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Association between systemic immune-inflammation index and risk of chronic kidney disease; a systematic review and meta-analysis

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ABSTRACT

Introduction: Inflammation is a hallmark feature of chronic kidney disease (CKD) and the systemic immune-inflammation index (SII) is a potent biomarker for assessing the inflammatory status. Taking note of these, the present systematic review and meta-analysis evaluated the correlation between SII and the risk for CKD.

Materials and Methods: ProQuest, Embase, PubMed, Web of Science, Cochrane, and Google Scholar databases were searched until November 20, 2024, without any restriction applied. Data were analyzed in Stata v14.0. The results with P<0.05 were considered to be statistically significant.

Results: Elevated SII values enhanced the overall risk of CKD (OR: 1.24; 95% CI: 1.52, 1.267), CKD risk in females (OR: 1.03; 95% CI: 1, 1.07), and CKD risk in the USA (OR: 1.27; 95% CI: 1.16, 1.38). Contrarily, no significant correlation was observed between SII and the risk for CKD among males (OR: 1.03; 95% CI: 0.99, 1.07) and in China (OR: 1.15; 95% CI: 0.98, 1.34). The second tertile (OR: 1.14; 95% CI: 1.05, 1.25), third tertile (OR: 1.49; 95% CI: 1.28, 1.73), third quartile (OR: 1.16; 95% CI: 1.08, 1.24), and fourth quartile (OR: 1.42; 95% CI: 1.27, 1.59) of the SII index enhanced the risk of CKD. Elevated SII values (OR: 1.43; 95% CI: 1.20, 1.70) enhanced the risk for CKD. Likewise, high SII values enhanced the risk for CKD in patients with diabetes mellitus (DM) (OR: 1.42; 95% CI: 1.21, 1.68), low-estimated glomerular filtration rate (eGFR) (OR: 1.27; 95% CI: 1.14, 1.40), and albuminuria (OR: 1.46; 95% CI: 1.08, 1.97), as well as in patients with BMI>30 kg/m^2 (OR: 1.05; 95% CI: 1.01, 1.09).

Conclusion: Elevated SII values enhanced the risk of CKD, and the SII-CKD association was intensified in females, Americans, and patients with DM, low eGFR, albuminuria, and obesity. Accordingly, high SII levels are a robust indicator of CKD prognosis.

Registration: This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD42024619311) and Research Registry (UIN: reviewregistry1925,) websites.

Meta-analysis

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Implication for health policy/practice/research/medical education:
The findings indicate that elevated systemic immune-inflammation index (SII) values significantly increase the risk of chronic kidney disease (CKD), particularly among specific populations such as females, Americans, and individuals with diabetes mellitus, low-estimated glomerular filtration rate (eGFR), albuminuria, and obesity, underscore critical implications for health policy, practice, research, and medical education. Health policies should prioritize the integration of SII monitoring into routine clinical assessments to identify at-risk populations early, facilitating timely interventions. In clinical practice, healthcare providers should be trained to recognize the importance of SII as a prognostic marker for CKD, enabling tailored management strategies for patients exhibiting high SII levels. Furthermore, research initiatives should focus on elucidating the underlying mechanisms linking inflammation to CKD progression while exploring potential therapeutic targets. Finally, medical education curricula must incorporate the significance of inflammatory markers like SII in chronic disease management to prepare future healthcare professionals for evidence-based practice in nephrology and related fields.

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Introduction

Chronic kidney disease (CKD) is a progressive loss of kidney function and acts as a risk factor for end-stage kidney disease (ESKD) and premature mortality (1). CKD features a decline in an estimated glomerular filtration rate (eGFR) or a surge in the albumin-to-creatinine ratio (ACR) (2). With a prevalence rate of 11% to 13%, CKD is a global concern (3). By gender, the estimated worldwide prevalence of CKD is 11.8% (in adult females) and 10.4% (in adult males) (4). This disease is reportedly confirmed to correlate with cardiovascular, all-cause, and cancer mortalities and cancer risk (5-7). With an upsurge in obesity-related type 2 diabetes mellitus (T2DM) over the past decades, diabetic kidney disease (DKD or diabetic nephropathy) has become the most prevalent CKD, accounting for over 50% of all ESKD cases globally (8,9). DKD development involves multiple factors, encompassing hemodynamic changes, glycolipid metabolism disorders, stress, inflammation, and genetic susceptibility (10-12).

Inflammation, obesity, diabetes, hypertension, and cardiovascular diseases (CVDs) are risk factors for CKD (13). Inflammation and oxidative stress synergistically act during CKD progression to overproduce reactive oxygen species (ROS) and cause apoptosis of renal vascular endothelial cells and necrosis, culminating in kidney damage by disrupting microcirculatory regulation and renal perfusion distribution (14,15). Systemic immune-inflammation index (SII) is a robust indicator for assessing inflammatory status and reflects an aggravated systemic inflammatory response, thereby implying a higher burden of inflammation in the context of CKD (16). Besides tumors, SII can predict CVDs, neurological disorders, and metabolic, respiratory, and rheumatic diseases (17-23).

A recent cross-sectional study has reported a jump in the risk of CKD upon SII upsurge in the second and third tertiles (24). Another cross-sectional research has reported no significant correlation between SII upsurge and the risk of CKD in the second quartile (25). Taking note of these, the present systematic review and meta-analysis aims to clarify such uncertainties observed in the literature.

Materials and Methods

This research was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and its protocol was registered in the international Prospective Registry of Systematic Reviews (PROSPERO) and Research Registry websites (26).

Search strategy

Using keywords and their MeSH equivalents, ProQuest, Embase, PubMed, Web of Science, Cochrane, and Google Scholar search engine databases were searched until November 20, 2024. The search was conducted without time and place restrictions. The primary references were hand-searched. The keywords were searched using Medical Subject Headings (MeSH) and operators "AND" and "OR". The strategy employed to search in the PubMed database was as follows; (Systemic immune-inflammation OR SII index) AND (Chronic Renal Disease OR Chronic Kidney Disease OR "Renal Insufficiency, Chronic")

PECO components

Articles assessing the correlation between SII and CKD were reviewed. The exposure was high SII, and the primary outcome was the risk of CKD as compared with that in normal participants. Secondary outcomes were the association between DM, body mass index (BMI), low-eGFR, albuminuria, and systemic inflammation response index (SIRI) with the risk of CKD.

Inclusion criteria

Observational studies evaluating the correlation between SII and CKD were included in this meta-analysis.

Exclusion criteria

Reviews, letters to the editors, low-quality research,

research published in congresses or conferences, duplicated research, research with no full text, research evaluating the simultaneous impact of SII and an inflammatory marker, and research with incomplete data were excluded from this meta-analysis.

Quality assessment

The authors assessed the quality of the search articles using the Newcastle Ottawa Scale (NOS) tool. In NOS, each item is given a maximum of one star, and a maximum of two stars can be given for comparability. As such, the scores span from zero (the weakest quality) to ten (the highest quality). The questionnaire's cut-off point is six (27).

Data extraction

The data extracted from articles were the author's name, study duration, SII level, study date, stages, and type, country, age, odds ratio, and the nexus between SII and CKD risk (with upper and lower limit sit) in all participants and among females and males, sample size, etc.

Statistical analysis

Data were analyzed using the logarithm of odds ratio (OR), by merging all the articles. The extent of heterogeneity was measured by the I^2 index. Due to high heterogeneity, the random effects model was used for panel data analysis. The subgroup analysis was employed to assess how SII levels correlate with the risk of CKD, with variables including the study types, location, and stages. Meta-regression charts were drawn for further analysis. Data were analyzed in Stata version 14.0. The results with $P<0.05$ were regarded to be statistically significant.

Results

Study selection

Our search delivered 175 articles, of which 78 were omitted as they were duplicates. After checking abstracts, 19 out of the remaining 97 articles were omitted as they had no full abstract and text accessible. Of the remaining 78 articles, 32 were further omitted as they had no adequate data required for analyses. Likewise, 36 out of the remaining 46 articles were excluded due to exclusion criteria, and 10 were ultimately included in this systematic review and meta-analysis (Figure 1).

Table 1 presents the results of reviewing ten observational research (i.e., eight cross-sectional research and two case-control research), all targeting 187 503 participants.

As shown in Figure 2, elevated SII levels enhance the

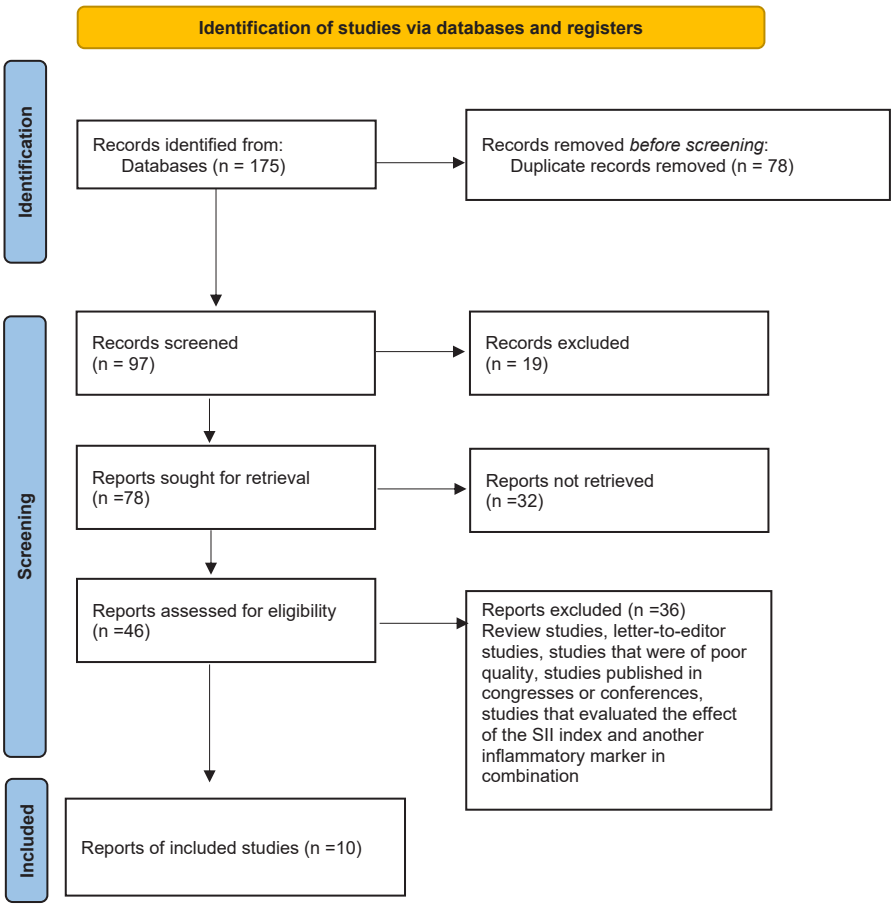

Figure 1. Flowchart of PRISMA of the study.

Table 1. Information of articles reviewed in this systematic review and meta-analysis

Author, year	Country	Type of Study	Duration of study	Sample size	Age (year)	Level of SII	Stage	The association between SII index and risk of CKD		
								OR	Low limit	Up limit
Li X, 2024 (24)	USA	Cross-sectional	between 1999 and 2020	41089	NR	493.21	Tertile 2	1.21	1.1	1.34
						784.68	Tertile 3	1.62	1.47	1.78
Liu X, 2024 (25)	USA	Cross-sectional	2007-2018	10787	NR	NR	Quartile 2	1.2	0.93	1.56
							Quartile 3	1.27	1.02	1.59
							Quartile 4	1.34	1.04	1.71
Guo L, 2024 (28)	USA	Cross-sectional	between 1999 and 2018	40388	NR	NR	Tertile 2	1.08	0.98	1.2
							Tertile 3	1.37	1.25	1.5
Li L, 2024 (29)	USA	Cross-sectional	2003-2018	40660	NR	NR	Quartile 2	0.99	0.86	1.15
							Quartile 3	1.2	1.05	1.38
							Quartile 4	1.61	1.41	1.85
Huang P, 2024 (30)	USA	Cross-sectional	1999-2018	40937	46	8.479–8.940	Quartile 2	1.08	0.96	1.22
						8.940–9.421	Quartile 3	1.1	0.99	1.23
						>9.421	Quartile 4	1.47	1.32	1.65
Liu W, 2024 (31)	China	Case-control	between Jan 2020 and Dec 2021	303	NR	NR	Total	3.24	1.179	8.905
Yan P, 2024 (32)	China	Cross-sectional	between Aug 2012 and Sep 2015	1922	NR	NR	Quartile 2	1.06	0.773	1.455
							Quartile 3	1.167	0.995	1.368
							Quartile 4	1.266	1.129	1.42
Li X, 2024-A (33)	USA	Cross-sectional	between 1999 and 2020	7153	48.91	NR	Tertile 2	1.17	0.37	3.75
							Tertile 3	1.65	0.47	5.8
Guo W, 2022 (34)	USA	Cross-sectional	between 2011 and 2018	3937	NR	≥445.21	Total	1.42	1.1	1.83
Zhao L, 2023 (35)	China	Case-control	from Jan to Dec 2021	327	NR	NR	Total	1.01	1	1.01

NR: Not reported; OR: Odds ratio; SII: systemic immune-inflammation; OR: Odds ratio; CKD: chronic kidney disease;

risk of CKD by 24% (OR: 1.24; 95% CI: 1.13, 1.37). The correlation between high SII and CKD risk is insignificant in China (OR: 1.15; 95% CI: 0.98, 1.34), whereas an upsurge in SII has enhanced the risk of CKD in the USA (OR: 1.27; 95% CI: 1.16, 1.38) (Figure 3).

When reviewing case-control articles, the correlation between high SII and CKD risk was insignificant (OR: 1.61; 95% CI: 0.53, 4.95). Contrarily, elevated SII levels have enhanced the risk of CKD in cross-sectional articles (OR: 1.25; 95% CI: 1.16, 1.35) (Figure 4). The second

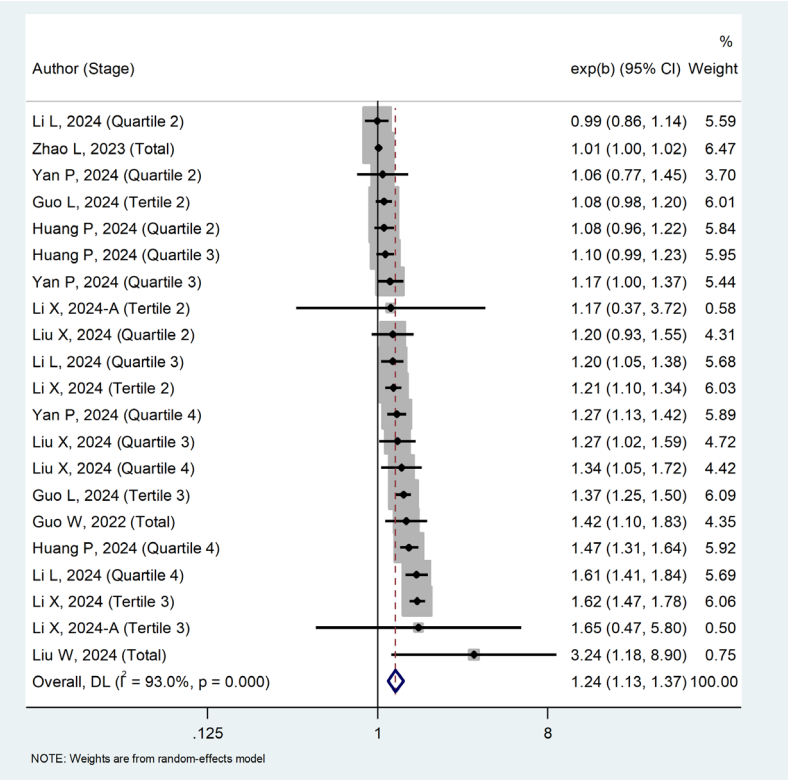

Figure 2. Forest plot showing the association between SII index and risk of CKD.

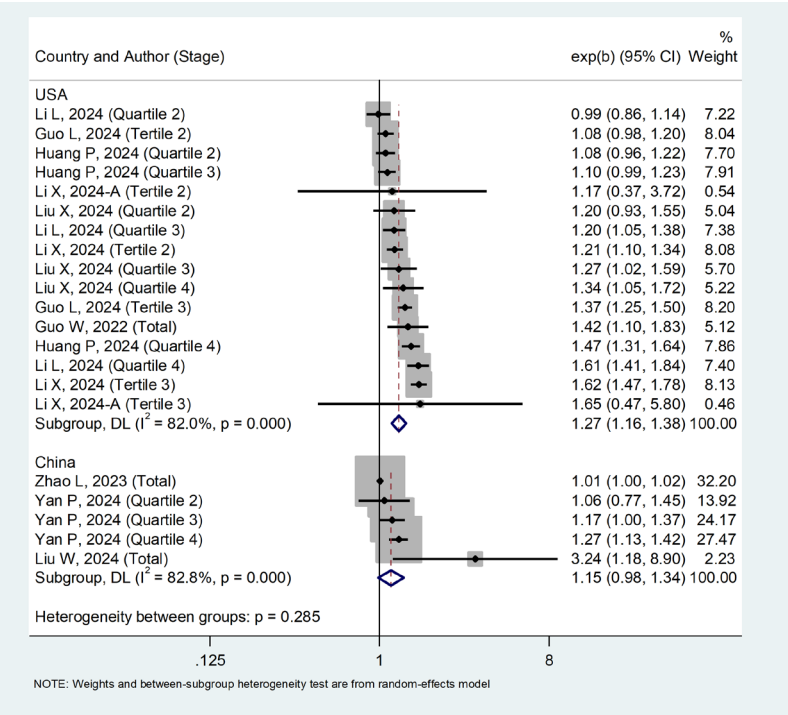

Figure 3. Forest plot showing the association between SII index and risk of CKD by country.

tertile (OR: 1.14; 95% CI: 1.05, 1.25) and third tertile (OR: 1.49; 95% CI: 1.28, 1.73) of the SII index enhanced the risk of CKD. Furthermore, the third quartile (OR: 1.16; 95% CI: 1.08, 1.24) and fourth quartile (OR: 1.42; 95% CI: 1.27, 1.59) of SII enhanced the risk of CKD. However, the correlation between CKD risk and the second quartile of SII was insignificant (OR: 1.06; 95% CI: 0.97, 1.15) (Figure 5).

The correlation between high SII and the risk of CKD was not significant in males (OR: 1.03; 95% CI: 0.99,

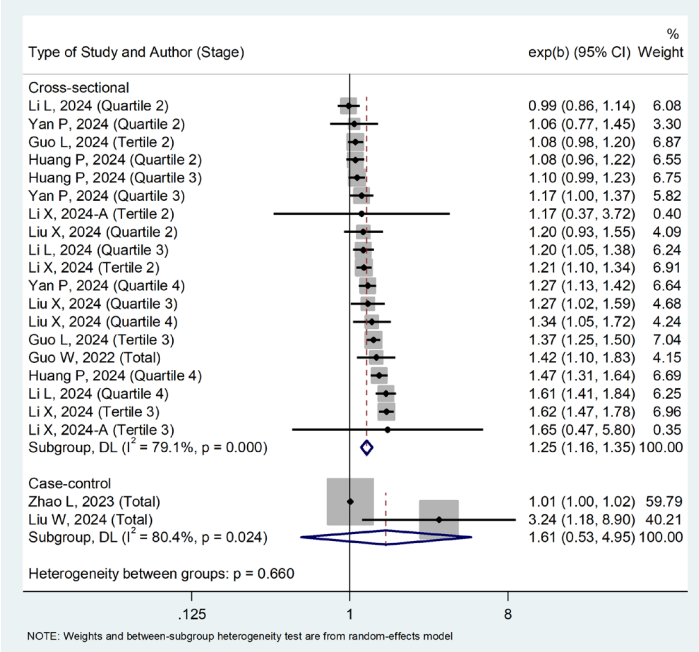

Figure 4. Forest plot showing the association between SII index and risk of CKD by design.

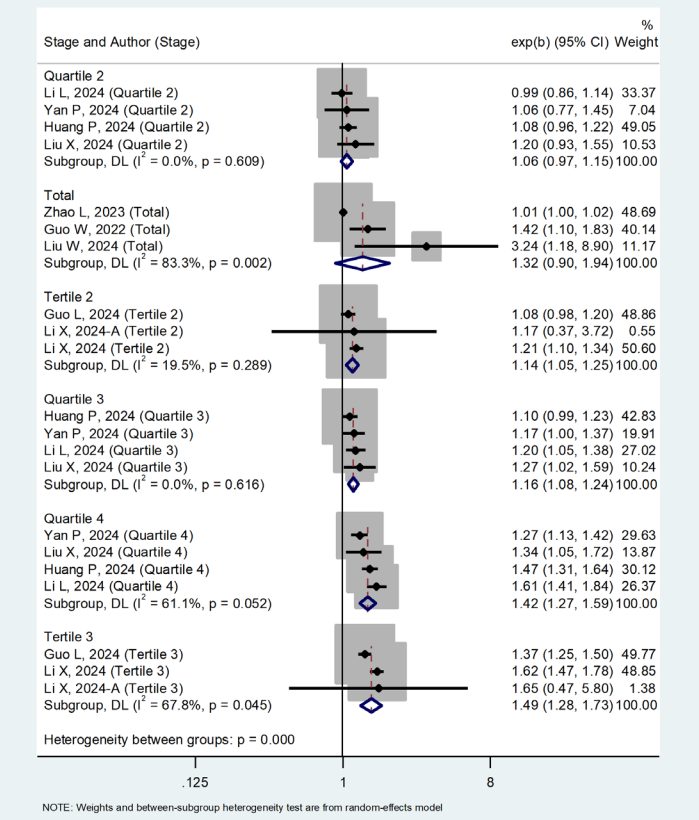

Figure 5. Forest plot showing the association between SII index and risk of CKD by stage of study.

1.07), however high SII enhanced the risk of CKD in females (OR: 1.03; 95% CI: 1, 1.07) (Figures 6 and 7).

High SIRI increased the risk of CKD (OR: 1.43; 95% CI: 1.20, 1.70). Similarly, high SII enhanced the risk of CKD in patients with DM (OR: 1.42; 95% CI: 1.21, 1.68), low eGFR (OR: 1.27; 95% CI: 1.14, 1.40), and albuminuria (OR: 1.46; 95 % CI: 1.08, 1.97), as well as in patients with BMI>30 (OR: 1.05; 95% CI: 1.01, 1.09) (Figures 8 to 12).

As with meta-regression analyses, the correlation between "high SII and CKD risk" and the publication year of articles was insignificant (*P*=0.820) (Figure 13).

Discussion

Ten observational research targeting 187,503 participants were reviewed. High SII and SIRI values enhanced the risk of CKD by 24% and 43%, respectively. Likewise, high SII enhanced the risk of CKD by 3% (in females), 5% (in obese patients), 27% (in Americans), 27% (in patients with low-eGFR), 42% (in patients with DM), and 46% (in patients with albuminuria). Besides, the second and third quartiles and the third and fourth quartiles enhanced the risk of CKD by 14%, 49%, 16%, and 42%, respectively.

A cross-sectional research by Guo et al on American

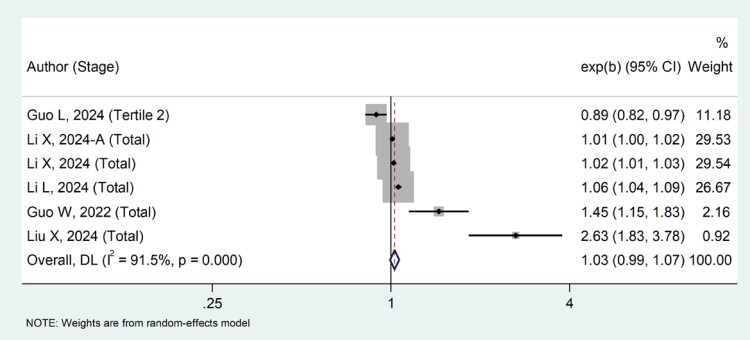

Figure 6. Forest plot showing the association between SII index and risk of CKD in males.

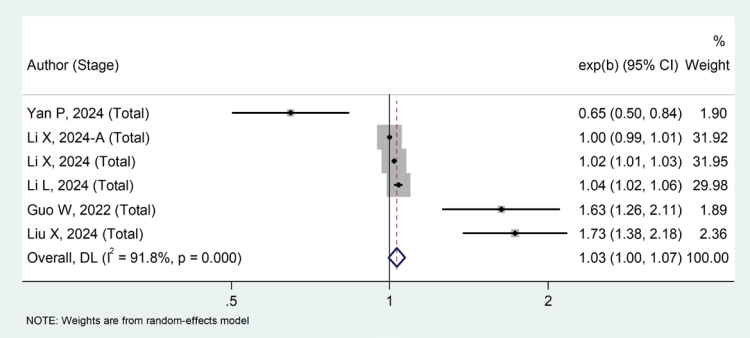

Figure 7. Forest plot showing the association between SII index and risk of CKD in females.

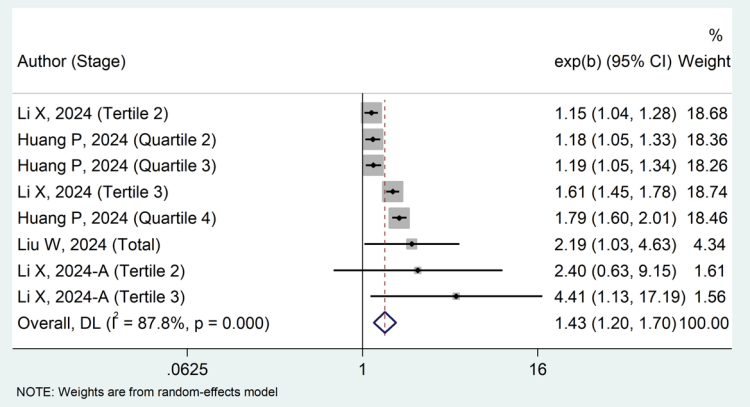

Figure 8. Forest plot showing the association between SII and risk of CKD.

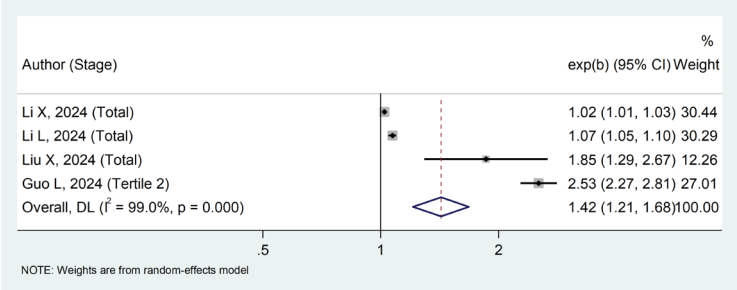

Figure 9. Forest plot showing the association between SII index and risk of CKD in diabetic patients.

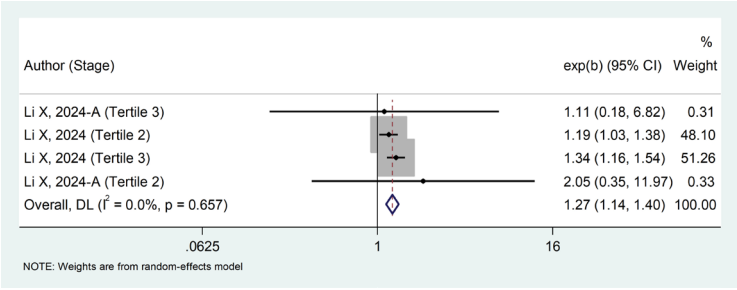

Figure 10. Forest plot showing the association between SII index and risk of CKD in patients with low-eGFR.

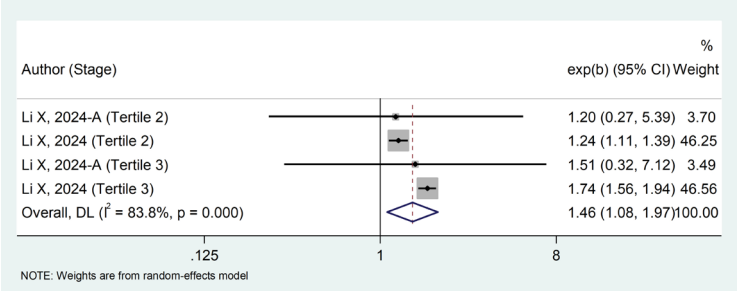

Figure 11. Forest plot showing the association between SII index and risk of CKD in patients with albuminuria.

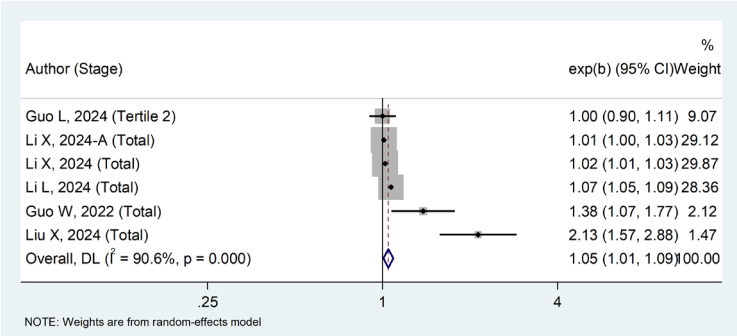

Figure 12. Forest plot showing the association between SII index and risk of CKD in patients with BMI>30 kg/m².

adults revealed that higher SII scores correlate with enhanced risk of CKD (OR: 1.37; 95% CI: 1.25, 1.50) (28). Elsewhere, Huang et al conducted cross-sectional research indicating that higher levels of SII (OR: 1.47; 95% CI: 1.32, 1.65) and SIRI (OR: 1.79; 95% CI: 1.60, 2.01) enhance the risk of CKD compared to their lower levels (30). Recently, Li et al reported that high SII enhances the risk of CKD (OR: 1.06; 95% CI: 1.04, 1.07) (29). In another cross-sectional research, Li et al reported a direct correlation between SIRI and CKD (OR: 1.24; 95% CI: 1.19, 1.30) and between SII and CKD (OR: 1.01; 95% CI: 1.01, 1.02) (24). In their cross-sectional research on patients with T2DM, Guo et al reported that high SII levels are correlated with elevated risk of DKD

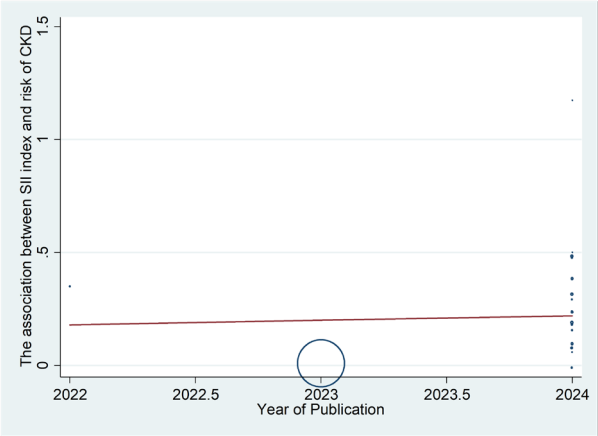

Figure 13. Meta-regression plot of the association between SII index and risk of CKD with year of publication.

(OR: 1.42; 95% CI: 1.10, 1.83) (34). Based on the results of a case-control study by Liu et al, high SIRI increased the risk of DKD (OR: 2.18; 95%CI: 1.03, 4.62) (31). In a cross-sectional study on patients with T2DM, Yan et al found that SII is correlated with DKD occurrence (OR: 2.73; 95% CI: 1.84, 4.06) (32). The above findings are in line with our results, suggesting high SII and SIRI levels as risk factors for CKD and DKD.

Liu et al reported that SII was associated with CKD incidence in US adults (OR: 1.36; 95% CI: 1.07, 1.73), particularly among males (OR: 2.62; 95% CI: 1.82, 3.77) (25). Their results agree with our results, indicating high SII levels enhance the risk of CKD. However, Liu et al reported that the risk of CKD is significantly enhanced in males, while our results implied an insignificant correlation between high SII and the risk of CKD among male participants.

Likewise, Di et al reported that high SII is associated with an enhanced risk of kidney stones in US adults (OR: 1.28; 95% CI: 1.02, 1.60) (36). In their cross-sectional research, Qin et al found that higher SII levels correlate with an enhanced risk of albuminuria (OR: 1.31; 95% CI: 1.17,1.48) (37). In another cross-sectional investigation, Nie et al found that SII correlates with an enhanced risk of DM (OR: 1.04; 95% CI: 1.02, 1.06) (38). In their cross-sectional study, Chen et al reported that patients in the highest SII quartile had a 12% enhanced risk of hypertension development compared to their lowest SII quartile (OR: 1.12; 95% CI: 1.01, 1.24) (39). The above findings are in line with our results, implying that high SII levels act as a risk factor for multiple diseases and showing that high SII can provide a good prognosis for many diseases. Accordingly, individuals with a high SII index need to be monitored for hypertension, diabetes, and renal function.

Conclusion

High SII and SIRI levels enhance the risk of CKD. In particular, females, US adults, obese individuals, and patients with DM, low-eGFR, and albuminuria need to regularly monitor their renal function, as they are more likely to develop CKD. Concerning the trivial number of articles reviewed, future research is recommended to review more observational studies to achieve more robust results.

Limitations of the study

The articles reviewed in this research were only from the USA and China. Likewise, the number of articles reviewed was a handful, and we couldn't analyze subgroups based on the age of the patients. The articles reviewed in this research were only from the USA and China. Additionally, the small number of reviewed articles restricted our ability to perform subgroup analyses based on the age of patients.

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Authors' contribution

Conceptualization: Sayed Yousef Mojtahedi and Hosein Shabani-Mirzaee.
Data curation: Maede Safari and Maryam Ghodsi.
Formal analysis: Reza Tavakolizadeh and Masoumeh Ghasempour Alamdari.
Investigation: Mohsen Jafari, Paniz Pourpashang, and Hosein Shabani-Mirzaee.
Methodology: Reza Tavakolizadeh and Niloufar Ghanbari
Project Management: Paniz Pourpashang.
Supervision: Sayed Yousef Mojtahedi.
Validation: Sayed Yousef Mojtahedi, Niloufar Ghanbari, and Maryam Ghodsi.
Visualization: Mohsen Jafari, Maede Safari, and Masoumeh Ghasempour Alamdari.
Writing-original draft: All authors.
Writing-reviewing and editing: All authors.

Conflicts of interest

There are no competing interests.

Ethical issues

This investigation has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (International Prospective Register of Systematic Reviews) with (ID: CRD42024619311) and Research Registry website with (Unique Identifying Number (UIN) reviewregistry1925) websites. Besides, the

authors have observed ethical issues (including plagiarism, data fabrication, and double publication).

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