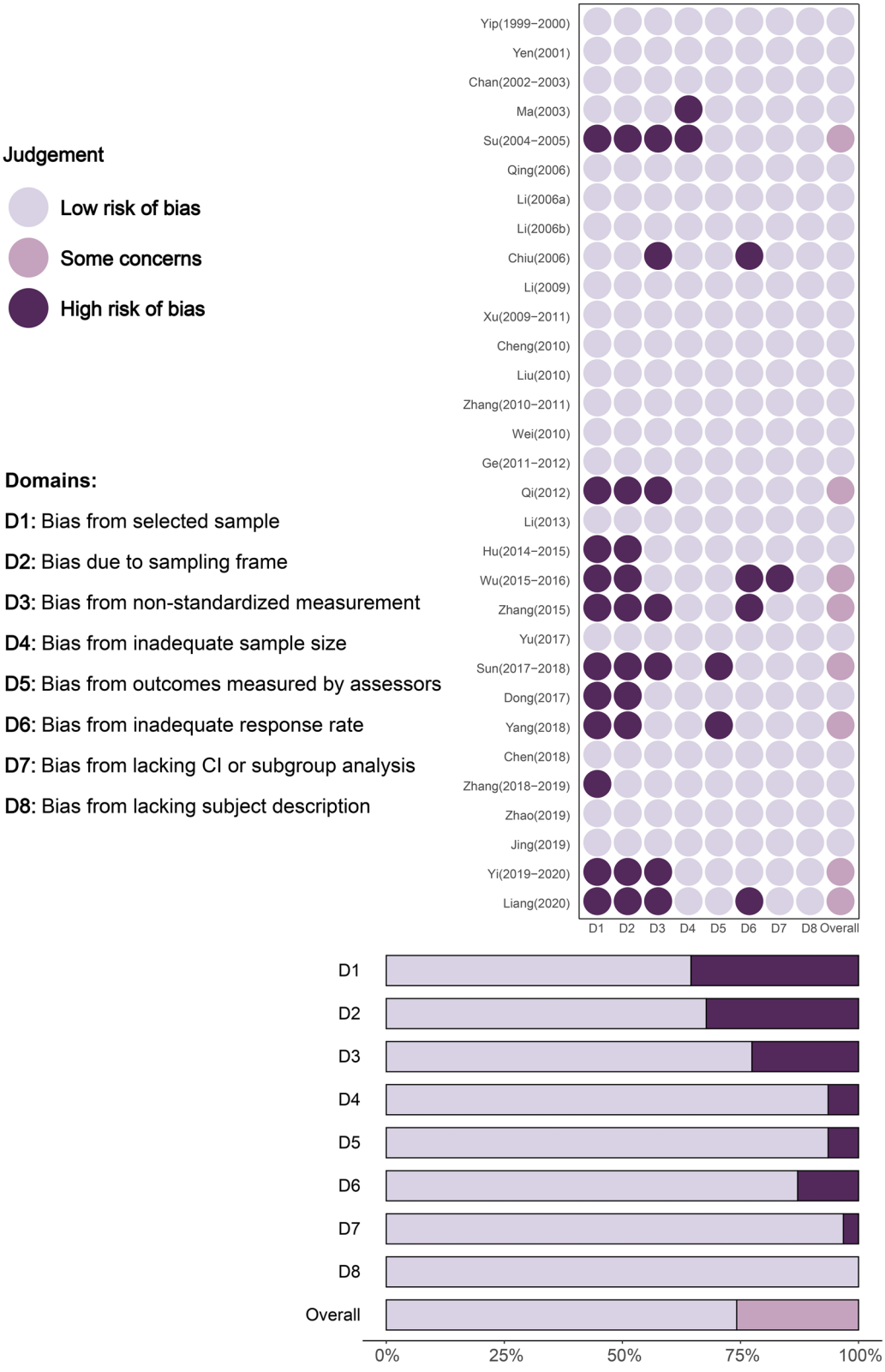

Fig. 4 Risk of bias in the 31 included studies

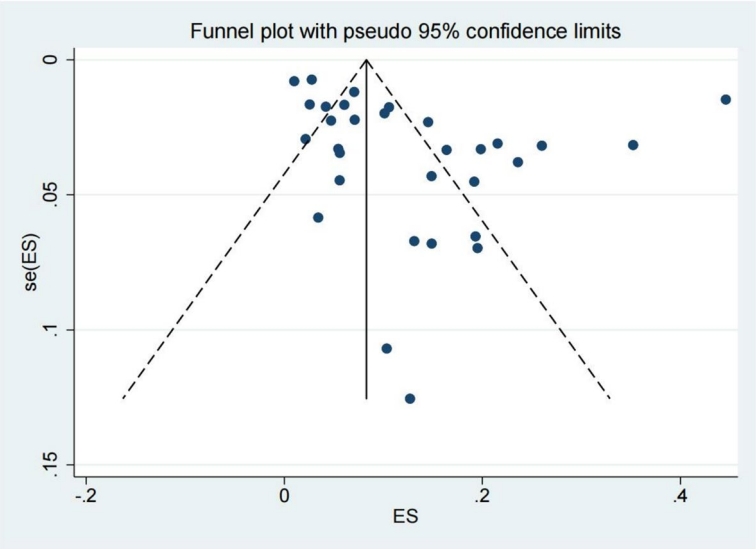

Fig. 5 Funnel plot illustrating publication bias in the 31 studies incorporated into the meta-analysis on the prevalence of suicidal ideation

health services are often insufficient to meet the high demand. Lastly, traditional Chinese cultural perspectives often discourage the older generation from burdening their young, and the stigma attached to SI may deter the elderly from seeking timely psychological help.

Nevertheless, studies have indicated that suicide mortality rates, including those of the elderly, have significantly decreased in China over recent decades [64–66]. This discrepancy between the high prevalence of SI and low suicide mortality could be attributed to several factors. First, according to the three-step theory of suicide [6] and Joiner's interpersonal theory of suicide [67], the shift from SI to actual suicide is complex and depends on the individual's ability to carry out the act. Despite higher SI due to psychological distress and perceived burdens, elderly individuals' limitations in age and physical condition often restrict their ability to prepare for and execute suicide. Second, in Chinese culture, suicide carries a significant stigma, which is seen as irresponsible and brings shame to the family [68]. This cultural stigma may cause the elderly to hesitate when considering suicide, leading them to choose other coping mechanisms instead. Third, the Chinese government's strict regulations on suicide methods like pesticides and firearms have greatly reduced the accessibility of these tools, thereby decreasing the likelihood of suicide attempts [66, 69]. Finally, the improvement in the level and accessibility of medical services in China has also reduced the mortality rate from impulsive suicide attempts among the elderly [66]. This further warns us to be cautious about inferring suicide from SI.

This study undertook extensive subgroup analyses in various areas, including demographics, physical and mental health, economics, spatial and temporal distribution, and measurement techniques over time to investigate heterogeneity sources. There are several crucial findings regarding the prevalence distribution that require considerable attention. First, there is a disparity in SI rates between urban and rural elders. This observation aligns with the urban–rural disparities in suicide rates among the elderly in China as reported in Li and Katikireddi's meta-analysis [70]. The reasons for these disparities remain ambiguous [70]. Factors such as economic, educational, and lifestyle differences inherent to the urban–rural divide in China, along with the country's urbanization process, potentially contribute to these disparities [66]. Second, elders with poor physical health, particularly those with chronic diseases and ADL disability, are predisposed to a higher prevalence of SI. Previous studies have shown a positive correlation between chronic diseases and SI, including cardiovascular disease, stroke, ischemic heart disease, cancer, diabetes, and renal failure [71, 72]. This is consistent with our findings. Functional disabilities, such as ADL disability, are recognized as indicators of severe psychological distress, which is closely linked to SI [73]. Third, older adults suffering from depressive symptoms and experiencing low life satisfaction have a remarkably high prevalence of SI, emphasizing the importance of regular depression screening and psychological interventions for the elderly. Fourth, compared to the central and western regions, the elderly in the eastern region exhibit a lower prevalence of SI. The division of China into eastern, central,

and western regions is an official classification based on the economic development levels and geographical concepts of various areas, which to some extent reflects the regional economic development and medical service levels. The elderly in the eastern region benefit from superior healthcare services and resources, more robust retirement pensions and welfare systems, greater social stability and security, and easier access to psychological health services compared to those in the central and western regions. These factors may contribute significantly to reducing the prevalence of SI among the elderly. Lastly, there's a notable discrepancy in the prevalence of SI among Chinese elders between 2001–2010 and 2011–2020. It is still unclear what caused the difference. Since 1999, China experienced dramatic changes, including rapid urbanization and increased aging. According to the China Development Report 2020, China's population aged 65 and older increased by 30 million from 2000 to 2010 and by 60 million from 2010 to 2020. This shift significantly impacted the country's demographic structure, affecting the healthcare and senior care systems. Several studies have shown that the elderly population is at the highest risk of suicide among all age groups [2, 3, 66]. The increase in the elderly population and the intensification of urbanization from 2011 to 2020 directly affected healthcare and nursing services, which are closely linked to the elderly population. This may explain the higher prevalence of SI among the elderly from 2011 to 2020, as partially outlined in the subgroup analysis of health and mental domains. Given the continuing rise in the aging population, it's likely that the high prevalence of SI among China's elderly will persist. Therefore, it is critical to conduct nationwide epidemiological surveys on mental health among the elderly and implement targeted preventative strategies as promptly as possible.

Additionally, this study embarked on exploring factors related to SI among the elderly using a variable-centric approach via a meta-analysis. Sixteen factors were found to be significantly associated with SI in this age group, with the majority aligning with prior findings. However, several factors warrant further discussion. From a demographic viewpoint, advanced age appears to pose a risk for SI, possibly due to poorer physical health, decreased mobility, and increased mental isolation prevalent in this group. In the physical domain, the concept of multimorbidity as a risk factor for SI has recently gained traction. Research conducted in Korea and America has underlined the significant relationship between multimorbidity and SI among the elderly [74, 75]. Seniors with multimorbidity are more likely to experience disabilities, poor physical health, and compromised mental wellness compared to their healthier counterparts [76], thereby escalating the risk of SI [58]. From a psychological perspective, the relationship between stress, religious orientation, and SI among the elderly did not yield significant results, which contradicts earlier studies [31, 77]. This discrepancy might stem from the limited volume of relevant literature included in our analysis. Notably, marriage and employment were found to have a significant inverse correlation with SI among the elderly, suggesting that companionship and active employment could, to some extent, mitigate SI in this population [31, 37, 77].

This study underscores the profound influence of statistical methods, measurement tools, and temporal aspects on the results of meta-analyses, reinforcing the findings of earlier related studies [14, 21]. It is noteworthy that many previous studies did not take into account the actual distribution of prevalence when conducting meta-analyses on the prevalence, instead presuming binomial or normal distribution. According to Barendregt et al., the prevalence does not always follow the standard binomial distribution [14]. When the prevalence of one disease is approximately 0.5, disregarding the actual distribution does not greatly alter the results [14]. However, when the prevalence is notably large or small, considerable variability in results can occur if the data isn't adjusted for its distribution [14]. Among the two most frequently used techniques for prevalence transformation, the double arcsine transformation yields more accurate results than the logit method [14]. Given the low prevalence of SI in the elderly, this study utilized the double arcsine transformation as recommended [14, 15, 21], resulting in a pooled prevalence for elderly SI in China of 11.47% (95% CI 7.82–15.71%). Alternatively, direct method without transformation and Logit method yielded prevalences of 12.84% (95% CI 10.78–14.89%) and 9.45% (95% CI 6.39–13.95%), respectively. These disparate results underscore the importance of outlining the statistical transformation techniques in prevalence meta-analyses, playing a crucial role in updating to the meta-analysis of Dong et al. [13]. Besides, this study discerned significant differences concerning the measurement tools and time points used. In terms of temporal effects on SI prevalence, we divided all time points into two categories (past $\leq$ 12 months, and past > 12 months) to ensure maximum study inclusion. Longer time points did not equate to higher prevalence, consistent with findings in Li et al. and Xiao et al. [21, 37]. Retrospective bias and proximate effect of events may account for this inconsistency. Hence, future studies targeting the elderly should employ narrower time frames due to potential memory loss and cognitive impairment [37]. Similarly, the use of various measurement tools led to substantial variations in prevalence. Over half of the studies employed single item for SI assessment. Yet, single-item assessments for SI demonstrated inferior validity compared to multi-item

scales [78]. Despite this, to boost response rates, large national epidemiological surveys persist in using single-item questions. In summary, future studies should promote more standardized tools with shorter time frames.

Strengths and limitations

This study is the first meta-analysis focused on the associated factors with SI among the elderly population in China. Meanwhile, we employed a more precise methodology to estimate the pooled prevalence of SI within this demographic. Additionally, our review identified 16 important factors associated with SI in the elderly through the pooling of effect sizes.

However, this study also has several limitations. First, a high level of heterogeneity persisted despite subgroup analysis, potentially contributing to publication bias. Second, there was inconsistency in the definition of SI across the studies included, which could introduce some bias to the results. Third, despite providing descriptions of reliability and validity or reasonable justifications, over half of the studies employed self-reported single item from either established or self-revised scales for rapid SI screening in large-scale epidemiological surveys. This reliance on single-item assessments may introduce potential bias. Lastly, the high pooled ORs for certain factors associated with SI, such as mental disorders, depressive symptoms, and low life satisfaction, may partly result from sparse effects and monotone likelihood due to sparse data or a small number of data points in certain categories [26, 27]. Previous research has shown that small sample sizes or sparse data could lead to extreme estimates and overestimation of effect sizes [26–28]. Although we used Firth's logistic regression to preprocess this potential estimation bias and conducted sensitivity analysis, we cannot completely eliminate its impact on our conclusions [29]. Therefore, we need to interpret these conclusions cautiously and further verify them in subsequent large-scale studies using more rigorous statistical methods.

Implication

The findings of this review have provided valuable insight into SI among Chinese elderly. Given the severe consequences of suicide in this age group and China's rapidly aging population, it is crucial to formulate targeted treatments or intervention strategies to prevent SI. Moreover, this review underscores the importance of employing proper methodologies when converting the prevalence rates from original studies to calculate the pooled prevalence of certain diseases. Lastly, due to the risk of retrospective bias and proximate effects associated with longer time points, it is of equal importance to develop reliable measuring instruments with more precise time points for SI.

Conclusion

This article presents a comprehensive systematic review exploring the epidemiological characteristics of SI among the elderly in China. SI among China's elderly showed relatively high prevalence and considerable heterogeneity across different characteristics and associated factors. Therefore, it is necessary to implement focused intervention strategies and standardized temporal assessments of SI to effectively address suicide risk in the older population.

Abbreviations

SI	Suicidal ideation
CRS	Cross-sectional study
NA	Not applicable
RE	Random effects analysis model
FE	Fixed effects analysis model
CI	Confidence interval
ADL disability	Activities of daily living disability
OR	Odds ratio

Supplementary Information

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Supplementary Material 1

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Authors' contributions

Yu Wu: literature collection and evaluation, data curation and analysis, data visualization and explanation, manuscript-writing, and writing-review & editing; Binbin Su: conceptualization, literature collection and evaluation, validation, and writing-review & editing; Yihao Zhao, Chen Chen and Panliang Zhong: literature collection and evaluation, and validation; Xiaoying Zheng: conceptualization, supervision, project administration, and writing-review & editing.

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Availability of data and materials

All data analyzed in this study are included in this published article and the original studies' publications.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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