

Association between metabolic syndrome and kidney cancer; a systematic review and meta-analysis

Bashirjamil Wahidi¹, Azadeh Haghir¹, Masoomah Vasheghani Farahani^{2*}, Zahra Abdan³, Mehrra Majdaeen⁴, Narges Mostafaloo⁵

¹Cancer Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

²Rajaei Clinical Research Development Unit (CRDU) of Shahid Rajaei Hospital, Alborz University of Medical Sciences, Karaj, Iran

³Clinical Research Development Center, Imam Reza Hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran

⁴Department of Radio-Oncology, Razi Hospital, Guilan University of Medical Sciences, Rasht, Iran

⁵Clinical Research Development Unit of Shahid Beheshti Hospital, Babol University of Medical Sciences, Babol, Iran

ARTICLE INFO

Article Type:
Meta-analysis

Article History:
Received: 9 Jul. 2026
Revised: 2 Sep. 2026
Accepted: 9 Sep. 2026
Published online: 22 Sep. 2026

Keywords:
Metabolic syndrome
Kidney neoplasms
Renal cell carcinoma
Kidney cancer

ABSTRACT

Introduction: Kidney neoplasm ranks as the fourteenth most prevalent malignancy globally. While some cancers have been associated with metabolic syndrome, the existing evidence on the relationship between metabolic syndrome and kidney neoplasm is inconsistent. Accordingly, the present study was designed to assess the association between metabolic syndrome and kidney neoplasm risk.

Materials and Methods: Initial studies were searched in the databases of Cochrane Library, Scopus, Web of Science, Embase, and PubMed, as well as the Google Scholar search engine. The literature search was updated up to 21 June 2026. Data were analyzed statistically using the STATA 14 software.

Results: In this study, we found that having metabolic syndrome increased the overall risk of kidney neoplasms (OR: 1.97, 95% CI: 1.51, 2.58), as well as the risk in women (OR: 1.42, 95% CI: 1.32, 1.53), men (OR: 1.58, 95% CI: 1.37, 1.82), individuals under 50 years of age (OR: 2.65, 95% CI: 1.90, 3.69), and those aged 50 years or older (OR: 2.10, 95% CI: 1.32, 3.34). Furthermore, factors such as hypertension (OR: 1.80, 95% CI: 1.47, 2.22), obesity (OR: 1.45, 95% CI: 1.32, 1.59), dyslipidemia (OR: 1.44, 95% CI: 1.07, 1.94), decreased high-density lipoprotein (HDL) (OR: 1.37, 95% CI: 1.32, 1.42), and increased triglyceride (TG) (OR: 1.22, 95% CI: 1.11, 1.35) increased the risk of kidney neoplasm. In addition, having one metabolic syndrome component (OR: 1.30, 95% CI: 1.23, 1.39), two components (OR: 1.49, 95% CI: 1.40, 1.59), three components (OR: 1.93, 95% CI: 1.68, 2.22), four components (OR: 2.29, 95% CI: 1.91, 2.75), and five components (OR: 2.67, 95% CI: 2.16, 3.30) increased the risk of kidney neoplasm.

Conclusion: Metabolic syndrome was a risk factor for kidney neoplasm. Male gender was more likely than female gender, and age under 50 years was more likely than age greater than or equal to 50 years to develop kidney neoplasm. Hypertension, obesity, dyslipidemia, decreased HDL, and increased TG were the most influential factors in kidney neoplasm, respectively, and the more of these components were present in an individual, the higher the risk of kidney neoplasm.

Registration: This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD420261441802) website.

Implication for health policy/practice/research/medical education:

In a systematic review and meta-analysis to find the association between metabolic syndrome and kidney cancer, we found metabolic syndrome was a risk factor for kidney neoplasm. Male gender was more likely than female gender, and age under 50 years was more likely than age greater than or equal to 50 years to develop kidney neoplasm. We also detected, hypertension, obesity, dyslipidemia, decreased high-density lipoprotein (HDL), and increased triglyceride (TG) were the most influential factors in kidney neoplasm, respectively.

Please cite this paper as: Wahidi B, Haghir A, Vasheghani Farahani M, Abdan Z, Majdaeen M, Mostafaloo N. Association between metabolic syndrome and kidney cancer; a systematic review and meta-analysis. J Renal Inj Prev. 2026; 15(4): e38786. doi: 10.34172/jrip.38786.

Introduction

Metabolic syndrome is defined as a cluster of interrelated metabolic abnormalities, including obesity, hyperglycemia, type 2 diabetes mellitus, dyslipidemia, and hypertension (1). The increasing prevalence of this syndrome has imposed considerable burdens on global public health (1). Accumulating evidence indicated that metabolic syndrome is associated with an elevated risk of cardiovascular disease, stroke, type 2 diabetes, and various malignancies (2,3).

Genitourinary malignancies represent a critical threat to human health (4). Although factors such as advanced age, ethnicity, family history of malignancy and cigarette smoking are well-established risk factors, the precise etiology of these neoplasms remains unclear (3,5-7). Kidney neoplasm is the fourteenth most common malignancy worldwide, accounting for over 342,000 new cases and 131,000 deaths annually (4,8,9). Furthermore, epidemiological data indicate a rising global burden of kidney neoplasm incidence over the past decade (10). Kidney cancer is the third most common urological malignancy in men, after prostate and bladder cancers (11). Although risk factors including obesity, diabetes, tobacco use, and hypertension have been implicated in the development of kidney neoplasm, its underlying cause remains largely unknown (12). Consequently, the identification of high-risk populations for kidney neoplasm is of paramount importance (13,14). Previous studies suggested that metabolic syndrome is a risk factor for kidney neoplasm (15,16), whereas others have reported no significant association between metabolic syndrome and kidney neoplasm (17). Therefore, the aim of the present study was to evaluate the relationship between metabolic syndrome and kidney neoplasm.

Materials and Methods

The protocol of this study was designed based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) checklist (18) and registered in the PROSPERO website.

Search strategy

To identify related sources, the Cochrane Library, Scopus, Web of Science, Embase, and PubMed databases, as well as the Google Scholar search engine, were searched up to 21 June 2026. The searches were conducted without any time or language restrictions. Standard keywords, along with their Medical Subject Headings (MeSH) equivalents were conducted for the search. Logical operators (AND, OR) were employed during the advanced search stage to combine the keywords (see [Supplementary file 1](#)). In addition, the reference lists of selected studies were manually examined to identify further relevant sources.

PICO components

- Population: Studies that examined the association

between metabolic syndrome and kidney neoplasm.

- Exposure: Having metabolic syndrome.
- Comparison: Non- metabolic syndrome.
- Outcome: Kidney neoplasm.

Inclusion criterion

Studies that examined the association between metabolic syndrome and kidney neoplasm.

Exclusion criteria

Meta-analysis or systematic review studies- those that did not report data- conference abstracts- studies without accessible full texts, despite sending emails to authors- and repeated studies.

Quality assessment

Two researchers independently assessed the quality of the included articles using the Newcastle-Ottawa Scale. Except for one item, this scale awards at most one star per question, yielding overall scores from 0 (lowest quality) to 10 (highest quality), with scores below 5 designating low-quality studies (19).

Data extraction

Data were extracted by two researchers independently using SPSS 19 software. Extracted data consisted of the first author, year, total number, country, design, and association between metabolic syndrome and kidney neoplasm by hazard ratio (HR) or odds ratio (OR).

Statistical analysis

We used log-transformed ORs and HRs for data processing, then pooled the results from the different studies. Heterogeneity among the selected studies was evaluated using the I^2 index, and a random-effects model was finally chosen to combine the overall estimates. Data were analyzed statistically with STATA 14 at a significance level of $P < 0.05$ for all tests.

Results

Out of 645 records initially identified, 399 duplicates were removed, leaving 246 studies for further screening. Following abstract review, 27 articles were excluded due to incomplete abstracts or unavailable full texts. The full texts of the remaining 219 articles were then assessed for eligibility; of these, 105 studies were omitted owing to insufficient data required for the analysis. Furthermore, 100 studies were excluded based on other pre-specified criteria, ultimately yielding 14 articles ([Figure 1](#)).

A total of 14 observational studies, encompassing 10,264,494 individuals with metabolic syndrome, were evaluated in this review. Further details regarding the included primary studies are presented in [Table 1](#).

Finding from [Figure 2](#) demonstrated a statistically significant positive correlation between metabolic syndrome and heightened risk of kidney neoplasm (OR:

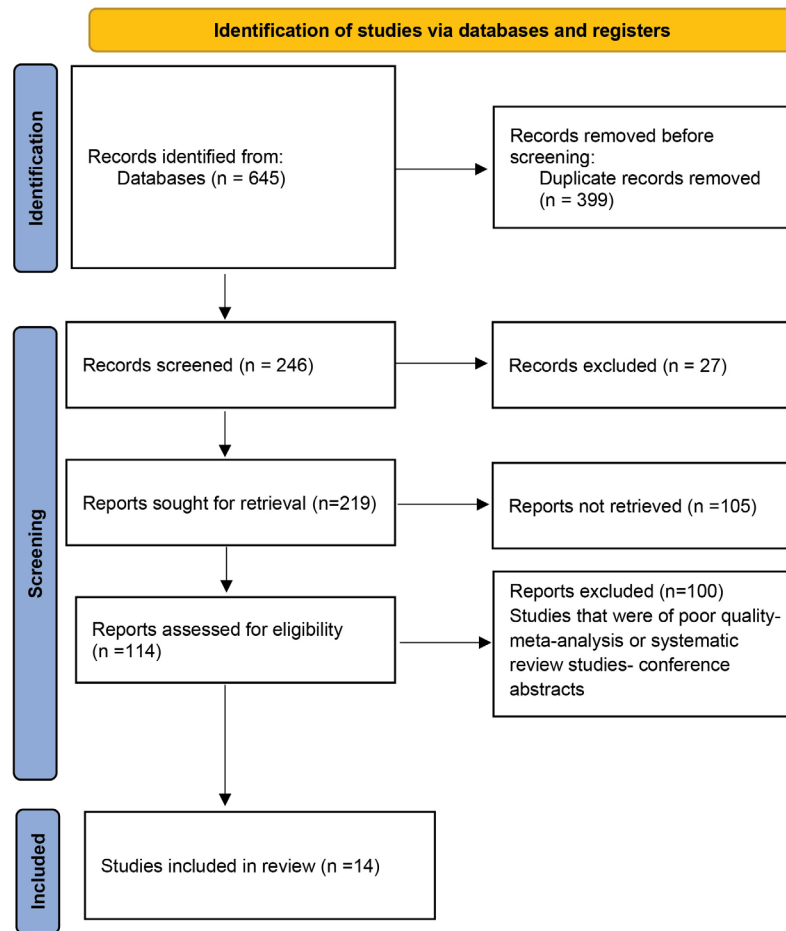


Figure 1. PRISMA 2020 flow diagram of the study

Table 1. Summarized information of the studies

Author, year	Country	Design	Duration of study	Total number	Age group (year)
Jung M, 2026 (15)	USA	Case-control	2007–2022	48587	59.6
Deng L, 2024 (16)	China	Cohort	between 2006 and 2010	4657	49.26
Suarez Arbelaez MC, 2023 (20)	USA	Cross-sectional	from Jul 2015 to Feb 2022	1011728	65
Jiang R, 2023a (21)	China	Cohort	from May 2006 to Dec 2007	31359	54.52
Bulut S, 2014(22)	Turkey	Case-control	between Jul 2010 and Jun 2013	117	57.01
Wang L, 2024 (23)	UK	Cohort	2006–2010	98193	58.2
Jiang R, 2023b (24)	China	Cohort	May 2006 to Dec 2019	217	61.09
Lee HY, 2023 (25)	South Korea	Cohort	between Jan 2009 and Dec 2009	12758	≥20
Li X, 2020 (26)	China	Cohort	2006-2008	104274	51.21
Oh TR, 2019 (27)	South Korea	Cohort	from 2009 to 2010	7613865	≥20
Ko S, 2016 (17)	South Korea	Cohort	2002-2013	12618	≥20
Haggstrom C, 2013 (male) (28)	Norway, Austria, and Sweden	Cohort	2003-2006	278920	42
Haggstrom C, 2013 (female) (28)	Norway, Austria, and Sweden	Cohort	2003-2006	281468	42
Choe JW, 2021(29)	South Korea	Cohort	between 2009 and 2016	582449	56.4
Lopez-Jimenez T, 2022(30)	Spain	Case-control	between Jan 2008 ans Dec 2017	183284	67.5

1.97, 95% CI: 1.51, 2.58). Metabolic syndrome conferred an increased risk of kidney neoplasm among both female (OR: 1.42, 95% CI: 1.32, 1.53), and male (OR: 1.58, 95% CI: 1.37, 1.82) participants (Figures 3 and 4). Collectively, patients with metabolic syndrome exhibited greater odds of kidney neoplasm relative to those without metabolic syndrome.

In both the < 50 years (OR: 2.65, 95% CI: 1.90, 3.69) and $\geq$ 50 years (OR: 2.10, 95% CI: 1.32, 3.34), metabolic syndrome was associated with an elevated risk of kidney

neoplasm relative to the non- metabolic syndrome population (Figure 5).

Factors such as hypertension (OR: 1.80, 95% CI: 1.47, 2.22), obesity (OR: 1.45, 95% CI: 1.32, 1.59), dyslipidemia (OR: 1.44, 95% CI: 1.07, 1.94), decreased high-density lipoprotein (HDL) (OR: 1.37, 95% CI: 1.32, 1.42) and increased triglyceride (TG) (OR: 1.22, 95% CI: 1.11, 1.35) increased the risk of kidney neoplasm. In contrast, there was no significant association between FBG (fasting blood glucose) (OR: 1.24, 95% CI: 0.99, 1.56), diabetes (OR:

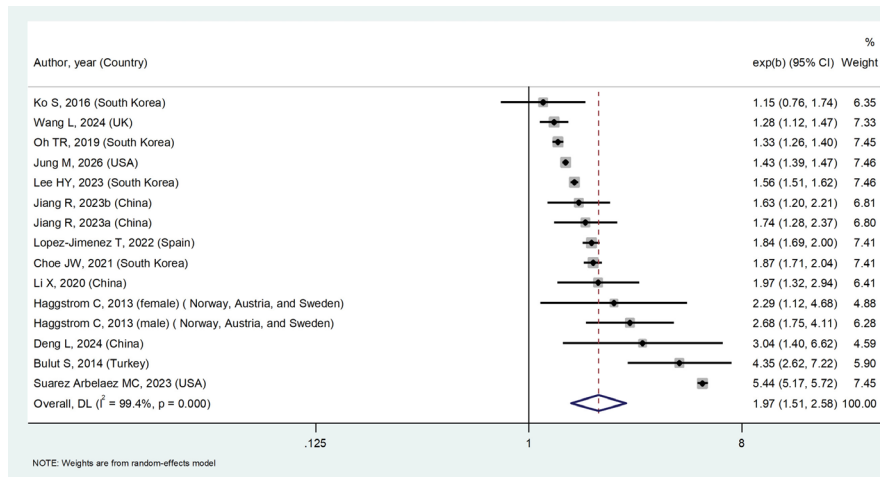


Figure 2. Forest plot showing the association between metabolic syndrome and kidney cancer.

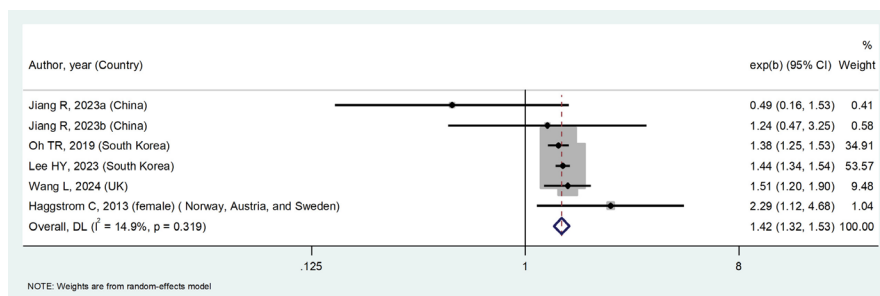


Figure 3. Forest plot showing the association between metabolic syndrome and kidney cancer in females.

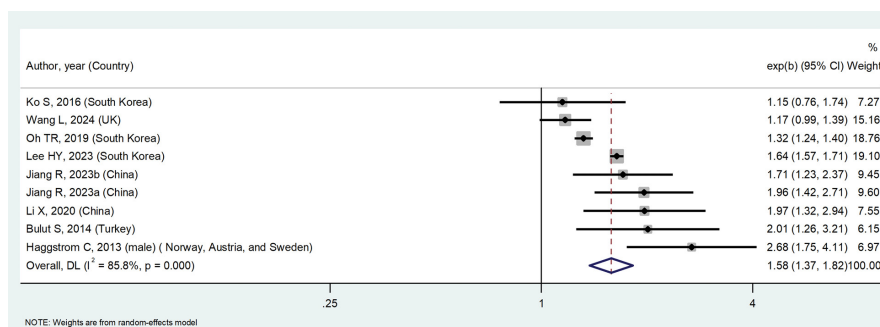


Figure 4. Forest plot showing the association between metabolic syndrome and kidney cancer in males.

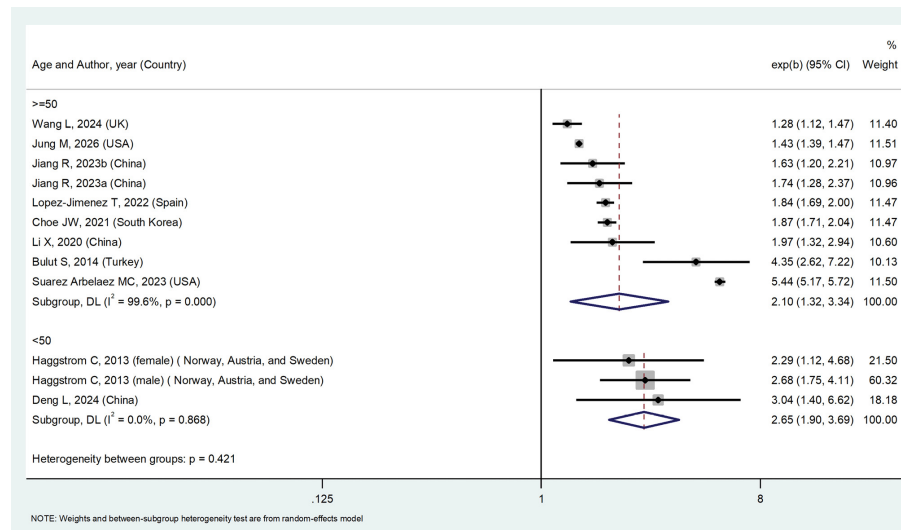


Figure 5. Forest plot showing the association between metabolic syndrome and kidney cancer by age group.

1.57, 95% CI: 0.83, 2.93), and waist circumference (OR: 1.34, 95% CI: 0.82, 2.18) and the risk of kidney neoplasm (Table 2).

Having one metabolic syndrome component (OR: 1.30, 95% CI: 1.23, 1.39), two components (OR: 1.49, 95% CI: 1.40, 1.59), three components (OR: 1.93, 95% CI: 1.68, 2.22), four components (OR: 2.29, 95% CI: 1.91, 2.75), and five components (OR: 2.67, 95% CI: 2.16, 3.30) increased the risk of kidney neoplasm (Figure 6).

Figure 7 showed that there was no publication bias in the source search phase of this meta-analysis and all studies relevant to the current article title were reviewed and screened ($P=0.649$).

Discussion

The presence of metabolic syndrome was associated with an increased risk of kidney neoplasm overall, with risk elevations of 97% in the total population, 42% in women, and 37% in men. Stratified by age, the increased risk was 2.65-fold in individuals under 50 years and 2.10-fold in those aged ≥ 50 years. Among individual metabolic syndrome components, hypertension (80% increased risk), obesity (45%), dyslipidemia (44%), decreased HDL (37%), and elevated triglycerides (22%) each independently

contributed to elevated renal cell carcinoma (RCC) risk. Furthermore, the presence of one, two, three, four, and five metabolic syndrome components was associated with risk increases of 30%, 49%, 93%, 2.29-fold, and 2.67-fold, respectively.

In a meta-analysis of six studies by Zhou et al, metabolic syndrome was identified as a risk factor for RCC (HR: 1.44, 95% CI: 1.31, 1.59) (31). Similarly, Du et al conducted a meta-analysis of eight studies and found that metabolic syndrome was associated with an increased risk of RCC (RR: 1.62, 95% CI: 1.40, 1.87) (32). In line with these findings, the present meta-analysis demonstrated that metabolic syndrome significantly increased the risk of developing kidney neoplasm. Importantly, our study is more comprehensive than previous meta-analyses, incorporating a larger sample size.

In a different context, Mariani et al performed a meta-analysis examining the association between metabolic syndrome and gastric cancer risk, concluding that there was no significant relationship between the two (HR: 1.05, 95% CI: 0.92, 1.18) (33). This finding contrasts with the results of the current study, indicating that metabolic syndrome does not elevate the risk of gastric cancer.

Table 2. Association between components of metabolic syndrome and the risk of kidney cancer

Variables	OR	Low limit	Up limit	I^2 (%)	P value
Obesity	1.45	1.32	1.59	94	<0.001
Hypertension	1.80	1.47	2.22	98.8	<0.001
Dyslipidemia	1.44	1.07	1.94	98.7	<0.001
HDL	1.37	1.32	1.42	0	0.679
TG	1.22	1.11	1.35	70.2	0.001
FBG	1.24	0.99	1.56	64.6	0.037
Diabetes	1.57	0.83	2.93	99.8	<0.001
WC	1.34	0.82	2.18	92.6	<0.001

OR: Odds ratio, HDL: High-density lipoprotein, TG: Triglycerides, FBG: Fasting blood glucose, WC: Waist circumference.

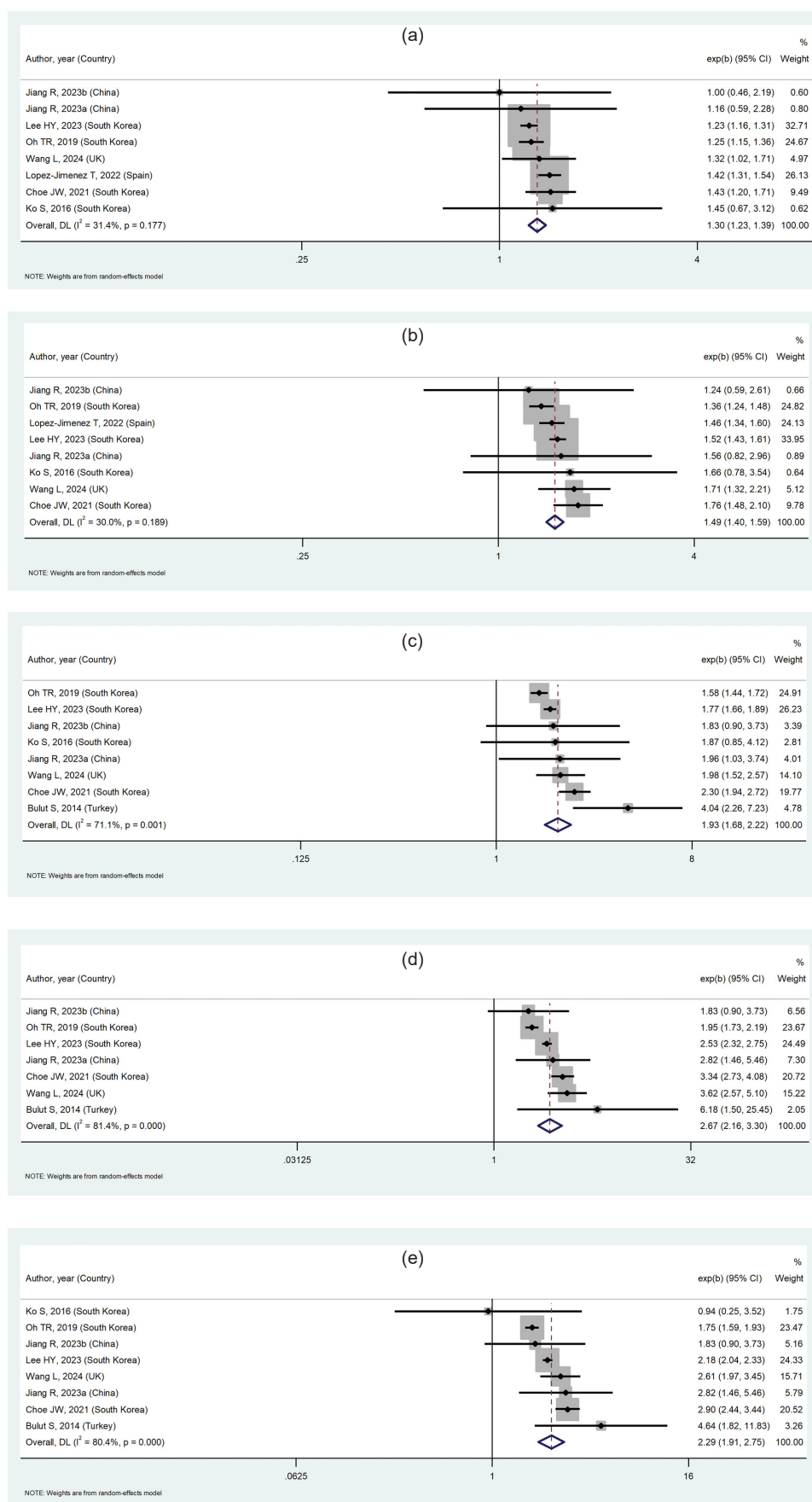


Figure 6. Forest plot showing the association between number of metabolic syndrome components 1 (a), 2 (b), 3 (c), 4 (d) and kidney cancer.

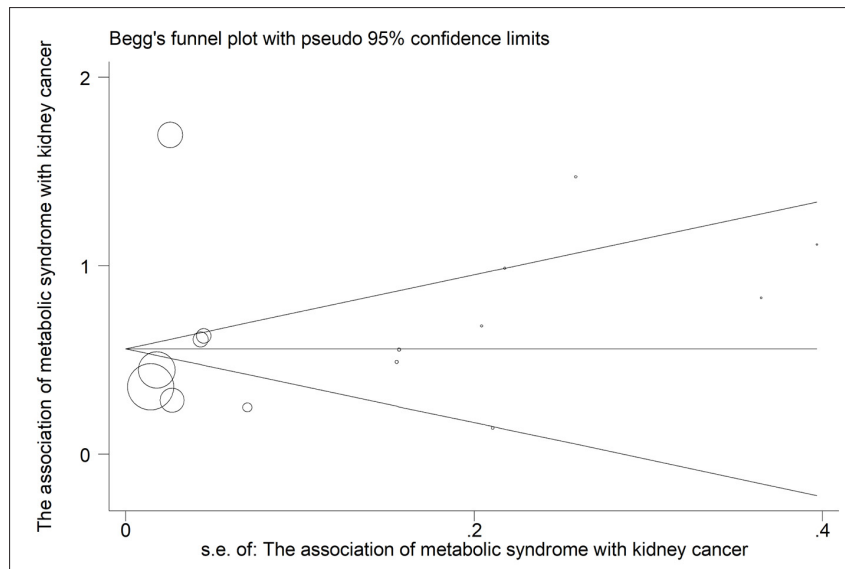


Figure 7. Publication bias.

Conversely, a number of meta-analyses have reported positive associations between metabolic syndrome and various other cancers. Esposito et al demonstrated that metabolic syndrome is associated with an increased risk of common cancers (3). Moreover, Zhong et al reported a positive and significant association between metabolic syndrome and pancreatic cancer risk (RR: 1.34, 95% CI: 1.23, 1.46) (34). In a previous meta-analytic approach, Shen et al showed that individuals with metabolic syndrome had a higher risk of colorectal cancer compared with the general population, an association observed in both men and women (RR: 1.36, 95% CI: 1.26, 1.47) (35). Likewise, Bhandari et al, in a meta-analysis focused on women, found a direct and significant association between metabolic syndrome and breast cancer risk (RR: 1.47, 95% CI: 1.15, 1.87) (36). Zhang et al reported that metabolic syndrome was directly associated with an elevated risk of esophageal cancer (OR: 1.16, 95% CI: 1.08, 1.25) (37). In another study, Zhang et al conducted a meta-analysis on lung cancer and concluded that metabolic syndrome independently increased lung cancer risk (RR: 1.15, 95% CI: 1.05, 1.26) (38). Collectively, these studies are consistent with the overall finding of our investigation, indicating that individuals with metabolic syndrome are at greater risk of developing various malignancies including pancreatic, colorectal, breast, esophageal, and lung cancers and that metabolic syndrome functions as an independent risk factor for these neoplasms.

Further supporting evidence comes from Esposito et al, whose meta-analysis indicated that metabolic syndrome may increase the risk of prostate cancer by 12% (39). Additionally, a meta-analysis by Yuan et al reported that patients with metabolic syndrome had a higher risk of bladder cancer compared with those without metabolic syndrome (OR: 1.62, 95% CI: 1.08, 2.43) (40). Taken

together, these studies suggest that metabolic syndrome is a risk factor not only for kidney cancer but also for other malignancies of the genitourinary tract.

Conclusion

Having metabolic syndrome increased the risk of developing kidney neoplasm, and among people with metabolic syndrome, men were more likely to develop kidney neoplasm than women, and people < 50 years of age were more likely to develop kidney neoplasm than people ≥50 years of age. Among the factors associated with metabolic syndrome, the greatest impact on the development of kidney neoplasm belonged to hypertension, obesity, dyslipidemia, decreased HDL, and increased TG, respectively. In addition, among individuals with metabolic syndrome, the risk of incident renal neoplasms increases with the accumulation of metabolic syndrome components.

Limitations of the study

All the studies reviewed were observational, but the number of studies in each category (cohort, cross-sectional, and case-control) was different from the other - different studies reported the risk with different indices (HR, OR) - the diagnostic criteria for metabolic syndrome may not have been the same in the original studies.

Acknowledgments

The authors would like to thank Diana Sarokhani and Mohsen Abdi for their guidance and editing of the manuscript registration on the PROSPERO website.

Authors' contribution

Conceptualization: Bashirjamail Wahidi and Masoomah Vasheghani Farahani.

Data curation: Bashirjamail Wahidi and Masoomah Vasheghani Farahani.

Formal analysis: Azadeh Haghiri and Mehra Majdaeen.

Investigation: Zahra Abdan and Narges Mostafaloo.

Methodology: Azadeh Haghiri and Narges Mostafaloo.

Project administration: Masoomeh Vasheghani Farahani and Bashirjamail Wahidi.

Supervision: All authors.

Validation: Zahra Abdan and Narges Mostafaloo.

Visualization: Azadeh Haghiri and Mehra Majdaeen.

Writing—original draft: All authors.

Writing—review and editing: All authors.

Conflicts of interest

The authors declare that they have no competing interests.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilized AI tool (DeepSeek) to refine grammatical points and language style in their writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the accuracy and content of the publication.

Ethical issues

This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO website (ID: [CRD420261441802](https://www.crd420261441802)) website. Besides, ethical issues (including plagiarism, data fabrication, and double publication) have been completely observed by the author.

Funding/Support

None.

References

- Alberti K, Eckel R, Grundy S, Zimmet P, Cleeman J, Donato K, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation*. 2009;120:1640-5. doi: 10.1161/CIRCULATIONAHA.109.192644.
- Lemieux I, Després J. Metabolic syndrome: past, present and future. *Nutrients*. 2020;12:3501. doi: 10.3390/nu12113501.
- Esposito K, Chiodini P, Colao A, Lenzi A, Giugliano D. Metabolic syndrome and risk of cancer: a systematic review and meta-analysis. *Diabetes Care*. 2012;35:2402-11. doi: 10.2337/dc12-0336.
- Sung H, Ferlay J, Siegel R, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71:209-49. doi: 10.3322/caac.21660.
- Mantica G, Terrone C, Der Merwe A. Bladder cancer and associated risk factors: the african panorama. *Eur Urol*. 2021;79:568-70. doi: 10.1016/j.eururo.2020.11.041.
- Campi R, Brookman-May S, Henríquez J, Akdoğan B, Brausi M, Klatte T, et al. Impact of metabolic diseases, drugs, and dietary factors on prostate cancer risk, recurrence, and survival: a systematic review by the European Association of Urology Section of Oncological Urology. *Eur Urol Focus*. 2019;5:1029-57. doi: 10.1016/j.euf.2018.04.001.
- Brookman-May S, Campi R, Henríquez J, Klatte T, Langenhuijsen J, Brausi M, et al. Latest evidence on the impact of smoking, sports, and sexual activity as modifiable lifestyle risk factors for prostate cancer incidence, recurrence, and progression: a systematic review of the literature by the European Association of Urology Section of Oncological Urology (ESOU). *Eur Urol Focus*. 2019;756-87. doi: 10.1016/j.euf.2018.02.007.
- Siegel R, Miller K, Fuchs H, Jemal A. Cancer statistics, 2021. *CA Cancer J Clin*. 2021;71:7-33. doi: 10.3322/caac.21654.
- Park J, Choi I, Han K, Park H, Kim K, Kim J. Association between fatty liver index and risk of breast cancer: a nationwide population-based study. *Clin Breast Cancer*. 2020;20:e450-e7. doi: 10.1016/j.clbc.2020.02.004.
- Gluba-Brzozka A, Rysz J, Ławiński J, Franczyk B. Renal cell cancer and obesity. *Int J Mol Sci*. 2022;23:3404. doi: 10.3390/ijms23063404.
- Xia C, Dong X, Li H, Cao M, Sun D, He S, et al. Cancer statistics in China and United States, 2022: profiles, trends, and determinants. *Chin Med J (Engl)*. 2022;135:584-90. doi: 10.1097/CM9.0000000000002108.
- Scelo G, Larose T. Epidemiology and risk factors for kidney cancer. *J Clin Oncol*. 2018;36:3574-81. doi: 10.1200/JCO.2018.79.1905.
- Rossi S, Klatte T, Usher-Smith J, Stewart G. Epidemiology and screening for renal cancer. *World J Urol*. 2018;36:1341-53. doi: 10.1007/s00345-018-2286-7.
- Turajlic S, Swanton C, Boshoff C. Kidney cancer: the next decade. *J Exp Med*. 2018;215:2477-9. doi: 10.1084/jem.20181617.
- Jung M, Wang X, Jeon S, Graff R, Deng Z, L'Espérance K, et al. Metabolic syndrome and risk of kidney cancer in the United States. *Cancer*. 2026;132:e70435. doi: 10.1002/cncr.70435.
- Deng L, Liu T, Liu C, Zhang Q, Song M, Lin S, et al. The association of metabolic syndrome score trajectory patterns with risk of all cancer types. *Cancer*. 2024;130:2150-9. doi: 10.1002/cncr.35235.
- Ko S, Yoon S, Kim D, Kim A, Kim E, Seo H. Metabolic risk profile and cancer in Korean men and women. *J Prev Med Public Health*. 2016;49:143-52. doi: 10.3961/jpmph.16.021.
- Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev J*. 2015;4:1e9. doi: 10.1186/2046-4053-4-1.
- Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol*. 2010;25:603e5.
- Suarez Arbelaez M, Nackeeran S, Shah K, Blachman-Braun R, Bronson I, Towe M, et al. Association between body mass index, metabolic syndrome and common urologic conditions: a cross-sectional study using a large multi-institutional database from the United States. *Ann Med*. 2023;55:2197293. doi: 10.1080/07853890.2023.2197293.
- Jiang R, Wang X, Li Z, Cai H, Sun Z, Wu S, et al. Association of metabolic syndrome and its components with the risk of urologic cancers : a prospective cohort study. *BMC Urol*. 2023;23:150. doi: 10.1186/s12894-023-01324-4.
- Bulut S, Aktas B, Erkmén A, Özden C, Gökaya C, Baykam M, et al. Metabolic syndrome prevalence in renal cell cancer patients. *Asian Pac J Cancer Prev*. 2014;15:7925-8. doi: 10.7314/apjcp.2014.15.18.7925.
- Wang L, Du H, Sheng C, Dai H, Chen K. Association between metabolic syndrome and kidney cancer risk: a prospective cohort study. *Lipids Health Dis*. 2024;23:142. doi: 10.1186/s12944-024-02138-5.
- Jiang R, Li Z, Wang X, Cai H, Wu S, Chen S, et al. Association of metabolic syndrome and its components with the risk of kidney cancer: A cohort-based case-control study. *Technol Health Care*. 2023;31:1235-44. doi: 10.3233/THC-220482.
- Lee H, Han K, Woo I, Kwon H. Association of metabolic

- syndrome components and nutritional status with kidney cancer in young adult population: a nationwide population-based cohort study in Korea. *Biomedicines*. 2023 May 11;14:25. doi: 10.3390/biomedicines11051425.
26. Li X, Li N, Wen Y, Lyu Z, Feng X, Wei L, et al. Metabolic syndrome components and renal cell cancer risk in Chinese males: a population-based prospective study. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2020;54:638-43. doi: 10.3760/cma.j.cn112150-20190711-00558.
 27. Oh T, Han K, Choi H, Kim C, Bae E, Ma S, et al. Metabolic syndrome resolved within two years is still a risk factor for kidney cancer. *J Clin Med*. 2019;8:1329. doi: 10.3390/jcm8091329.
 28. Häggström C, Rapp K, Stocks T, Manjer J, Bjørge T, Ulmer H, et al. Metabolic factors associated with risk of renal cell carcinoma. *PLoS One*. 2013 8:e57475. doi: 10.1371/journal.pone.0057475.
 29. Choe J, Hyun J, Kim B, Han K. Influence of metabolic syndrome on cancer risk in HBV carriers: a nationwide population based study using the national health insurance service database. *J Clin Med*. 2021;10:2401. doi: 10.3390/jcm10112401.
 30. López-Jiménez T, Duarte-Salles T, Plana-Ripoll O, Recalde M, Xavier-Cos F, Puente D. Association between metabolic syndrome and 13 types of cancer in Catalonia: A matched case-control study. *PLoS One*. 2022;17:e0264634. doi: 10.1371/journal.pone.0264634.
 31. Zhou Y, Chen Y, Yang H, Xu Z, Zhuang J, Bian Q, et al. Metabolic syndrome and increased susceptibility to renal cell carcinoma—a meta-analysis. *BMC Nephrol*. 2025;26:102. doi: 10.1186/s12882-025-04013-6.
 32. Du W, Guo K, Jin H, Sun L, Ruan S, Song Q. Association between metabolic syndrome and risk of renal cell cancer: a meta-analysis. *Front Oncol*. 2022;12:928619. doi: 10.3389/fonc.2022.928619.
 33. Mariani M, Sassano M, Boccia S. Metabolic syndrome and gastric cancer risk: a systematic review and meta-analysis. *Eur J Cancer Prev*. 2021;30:239-50. doi: 10.1097/CEJ.0000000000000618.
 34. Zhong L, Liu J, Liu S, Tan G. Correlation between pancreatic cancer and metabolic syndrome: A systematic review and meta-analysis. *Front Endocrinol (Lausanne)*. 2023;14:1116582. doi: 10.3389/fendo.2023.1116582.
 35. Shen X, Wang Y, Zhao R, Wan Q, Wu Y, Zhao L, et al. Metabolic syndrome and the risk of colorectal cancer: a systematic review and meta-analysis. *Int J Colorectal Dis*. 2021;36:2215-25. doi: 10.1007/s00384-021-03974-y.
 36. Bhandari R, Kelley G, Hartley T, Rockett I. Metabolic syndrome is associated with increased breast cancer risk: a systematic review with meta-analysis. *Int J Breast Cancer*. 2014;2014:189384. doi: 10.1155/2014/189384.
 37. Zhang J, Wu H, Wang R. Metabolic syndrome and esophageal cancer risk: a systematic review and meta-analysis. *Diabetol Metab Syndr*. 2021;13:8. doi: 10.1186/s13098-021-00627-6.
 38. Zhang Z, Liu Q, Huang C, Wu J, Wen Y. Association between metabolic syndrome and the risk of lung cancer: A Meta-Analysis. *Horm Metab Res*. 2023;55:846-54. doi: 10.1055/a-2179-0809.
 39. Esposito K, Chiodini P, Capuano A, Bellastella G, Maiorino M, Parretta E, et al. Effect of metabolic syndrome and its components on prostate cancer risk: meta-analysis. *J Endocrinol Invest*. 2013;36:132-9. doi: 10.1007/BF03346748.
 40. Yuan Y, Liu T, Yao Y, Ma Q, Sun L, Zhang G. Metabolic syndrome and bladder cancer risk: a comprehensive evidence synthesis combining bibliometric and meta-analysis approaches. *BMC Urol*. 2025;25:132. doi: 10.1186/s12894-025-01812-9.