About half of older adults have two or more chronic conditions at the same time: a systematic review and meta-analysis

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Submitted to: JMIR Public Health and Surveillance
on: November 30, 2024

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Abstract

Background The issue of population aging is becoming increasingly significant, accompanied by a rise in the number of elderly individuals experiencing comorbid chronic diseases. This study undertakes a comprehensive synthesis and analysis of evidence regarding the prevalence and influencing factors of chronic disease comorbidities among the elderly, utilizing systematic review and meta-analysis methodologies. Methods This study included cross-sectional research on the prevalence and influencing factors of chronic disease comorbidities in the elderly. A systematic search was conducted across several databases, including PubMed, Web of Science, Embase, Cochrane Library, CNKI, WANFANG, CBM, and VIP, covering the period from the establishment of each database until August 15, 2024. The methodological quality of the included studies was evaluated using the AHRQ tool. A random effects model was employed to calculate the pooled effect size for the prevalence of chronic disease comorbidities among the elderly. To assess potential publication bias, funnel plots and Egger tests were utilized. Subgroup analyses were conducted to investigate significant factors contributing to heterogeneity. Additionally, sensitivity analyses were performed to evaluate the robustness of the meta-analysis results. All statistical tests were executed using Stata 18.0 software. Results This study included a total of 49 medium to high-quality documents, encompassing 729,043 elderly respondents. The findings indicated that the prevalence of chronic disease comorbidities among the elderly was 46.0% (95% CI = 38.0–55.0%, I^2 = 99.98%, P = 0.000). The summary results of the subgroup analysis are as follows: men (0.41, 95% CI = 0.35–0.47) versus women (0.48, 95% CI = 0.41–0.55); respondents from China (0.40, 95% CI = 0.33–0.47) compared to those from other countries (0.53, 95% CI = 0.44–0.63); surveys conducted before 2020 (0.49, 95% CI = 0.39–0.59) versus those conducted after 2020 (0.39, 95% CI = 0.30–0.49). Furthermore, the identified risk factors influencing the comorbidity of chronic diseases in the elderly include age (?70 years), gender (female), body mass index (BMI ? 28 kg/m^2), education level (at least junior high school), marital status (single, widowed, or divorced), and higher income levels. Conclusion Research indicates that approximately half of older adults experience multiple chronic diseases simultaneously. The modifiable risk factors contributing to the development of chronic comorbidities in the elderly primarily include obesity, low educational attainment, poor marital status, and the income level is low. The findings of this study offer significant insights for policymakers aimed at mitigating the burden of chronic disease comorbidities in the elderly and enhancing their quality of life.

(JMIR Preprints 30/11/2024:69455)
DOI: https://doi.org/10.2196/preprints.69455

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Original Manuscript

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Abstract

Background The issue of population aging is becoming increasingly significant, accompanied by a rise in the number of elderly individuals experiencing comorbid chronic diseases. This study undertakes a comprehensive synthesis and analysis of evidence regarding the prevalence and influencing factors of chronic disease comorbidities among the elderly, utilizing systematic review and meta-analysis methodologies. **Methods** This study included cross-sectional research on the prevalence and influencing factors of chronic disease comorbidities in the elderly. A systematic search was conducted across several databases, including PubMed, Web of Science, Embase, Cochrane Library, CNKI, WANFANG, CBM, and VIP, covering the period from the establishment of each database until August 15, 2024. The methodological quality of the included studies was evaluated using the AHRQ tool. A random effects model was employed to calculate the pooled effect size for the prevalence of chronic disease comorbidities among the elderly. To assess potential publication bias, funnel plots and Egger tests were utilized. Subgroup analyses were conducted to investigate significant factors contributing to heterogeneity. Additionally, sensitivity analyses were performed to evaluate the robustness of the meta-analysis results. All statistical tests were executed using Stata 18.0 software. **Results** This study included a total of 49 medium to high-quality documents, encompassing 729,043 elderly respondents. The findings indicated that the prevalence of chronic disease comorbidities among the elderly was 46.0% (95% CI = 38.0–55.0%, I^2 = 99.98%, *P* = 0.000). The summary results of the subgroup analysis are as follows: men (0.41, 95% CI = 0.35–0.47) versus women (0.48, 95% CI = 0.41–0.55); respondents from China (0.40, 95% CI = 0.33–0.47) compared to those from other countries (0.53, 95% CI = 0.44–0.63); surveys conducted before 2020 (0.49, 95% CI = 0.39–0.59) versus those conducted after 2020 (0.39, 95% CI = 0.30–0.49). Furthermore, the identified risk factors influencing the comorbidity of chronic diseases in the elderly include age (≥70 years), gender (female), body mass index (BMI ≥ 28 kg/m²), education level (at least junior high school), marital status (single, widowed, or divorced), and higher income levels. **Conclusion** Research indicates that approximately half of older adults experience multiple chronic diseases simultaneously. The modifiable risk factors contributing to the development of chronic

comorbidities in the elderly primarily include obesity, low educational attainment, poor marital status, and the income level is low. The findings of this study offer significant insights for policymakers aimed at mitigating the burden of chronic disease comorbidities in the elderly and enhancing their quality of life.

Keywords Chronic disease comorbidity, Elderly, Prevalence, Risk factors, Meta-analysis

Introduction

Global population aging has become an important social challenge in the 21st century [1]. According to statistics from the World Health Organization (WHO) [2], the global proportion of people aged 60 and over has increased significantly over the past few decades. This age group is expected to account for 20% of the global population by 2050. The trend of population aging is not only obvious in developed countries, such as Japan, Germany and Italy, but also gradually showing this feature in developing countries, such as China and India [3]. The phenomenon of population aging has caused a series of problems, which not only lead to lower fertility rates and fewer labor resources, but also directly increase the pressure on public health systems. At present, with the increasingly prominent health problems of the elderly, especially the comorbidity of chronic diseases, has become a challenge that cannot be ignored [4].

The risk of chronic diseases increases significantly with age. Chronic disease comorbidity refers to the condition in which a patient is affected by two or more chronic diseases at the same time [5]. This phenomenon is particularly prevalent in the elderly, mainly due to the gradual decline of the immune system, changes in lifestyle, and the long-term accumulation of multiple chronic diseases [6]. Studies have shown that the incidence of chronic disease comorbidity among the elderly aged 65 and above has exceeded 70% [7]. The coexistence of chronic diseases not only has a serious impact on the quality of life of patients, but also leads to the increase of medical resource consumption and economic burden. According to statistics, the medical cost of patients with chronic diseases is usually several times that of patients with a single chronic disease, which brings heavy economic pressure to individuals, families and even the whole society [8]. In addition, older people with chronic comorbidities often face reduced or lost working capacity, which not only affects their personal lives, but also reduces overall economic productivity, which in turn negatively affects the economic development of the country.

In view of the high prevalence rate of chronic disease comorbidity in the global elderly population and the serious health burden brought by it, more and more researchers have begun to pay attention to the phenomenon of chronic disease comorbidity in the elderly and conducted a large number of related studies [9]. Therefore, it is particularly necessary to conduct systematic evaluation and meta-

analysis of the problems in this field. The purpose of this study is to systematically summarize and meta-analyze existing cross-sectional survey data to understand more deeply and comprehensively the prevalence of chronic comorbidity in the elderly and its related influencing factors, so as to provide a solid scientific basis for the formulation of effective intervention strategies and health policies. Ultimately, we hope to provide strong scientific support for addressing the challenges of global population aging and chronic disease comorbidities.

Materials and methods

Registration

This study was prepared in strict accordance with the PRISMA declaration specification. In order to elaborate on the specific report content of this study, the items in the PRISMA2020 list are listed in supplementary Table 1. In addition, detailed information on the study program is available online through the Prospective Register for Systematic Reviews (PROSPERO: CRD42024602631).

Search strategy

In the literature search phase, two researchers independently used computers to conduct a comprehensive literature search on eight Chinese and English databases, including PubMed, Web of Science, Embase, Cochrane Library, CNKI, WAMFANG, VIP and CBM. The search was conducted from the establishment of the database until August 15, 2024. In order to develop an effective search strategy, we use a search method combining subject terms and free words. The keywords used include: "Multimorbidity" OR "Comorbidity" OR "Multiple Chronic Illnesses" OR "Multiple Chronic Conditions", "Prevalence" OR "Morbidity" OR "Incidence" OR "Epidemiology", "Risk" OR "Risk Factors" OR "Protective Factors", "Aged" OR "Elderly" OR "Older" OR "Elder". In the Chinese database, we also use the Chinese terms corresponding to the above English keywords to search. Specific search strategies, including the combination of subject terms and free words, are detailed in supplementary Table 2. To ensure the comprehensiveness of the relevant literature we collected, we also used a literature tracking approach, reviewing the references cited in the included articles to determine if there were other studies that met our inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria of this study clearly specify several important conditions: (1) The term "chronic disease comorbidity" should be clearly defined in the article, that is, the same individual has two or more chronic diseases at the same time; (2) Cross-sectional design was adopted in the study; (3) The subjects were older people ≥60 years old or ≥65 years old; (4) The prevalence of chronic disease comorbidity needs to be clearly reported in the study, or it can be calculated by the formula: comorbidity = (number of comorbidity/total number of people) ×100%. In addition, exclusion

criteria for studies are equally important, including: (1) duplicate publications; (2) Literature not published in Chinese or English; (3) Studies in which the original data cannot be extracted or transformed; (4) The full text of the literature cannot be obtained. In order to avoid data redundancy, for multiple studies conducted in the same region or population, only the data with the largest or most recent sample size was selected to be included in this study.

Study selection and data extraction

Import all the literature in the database into Endnote software for the purpose of literature selection and management. First, duplicate publications need to be removed. Subsequently, two researchers independently conducted a preliminary screening of the titles and abstracts according to the set inclusion and exclusion criteria to exclude irrelevant references. Finally, the researchers will read the full text and screen again to determine the final literature to be included. If there are differences of opinion between the two researchers during this process, these differences will be resolved through negotiation or consultation with a third researcher. In the data extraction process, Excel software was used to establish a data extraction table, which included: first author, publication year, survey time, survey location, study design, sample size, sample gender ratio, prevalence of chronic diseases, prevalence of chronic disease comorbidity and related risk factors.

Methodological quality assessment

Two researchers independently assessed the methodological quality of the final included literature. They systematically scored the included studies using cross-sectional study evaluation criteria recommended by the Agency for Healthcare Research and Quality (AHRQ) [10]. The AHRQ methodological Checklist is widely recognized as an effective tool for assessing the quality of cross-sectional studies and is currently accepted and used by researchers in multiple fields [11]. The list can be found at http://www.ncbi.nlm.nih.gov/books/NBK35156/. The tool contains 11 assessment items relating to data sources, inclusion and exclusion criteria, timing and order of inclusion of subjects, influence of evaluator subjective factors, assessment of quality assurance, interpretation of data exclusions, control for confounding variables, management of missing data, integrity of data collection, and follow-up. Each assessment item is graded with "Yes", "no" or "unclear", where "yes" is awarded 1 point, and the remaining options are not awarded points. Depending on the score, a score of 0-3 indicates "low" methodological quality, a score of 4-7 indicates "medium" methodological quality, and a score of 8-11 indicates "high" methodological quality. In addition, the process of quality evaluation was independently conducted by two researchers, and the consistency of their scores was evaluated by Cohen's Kappa coefficient [12]. For literature with inconsistent evaluation results, the researchers resolved these differences by discussing them with a third

investigator.

Subgroup analysis

The purpose of subgroup analysis was to explore the significant influencing factors of heterogeneity in the included studies. To do so, we conducted a meticulous subgroup analysis based on age, sex, study quality, survey location, survey duration, and sample size to determine whether these different subgroups had a significant impact on the overall estimate of chronic disease comorbidity in older adults.

Data analysis and synthesis

In this study, State 18.0 software was used to conduct a meta-analysis of the included literatures. The percentage of chronic disease comorbidities in the elderly was extracted from the included studies, and for studies without a clear prevalence report, the number of comorbidities was calculated by dividing it by the total sample size. Pooled results were estimated using weighted points for the prevalence of chronic comorbidity and reported with 95% confidence intervals (95%CI). The heterogeneity of the included studies was assessed by Chi-square test (test level α=0.10) combined with I^2 test. If I^2 is less than 50% or $P > 0.10$, the heterogeneity among studies is small, and the fixed effect model should be adopted. If $I^2 > 50\%$ or $P \leq 0.10$, it indicates moderate or high heterogeneity among studies, and a random effects model should be used [13]. We performed a sensitivity analysis to test the robustness of the results by excluding one study at a time and looking at changes in co-prevalence in the remaining studies. For the combined effect size of the influencing factors, the combined OR value and 95%CI of the influencing factors were obtained by comparing the fixed effect model and the random effect model. If the results of the two models are similar, it can be inferred that the results of this study have good reliability and stability. In addition, the funnel plot and Egger test were used to evaluate the potential publication bias, and the results showed that when $P > 0.05$, the risk of publication bias was low, and when $P < 0.05$, the difference was statistically significant.

Results

Search results

A flow chart of the document selection process is shown in Figure 1. The initial search results showed a total of 80,925 studies were obtained, and after 36,212 duplications were removed, 44,713 studies were included in the next round of screening. After preliminary screening and re-screening,49 original studies on the prevalence of chronic disease comorbidity in the elderly were finally identified for meta-analysis [15-22,24-27,33-34,49-83].

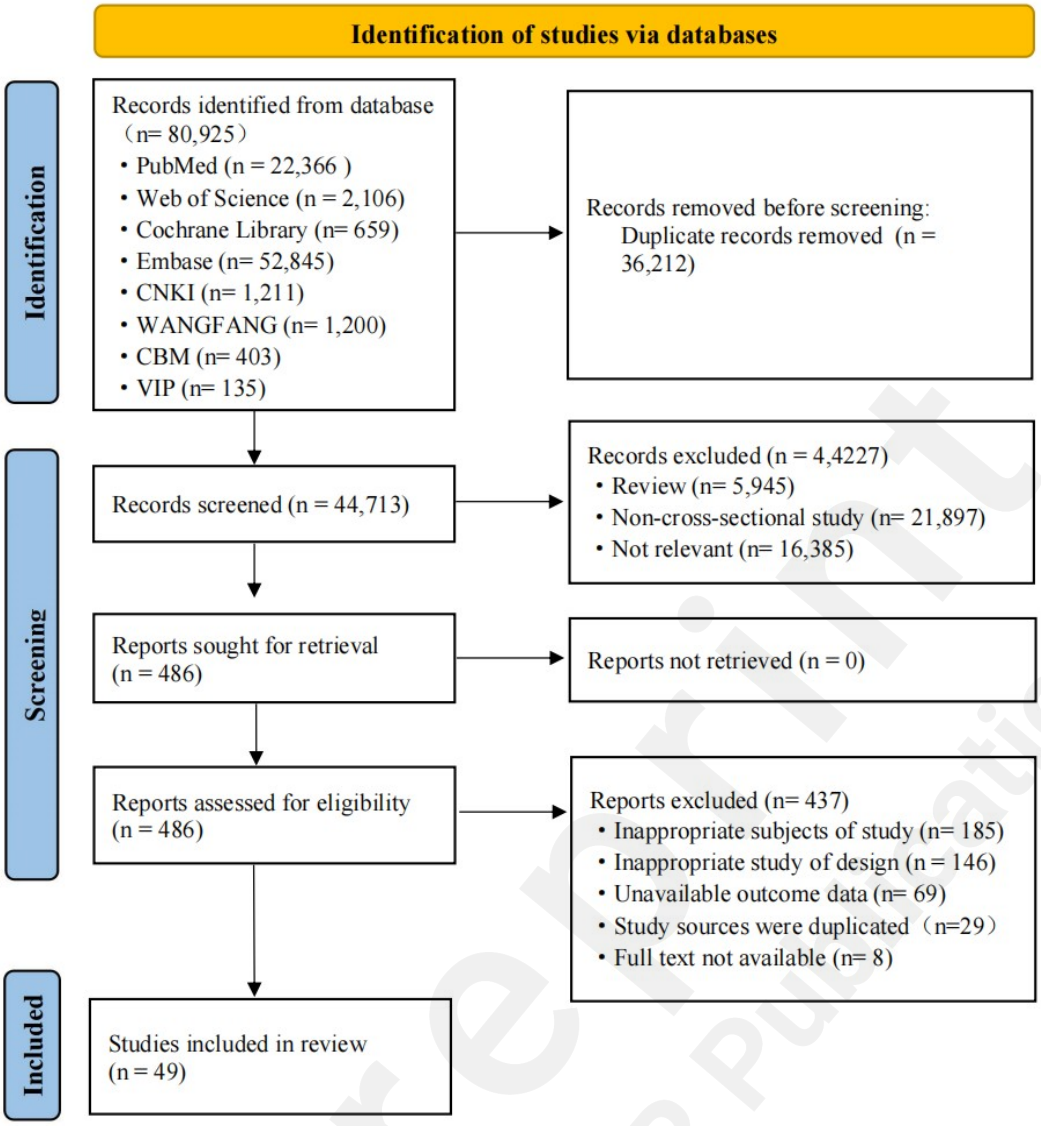

Fig. 1 PRISMA flow diagram of literature search and selection

Studies characteristics

All features included in this study are shown in Table 1. Finally, 49 studies were selected for analysis. The studies included 729,043 elderly respondents, of whom 347,779 had two or more chronic conditions at the same time. The studies were published between 2010 and 2022, with sample sizes ranging from 279 to 229,493 people. Of the 49 studies, 26 were from China, while the remaining 23 were from 21 countries, including the United States, Japan, South Korea, India, Vietnam, Germany, Switzerland and others. Of these, 17 studies clearly reported various factors influencing chronic comorbidities. All included studies scored from a minimum of 4 to a maximum of 8 on the quality assessment.

Table 1 Characteristic summary of included studies on the prevalence of chronic disease comorbidity in the elderly

Author,year	Area	Time of survey	Sampling method	Sample size(n)	Age	Gender		Methodological quality score	C r
						Male(n(%))	Female(n(%))		
Liu YT et al.2022	Nanjing,China	2019	Cluster sampling	1552	≥60	837（53.92）	715（46.08）	8	65
Chen YT et al.2023	Fujian,China	2018	Convenience sampling	1262	≥60	613（48.57）	649（51.43）	8	27
Li GX et al.2023	Guangzhou,Suzhou,Qingdao,China	2021	Random sampling	1310	≥60	586（44.73）	724（55.27）	8	68
Guo D et al.2022	Beijing,Sichuan, China	2018	Stratified quota sampling	7507	≥65	3734（49.74）	3773（50.26）	7	53
Kong Y et al.2021	Guizhou,China	2021	Multistage cluster sampling	10062	≥60	4930（48.99）	5132（51.01）	4	20
Li X et al.2019	Yunnan,China	2017	Multi-stage stratified random sampling	4833	≥60	2199（45.49）	2634（54.51）	6	77
Zhang H et al.2019	China	2015	Multistage stratified cluster sampling	23718	≥60	10533（44.41）	13185（55.59）	5	130
Qi YT et al.2023	China	2018	Multilevel random sampling	7354	≥60	3727（50.68）	3627（49.32）	7	47
Liu XX et al.2023	Mianyang,China	2019	Multi-stage random sampling	107177	≥60	48841（45.57）	58336（54.43）	5	145
Tian L et al.2023	Heilongjiang,China	2021	Cluster sampling	15899	≥65	6787（42.69）	9112（57.31）	5	54
Zhu PY et al.2023	Chengdu,China	2019	Multi-stage random sampling	8335	≥60	3484（41.79）	4851（58.21）	7	13
Yu ZJ et al.2023	Zhangjiagang,China	2020	/	1849	≥60	801（43.32）	1048（56.68）	4	10
He YZ et al.2023	Ningxia,China	2021	Cluster sampling	2010	≥65	963（47.91）	1047（52.09）	8	62
Wang WH et al.2024	Jiangsu,China	2021	Multistage stratified cluster sampling	20724	≥65	9787（47.22）	10937（52.78）	5	97
Mu YJ et al.2023	Shenzhen,China	2019	Cluster sampling	4475	≥65	1905（42.56）	2570（57.44）	8	27
Yao YL et al.2022	Zhengzhou,China	2020	/	2506	≥60	1041（41.54）	1465（58.46）	4	56
Cao M et al.2021	Henan,China	2019	Multistage stratified cluster sampling	1336	≥60	645（48.28）	691（51.72）	8	49
Hou YT et al.2020	Wuhan,China	2016	Multi-stage random sampling	622	≥65	264（42.44）	358（57.56）	6	31
Liu DN et al.2023	Shanghai,China	2017	Multi-stage stratified random sampling	12507	≥60	5298（48.25）	7209（51.75）	5	69
Zhang XQ et al.2024	Gansu,China	2021	/	1491	≥60	596（39.97）	895（60.03）	8	11
Zhou FK et al.2023	Hubei,China	2018-2020	Cluster sampling	8221	≥65	3772（45.88）	4449（54.12）	6	24
Marzban M et al.2024	Iran	2015	/	2426	≥60	1161（47.85）	1265（52.15）	5	19
Oliveira-Figueiredo DST et al.2024	Brazil	2020	Random sampling	22728	≥60	10193（44.84）	12535（55.16）	7	117
Ko S et al.2024	India	2018	Multi-stage stratified sampling	12316	≥60	6158（50.00）	6158（50.00）	8	30
Su W et al.2024	Kunming,China	2020-2021	Stratified random sampling	1161	≥60	499（42.98）	662（57.02）	8	36
Kohler S et al.2024	Dares Salaam	2017-2018	Random sampling	555	≥60	243（43.78）	312（56.21）	7	46
Lee C et al.2024	Korea	2019	/	1041	≥65	233（22.38）	808（77.62）	6	93
Maimaitiwusiman Z et al.2023	Xinjiang,China	2019	Multi-stage random sampling	86510	≥60	41188（47.61）	45322（52.39）	7	288
Reyes-Ortiz CA et al.2023	Colombia	2015	Multi-stage stratified random sampling	18873	≥60	8757（46.39）	10116（53.61）	7	81
You L et al.2023	Zhejiang,China	2022	Multistage stratified cluster sampling	7774	≥60	3876（49.89）	3898（50.11）	8	38
Yang K et al.2023	Shanxi,China	2021	Convenience sampling	4803	≥60	2276（47.38）	2527（52.62）	8	18
Honda Y et al.2022	Japan	2013	Stratified random sampling	23340	≥65	10266（43.98）	13074（56.02）	5	95
Lynch DH et al.2022	United States	2005-2014	Multi-stage random sampling	7261	≥60	3652（50.30）	3609（49.70）	6	49
Balakrishnan S et al.2022	Eastern Nepal	2020	Multistage cluster sampling	843	≥60	431（51.12）	412（48.88）	8	19
Keomma K et al.2022	São Paulo	2015	Complex probability sampling	1019	≥60	387（37.97）	632（62.03）	7	40
Shariff Ghazali S et al.2021	Malaysia	2018	Two-stage stratified cluster sampling	3966	≥60	1868（47.10）	2098（52.90）	5	15
Lin WQ et al.2022	Guangzhou,China	2020	Multi-stage stratified random sampling	31708	≥65	14046（44.29）	17662（55.71）	5	48
Sara HH et al.2018	Bangladesh	2017	Two-stage stratified random sampling	566	≥60	432（76.32）	134（23.68）	7	31
Smith L et al.2022	Irish	2009-2011	Multistage stratified cluster sampling	2941	≥65	1323（44.98）	1618（55.02）	8	20
Jovic D et al.2016	Serbia	2013	Two-stage stratified random sampling	2749	≥65	1174（42.70）	1575（57.30）	5	15
Puth MT et al.2017	Germany	2012-2013	Two-stage random sampling	7152	≥60	3454（48.29）	3698（51.71）	5	48
Bähler C et al.2015	Switzerland	2013	/	229493	≥65	98124（42.76）	131369（57.24）	5	175
Ha NT et al.2015	Vietnam	2010	Multi-stage random sampling	2400	≥60	834（34.75）	1566（65.25）	7	94
Yadav UN et al.2021	Nepal	2018	Multistage cluster sampling	794	≥60	400（50.38）	394（49.62）	8	11
Hien H et al.2014	Burkina Faso	2012	Random sampling	389	≥60	215（55.27）	174（44.73）	8	25
Aye SKK et al.2019	Myanmar	2016	Multi-stage random sampling	4859	≥60	1841（37.89）	3018（62.11）	7	16
Asante D et al.2022	Australia	2013-2017	Random sampling	5920	≥60	2442（41.25）	3478（58.75）	7	19
Abdulazeez ZU et al.2021	Nigeria	2018	Random sampling	279	≥60	93（33.40）	186（66.70）	8	20
Nugraha S et al.2020	Indonesia	2018	Random sampling	427	≥60	137（32.08）	290（67.92）	5	25

Methodological quality assessment results

The quality evaluation results of this study showed that 16 studies (32.65%) were rated as high quality, while 33 studies (67.35%) were rated as medium quality. All included studies defined chronic comorbidity and were cross-sectional studies. More than half of the studies (51.02%) clarified the inclusion and exclusion criteria for study subjects. In most of the included studies, assessments to assure study quality (89.79%) and summaries of patient response rates and data integrity (71.43%) were reported. However, none of the studies described the impact of the evaluators' subjective factors on the findings, nor did they detail how missing data was dealt with in their analyses. Details are given in supplementary Table 3.

Meta-analysis of the prevalence of chronic disease comorbidity

A random effects model was used to conduct a meta-analysis of 49 included studies. The results showed that the prevalence of chronic disease comorbidity in the elderly population reached 46.0% (95%CI= 38.0-55.0%, I^2=99.98%, *P*=0.00). The forest map is shown in Figure 2.

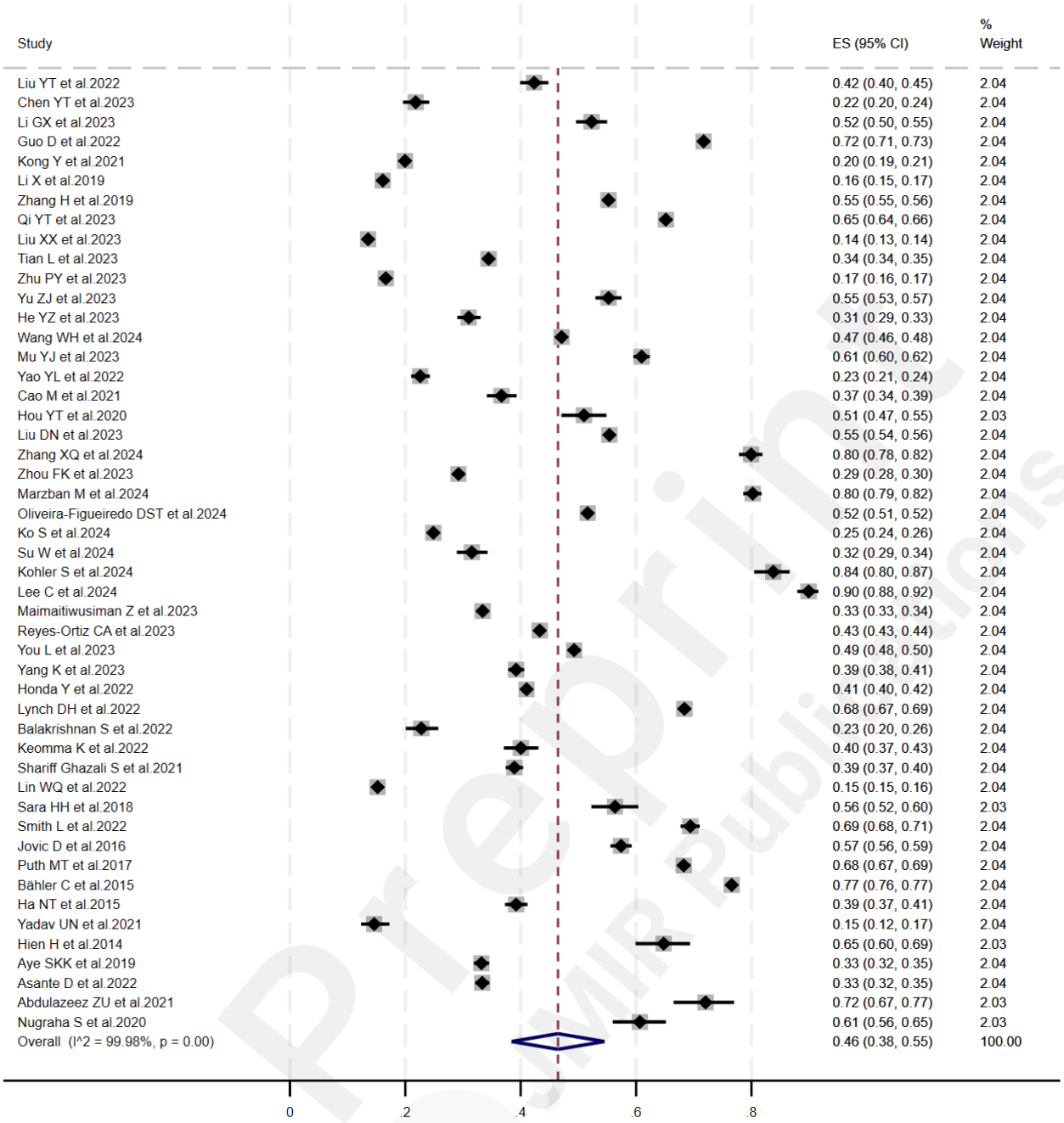

Fig 2 Meta-analysis of the prevalence of chronic disease comorbidity in the elderly

Subgroup analysis

The results of subgroup analysis by age, sex, study quality, survey location, survey time, and sample size showed that the prevalence of chronic disease comorbidity in older adults was summarized as follows: Men (0.41, 95%CI=0.35-0.47) vs. women (0.48, 95%CI=0.41-0.55), age ≥60 years (0.44, 95%CI=0.38-0.51) vs. age ≥65 years (0.52, 95%CI=0.35-0.69), Medium study quality (0.48, 95%CI=0.39-0.57) vs high study quality (0.41, 95%CI=0.27-0.54), China (0.40, 95%CI=0.33-0.47) vs other countries (0.53, 95%CI=0.44-0.63), Pre-2020 surveys (0.49, 95%CI=0.39-0.59) vs post-2020 surveys (0.39, 95%CI=0.30-0.49) with sample sizes greater than 10,000 (0.39, 95%CI=0.30-

0.49) 95%CI=0.23-0.56) vs Sample size 1000-10000 people (0.48, 95%CI=0.40-0.56) vs sample size less than 1000 people (0.53, 95%CI=0.38-0.55). This section is described in detail in Table 2.

Table 2 Subgroup analysis of the prevalence of chronic disease comorbidity in the elderly

Subgroup	Studies, n	Heterogeneity		Effect model	Pooled estimate (95%CI)
		I^2	*P*-value		
Gender		99.91%	<0.001		0.45(0.40-0.49)
Male	37	99.88%	<0.001	Random	0.41(0.35-0.47)
Female	37	99.93%	<0.001	Random	0.48(0.41-0.55)
Age		99.98%	<0.001		0.46(0.38-0.55)
≥60	36	99.95%	<0.001	Random	0.44(0.38-0.51)
≥65	13	99.99%	<0.001	Random	0.52(0.35-0.69)
Research quality		99.98%	<0.001		0.46(0.38-0.55)
Medium	33	99.99%	<0.001	Random	0.48(0.39-0.57)
High	16	99.88%	<0.001	Random	0.41(0.27-0.54)
Country		99.98%	<0.001		0.46(0.38-0.55)
China	26	99.96%	<0.001	Random	0.40(0.33-0.47)
Other	23	99.95%	<0.001	Random	0.53(0.44-0.63)
Survey time		99.98%	<0.001		0.46(0.38-0.55)
~2020	35	99.99%	<0.001	Random	0.49(0.39-0.59)
2021~	14	99.92%	<0.001	Random	0.39(0.30-0.49)
Sample size		99.98%	<0.001		0.46(0.38-0.55)
10000~	13	100.00%	<0.001	Random	0.39(0.23-0.56)
1001~9999	28	99.89%	<0.001	Random	0.48(0.40-0.56)
~1000	8	99.59%	<0.001	Random	0.53(0.38-0.55)

Sensitivity analysis

The robustness of the findings was assessed by the leave-one method, and each study was individually excluded for analysis. The prevalence of chronic disease comorbidity in the elderly ranged from 45.56% to 47.15%, indicating that the overall prevalence of comorbidity fluctuated less, which meant that the study results were stable and reliable. In addition, a sensitivity analysis of 33 medium-quality studies showed that the prevalence of chronic comorbidities in the elderly ranged from 46.82% to 48.83%, further suggesting that the findings were also stable and reliable in medium-quality studies.

Publication bias

Funnel plot and Egger test were used to assess publication bias in 49 included studies. The result of Egger test showed that no significant publication bias was found in the study on the prevalence of chronic disease comorbidity in the elderly (P=0.798 > 0.05). The analysis results of the funnel plot showed that each study was roughly evenly distributed on both sides of the effect value, as shown in Figure 3.

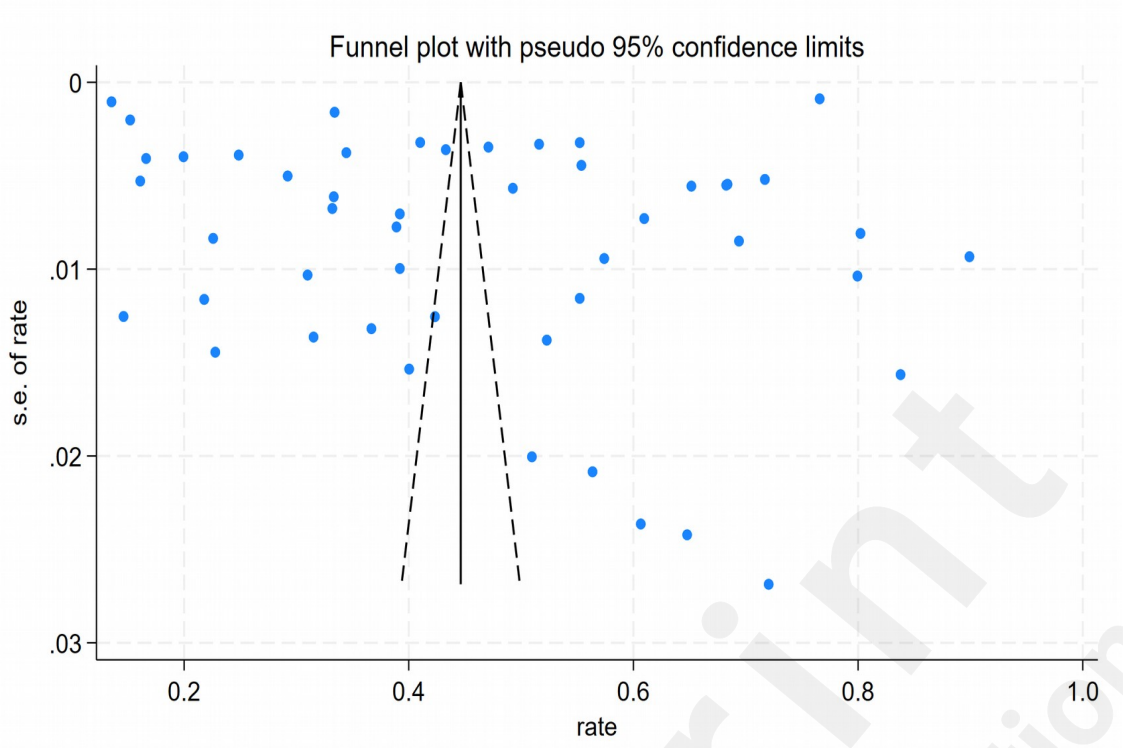

Fig 3 Funnel plot of publication bias

Meta-analysis of influencing factors of chronic disease comorbidity

Of the 49 studies included, 17 examined factors influencing chronic comorbidity in older adults. Through the extraction of data from these 17 studies, 10 risk factors associated with chronic disease comorbidities were identified and their effect sizes were pooled for analysis. The results of the analysis showed that the following factors were identified as significant risk factors for comorbidities in older adults: age (≥70 years), gender (female), body mass index (BMI≥28kg/m^2), education level (at least junior high school level), marital status (single, widowed, divorced), and higher income level. However, this study did not find that smoking, alcohol consumption, lack of exercise, and place of residence had significant effects on the occurrence of chronic disease comorbidities. Detailed data are shown in Table 3.

Table 3 Results of meta-analysis of risk factors for chronic disease comorbidity in the elderly

Risk factors	Studies, n	Heterogeneity		Effect model	Pooled estimate			
		P	I^2(%)		OR	95%CI	Z	*P*
Age (≥70)	11	0.001	96.46	random	1.43	1.09-1.89	2.57	0.010 *
Gender (Female)	9	0.001	86.80	random	1.59	1.38-1.83	6.44	0.001 *
BMI(≥28.0kg/m^2)	7	0.001	96.73	random	1.97	1.28-3.03	3.1	0.002 *
Educational	6	0.072	55.18	random	0.56	0.43-0.73	-4.36	0.001 *
Smoking	10	0.006	62.92	random	1.09	0.99-1.20	1.71	0.088
Tipple	5	0.001	82.80	random	0.88	0.64-1.20	-0.81	0.416

Exercise(lack)	5	0.001	95.46	random	0.82	0.52-1.30	-0.85	0.397
Marital status	6	0.004	80.44	random	1.32	1.02-1.71	2.09	0.037*
Income(high)	8	0.001	83.93	random	1.46	1.11-1.91	2.71	0.007*
Live in the city	4	0.001	96.35	random	1.09	0.64-1.83	0.31	0.757

CI = confidence interval; * = $P < 0.05$

Sensitivity analysis

In this study, sensitivity analysis was conducted under fixed effects model and random effects model for OR values and 95%CI of each influencing factor. The results showed that although there were some differences in the calculation results of smoking and exercise, the OR values and 95%CI of the two models showed significant agreement in the analysis of other influencing factors. This finding indicates that the meta-analysis results of influencing factors in this study have good stability, and the details are shown in Table 4.

Table 4 Sensitivity analysis of risk factors

Risk factors	Fixed effect model			Random effects model		
	OR	**95%CI**	***P***	**OR**	**95%CI**	***P***
Age (≥70)	1.21	1.17-1.26	0.001*	1.43	1.09-1.89	0.010*
Gender (Female)	1.43	1.38-1.49	0.001*	1.59	1.38-1.83	0.001*
BMI(≥28.0kg/m^2)	1.57	1.47-1.68	0.001*	1.97	1.28-3.03	0.002*
Educational	0.58	0.51-0.67	0.001*	0.56	0.43-0.73	0.001*
Smoking	1.13	1.09-1.17	0.001*	1.09	0.99-1.20	0.088
Tipple	0.92	0.82-1.03	0.155	0.88	0.64-1.20	0.416
Exercise(lack)	1.12	1.03-1.22	0.011*	0.82	0.52-1.30	0.397
Marital status	1.21	1.09-1.34	0.001*	1.32	1.02-1.71	0.037*
Income(high)	1.51	1.37-1.66	0.001*	1.46	1.11-1.91	0.007*
Live in the city	1.05	0.96-1.15	0.257	1.09	0.64-1.83	0.757

CI = confidence interval; * = $P < 0.05$

Publication bias

Since there were more than 10 studies involving age and smoking, a funnel map was drawn. It is observed that the funnel plot presents an incomplete left-right symmetry, which suggests that there may be some degree of publication bias, as shown in Figure 4.

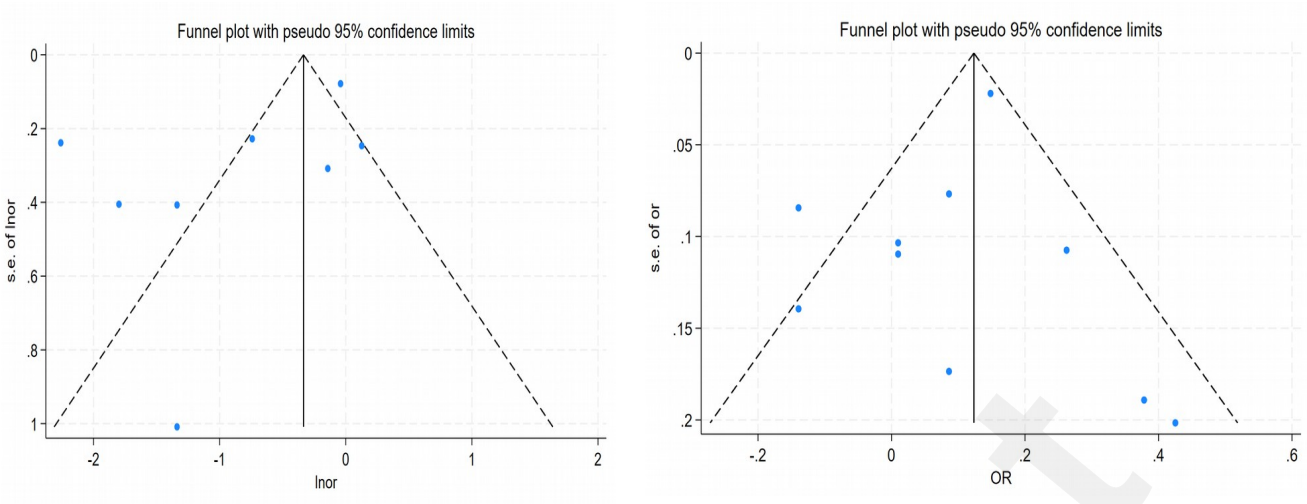

Fig 4 Age and smoking publication bias funnel plot, the picture on the left is age and the picture on the right is smoking.

Discussion

This study included 49 cross-sectional studies from 2010 to 2022 to comprehensively describe the prevalence of chronic comorbidities and their associated risk factors in the elderly through a meta-analysis. The study found that the prevalence of chronic comorbidity in the elderly population reached 46.0% (95%CI= 38.0-55.0%). There are several factors affecting the incidence of chronic disease comorbidity in the elderly, including age (≥70 years), gender (female), body mass index (BMI≥28kg/m2), education level (junior high school or above), marital status (single, widowed, divorced) and higher income level. These factors have a significant impact on the comorbidity of chronic diseases in the elderly.

Influence of age on chronic disease comorbidities

Age is widely recognized as an important risk factor for multiple chronic diseases [14], and our analysis further confirms this. Compared with those aged 60 to 69, people aged 70 and above have a significantly higher probability of chronic comorbidities [15-22]. This finding is closely related to the biological aging process, and over time, the cumulative effect of aging will promote the occurrence of multiple chronic diseases [23]. Given the increasing ageing of the global population and the increasing life expectancy, we must implement effective preventive measures for older persons to avoid a greater burden of chronic disease.

Influence of gender on chronic disease comorbidities

The study results further revealed the gender differences in the incidence of comorbidity in the elderly population, showing that the prevalence of comorbidity in elderly women was significantly higher than that in elderly men [16,18,19,21,22,24-27]. Specifically, older women are 1.59 times more likely to have chronic comorbidities than older men. This gender difference can be attributed to a variety of factors, including biological differences, lifestyle choices, and social determinants of health status [28]. First, women are generally more likely than men to report a health condition or

seek medical help, which is largely influenced by social norms and attitudes towards health care utilization [29,30]. In addition, changes in hormone levels during menopause in women and the fact that women generally live longer than men may also be important reasons for the significantly higher prevalence of comorbidity in women [31,32].

Influence of body mass index on chronic comorbidities

Body mass index (BMI) is one of the important factors affecting the occurrence of chronic disease comorbidities in the elderly. Our findings suggest that the risk of chronic comorbidity in older adults is significantly increased when BMI exceeds 28kg/m^2 [17,18,19,22,25,33,34]. It is well known that obesity and overweight are closely associated with the development of several chronic diseases, such as cardiovascular disease, diabetes, and certain types of cancer [35,36]. This finding suggests that by effectively controlling weight and adopting an active lifestyle, it may be possible to reduce the incidence of chronic disease comorbidity in older adults, thereby improving their quality of life and reducing healthcare costs.

Influence of educational level on chronic disease comorbidity

The effect of educational background on health outcomes has been extensively studied. The findings suggest that individuals with higher levels of education, especially those who have completed at least secondary school, have a lower risk of multiple chronic diseases [22,25,26,33]. However, some studies have found that there seems to be no direct correlation between education level and chronic disease comorbidity [24,27]. In general, people with higher levels of education tend to have stronger cognitive abilities and are able to adopt new knowledge and modern health concepts more quickly. This cognitive ability helps them develop healthy behaviors, making individuals more informed in health decisions and able to take necessary preventive measures in a timely manner [37,38]. In addition, people with higher levels of education may have better access to health care resources, combined with better economic conditions, which together promote the early diagnosis and effective management of chronic diseases.

Influence of marital status on chronic disease comorbidities

Marital status is considered to be an important predictor of chronic disease comorbidity in the elderly. Our analysis shows that older adults who are single, widowed or divorced are more likely to face comorbidities than those who are married, a finding that has been reflected in multiple studies [17,22,26,33,39,40]. Married people often have access to emotional support from their spouses and family care, which is important for effective health management [41]. In contrast, older people who are single, widowed, or divorced often experience emotional loneliness and stress while also facing a lack of social support, which may exacerbate the occurrence and progression of their chronic

diseases [42]. Therefore, social support is particularly important in maintaining the physical and mental health of the elderly. The lack of supportive social networks can weaken the effectiveness of chronic disease treatment, which reminds us that greater emphasis should be placed on enhancing social support, including the organization of beneficial community-based social activities, when caring for older persons with chronic diseases.

Influence of economic base on chronic disease comorbidities

Our pooled results suggest that higher income levels are an important protective factor against chronic comorbidity [16,17,21,33,39]. This combined result is consistent with the extensive literature showing a strong link between economic conditions and health outcomes. Individuals with higher incomes generally have access to better quality health care services, healthier living environments, and more adequate resources to manage and manage chronic diseases [43]. They were also more likely to engage in healthy lifestyles, such as regular exercise, maintaining a nutritionally balanced diet, and limiting tobacco and alcohol consumption. To address the challenges posed by economic disparities, implementing policies that reduce poverty, provide affordable housing and equitable access to health care could have a positive impact on reducing the burden of chronic comorbidities among older adults.

Influence of other factors on chronic disease comorbidities

Our findings suggest that factors such as smoking, alcohol consumption, exercise and place of residence do not significantly affect the occurrence of chronic disease comorbidities in older adults. Although some previous studies confirmed smoking and alcohol consumption as risk factors for comorbidities [44], our results failed to give a clear indication of their specific impact on chronic comorbidities. However, we still recommend that the elderly should actively develop a healthy lifestyle of smoking cessation, moderate drinking and moderate exercise in the process of preventing and managing chronic disease comorbidities.

The findings of this meta-analysis provide important reference value for public health policy formulation and practice. Given the high incidence of chronic comorbidities among the elderly, we believe that an integrated care model is necessary to address the complex health care needs of this group [45]. In addition, healthcare providers should receive systematic training on the principles of geriatric care, which should include a holistic approach to care that is oriented towards the physical, psychological and social needs of older persons [46]. For example, an interdisciplinary team of doctors, nurses, pharmacists, social workers, and other health care professionals could be assembled to work together to develop personalized care plans to improve health outcomes and improve quality of life for older adults [47]. Finally, public health initiatives to address modifiable risk factors, such

as obesity, literacy, smoking and alcohol consumption, will help to prevent the occurrence of chronic comorbidity and thus reduce the health burden on older persons. Community-based healthy aging promotion programs, such as exercise classes, nutrition counseling, and smoking cessation programs, will play a vital role in promoting health and independence for older adults [48].

Limitations

The limitations of this study are mainly reflected in the following three aspects: First, the studies included in this analysis are cross-sectional studies, and these studies show considerable heterogeneity. Confounding factors of uncertainty, such as survey methodology, survey timing and geographic diversity, may have contributed to this discrepancy, and these uncertainties may have led to bias in combining results. Although we have tried to analyze the possible sources of heterogeneity in our study, unfortunately, we have not found a valid explanation to clearly interpret this heterogeneity. Second, due to the inherent nature of observational studies, it is difficult to establish a causal relationship between various risk factors and chronic disease comorbidities, which poses a challenge to the interpretation of the results. Finally, the issue of publication bias is equally likely to have an impact on the pooled results, as studies with positive results or larger sample sizes may be more likely to be published, resulting in a bias in the results.

Conclusion

Taken together, the meta-analysis provides strong evidence that about half of older adults face two or more chronic conditions at the same time. Predictors of chronic disease comorbidities in older adults include age, sex, body mass index, education level, marital status, and higher income level. The results of this study once again highlight the severe burden of chronic disease comorbidity on older adults and the healthcare needs required by this group. The findings of this study can be used by policymakers to address modifiable risk factors and improve the quality of life of older people globally by promoting healthy ageing to reduce the burden of chronic disease comorbidity faced by older people.

Supplementary Information

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Acknowledgements

We thank all the researchers in this paper for their active cooperation and the original authors of the included studies for their excellent work.

Author contributions

XSZ and JCW planned and designed this study; HBM and FLL provide methodological support/advice; JCW and YHW tested the feasibility of the study; HBM and FLL extract data; YHW statistical analysis; XSZ wrote the manuscript; All authors approved the final manuscript.

Funding

This work was supported by the National Natural Science Foundation of China (72264002), Key Grant Project of Chinese Medicine Education Association (2022KTZ010). The funders who supported this study had no role in study design, preparation of the paper, data collection and analysis, decision to publish.

Data availability

The datasets and any other materials of our study are available from corresponding author on request.

Ethics approval and consent to participate

Ethical approval and participant consent were not required for this study because the study was based on a meta-analysis of published studies.

Competing interests

All authors of this article declare no conflict of interest.

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Supplementary Files

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