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Research paper

The World Society of Emergency Surgery Sepsis Severity Score shows no prognostic superiority over the Mannheim Peritonitis Index in patients with complicated intra-abdominal infections

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ABSTRACT

Introduction: Although various scoring systems are already available for early prognostic evaluation of patients with complicated intra-abdominal infections (cIAIs), none has shown the ideal characteristics in everyday practice. In this study, we aimed to find the most reliable prognostic score in patients with cIAIs.

Methods: This retrospective study involved 110 patients with cIAIs admitted to the Department of Surgical Diseases at University Hospital, "Prof. Dr. Stoyan Kirkovich" Stara Zagora from January 2017 to July 2019. We compared the prognostic values of Mannheim Peritonitis Index (MPI), World Society of Emergency Surgery Sepsis Severity Score (WSES SSS), quick sequential (sepsis-related) organ failure assessment score (qSOFA), and systemic inflammatory response syndrome (SIRS) using area under receiver operating characteristics (AUROC) curves. Bivariate correlation analysis was used to evaluate the association between scoring systems and the final outcome.

Results: The observed in-hospital mortality was 22.7%. Significant correlations were found between MPI and outcome ($r = 0.500$, $p < 0.001$), WSES SSS and outcome ($r = 0.483$, $p < 0.001$), and qSOFA and outcome ($r = 0.356$, $p < 0.001$). Of all the scoring systems, MPI showed the best prognostic performance (AUROC = 0.844, 95% confidence interval (CI) = 0.763–0.924). The identified sensitivity and specificity for MPI cut-off value >25 points were 80% and 77.6%, respectively.

Conclusion: The MPI is still one of the best options for prognostic evaluation of patients with cIAIs.

Keywords: MPI, WSES SSS, qSOFA, intra-abdominal infections, outcome, mortality

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INTRODUCTION

Despite significant progress in surgical management and antimicrobial therapy, complicated intra-abdominal infections (cIAIs) still represent a challenge for surgeons and intensivists. cIAIs are defined as infections that spread beyond the affected intra-abdominal organ and result in either local or diffuse peritonitis[1]. They are responsible for approximately one-fifth of the sepsis cases in intensive care units (ICUs) and are associated with unfavorable prognosis[2].

The early prognostic assessment of cIAIs provides an opportunity to differentiate the patients at a higher risk of death and a chance to effectively change their management strategy, which in turn might affect the poor outcome. Over the years, multiple prognostic scores have been developed; unfortunately, none of them has been widely accepted in everyday practice. Many of these scoring systems, such as the acute physiology and chronic health evaluation II (APACHE II) score and the sequential organ failure assessment (SOFA) score, have been proven to be reliable, however, are complex, difficult to calculate, time consuming, require many clinical and laboratory parameters, and can rarely be used outside ICUs.

The Mannheim Peritonitis Index (MPI) is one of the oldest, simplest, and most practical score for patients with secondary peritonitis. MPI, developed by Wacha and Linder[3] in 1983, is an independent, objective, and effective score for predicting mortality and has shown superiority over other scoring systems in patients with acute peritonitis[3-5]. In 2014, the World Society of Emergency Surgery (WSES) designed a prognostic scoring system specific for cIAIs and called it the WSES Sepsis Severity Score (WSES SSS)[6]. Several studies have validated this score globally[7-9] and have found it to be precise, easy to calculate, and practical for patients with cIAIs. In 1991, the systemic inflammatory response syndrome (SIRS) was first introduced as the criteria of defining sepsis and predicting in-hospital death[10]. In 2016, a working group created the current definitions of sepsis 3 and removed the term "SIRS" from the definition of sepsis[11]. The same group introduced the quick sequential organ failure assessment (qSOFA) score as a prognostic score that could immediately determine the patients with suspected infection wo were likely to need intensive care or die in the hospital[11]. A number of studies have shown the superiority of qSOFA over SIRS criteria in predicting mortality[12,14]. However, in surgical patients, qSOFA is considered the predictor of death, however, lacking sensitivity[15,16].

The aim of our study was to find the most accurate prognostic score among MPI, WSES SSS, SIRS, and qSOFA in patients with cIAIs.

MATERIAL AND METHODS

We performed a single-center retrospective study at the University Hospital "Prof. Dr. Stoyan Kirkovich" Stara Zagora. In total, 110 adult patients admitted to the Department of Surgical Diseases (DSD) from the Emergency Department (ED) and operated upon for cIAIs between January 2017 and July 2019 were included. Non-operative methods of treatment were not suitable for inclusion in the study group. A hundred and thirty one patients with cIAIs were admitted to DSD in this time period. Missing data about some clinical and laboratory parameters were found in 18 patients, two patients died before surgery, and one was 17 years old. Finally, we retrieved the demographic, laboratory, and clinical data from the medical records of 110 patients.

A positive SIRS was defined as having ≥ 2 of the following four signs; a heart rate >90/min, a respiratory rate >20/min, a body temperature <36°C or >38°C, and a leucocyte count $<4x10^9$/L or $>12x10^9$/L[10]. The qSOFA score was calculated according to the values of systolic blood pressure ≤ 100 mmHg, respiratory rate ≥ 22/min, and a Glasgow Coma Scale <15 points (1 point for each criterion to yield a score value between 0 and 3). A positive score was identified as ≥ 2 points[11]. SIRS and qSOFA were calculated based on the patient's clinical data at admission; MPI and WSES SSS were calculated postoperatively based on eight[3] (Table 1) and six[7] (Table 2) risk factors, respectively.

The obtained data were analyzed using SPSS Statistics 19.0 (IBM, Chicago, Illinois, USA) and MedCalc 14.8.1 (MedCalc Software, Ostend, Belgium). The ability of each score to prognosticate the fatal outcome was compared using the receiver operating characteristic (ROC) curve analysis. The association between the scores and clinical outcomes was evaluated using bivariate correlation analysis and Spearman correlation coefficient. Continuous variables were presented as mean (± standard deviation [SD]) for normally distributed data or median (interquartile range [IQR]) for non-normally distributed data. Comparisons of group differences for continuous variables were performed using the Student's t test or Mann-Whitney U test. Categorical variables were expressed as frequency

Table 1. MPI (0–47 score).

Risk factor	Points
Age >50 years	5
Female	5
Organ failure	7
Malignancy	4
Preoperative duration of peritonitis >24 hours	4
Origin of sepsis non-colonic	4
Diffuse peritonitis	6
Exudate	
Clear	0
Purulent	6
Fecal	12

Table 2. WSES SSS (0 – 18 score).

Risk factor	Points
Age >70 years	2
Immunosuppression	3
Setting of acquisition	
Healthcare-associated infection	2
Clinical condition at admission	
Severe sepsis	3
Septic shock	5
Origin of cIAIs	
Colonic non-diverticular perforation peritonitis	2
Diverticular diffuse peritonitis	2
Postoperative diffuse peritonitis	2
Small bowel perforation peritonitis	3
Delay in source control	
Delayed initial intervention >24 hours	3

(%) and compared using the chi-squared or Fisher exact tests. *P* value was considered significant at <0.05.

RESULTS

General characteristics

Of the 110 patients, 25 (22.7%) had an unfavorable outcome. They had a higher average age than the survivors (74.80 ± 12.64 vs. 56.84 ± 18.89, $p < 0.001$). Mortality was significantly higher in patients with chronic renal failure ($p = 0.004$) and malignancy ($p = 0.002$). We found no significant differences between survivors and non-survivors according to sex ($p = 0.693$), presence of arterial hypertension ($p = 0.353$), and diabetes ($p = 1.000$). In contrast, type of exudate ($p = 0.007$), spread ($p = 0.016$), and source of peritonitis ($p = 0.041$) differed significantly between the two groups (Table 3).

Clinical scores

We observed a qSOFA score ≥2 points in 11 (10.0%) patients, of whom only three survived ($p < 0.001$). A positive SIRS showed no prognostic value ($p = 0.172$). Non-survivors had higher scores of MPI: 30 (26–35.5) points vs. 21 (16–25) points and WSES SSS: 7 (5–8) points vs. 3 (0–5) points than survivors. MPI > 25 points was observed in 80% of non-survivors ($p < 0.001$), and 92% of patients who died had WSES SSS > 4 points. (Table 4).

Sensitivity, Specificity and AUROCs

Among the four scores, MPI showed the best prognostic performance ((AUROC = 0.844, 95% confidence interval [CI] = 0.763–0.924)). A cut-off value >25 points permitted prediction of death with a sensitivity of 80% and specificity of 77.6%. The WSES SSS was observed to have poorer predictive ability than MPI (AUROC = 0.825, 95% CI = 0.749–0.902). The identified sensitivity and specificity for WSES SSS threshold >4 points were 92.0% and 68.2%, respectively. In contrast, qSOFA

Table 3. Patient characteristics.

Variable	Total population	Survivors ($n = 85$)	Non-survivors ($n = 25$)	p value
Sex, *n* (%) *men/women*	61(55.5)/49(45.5)	48(78.7)/37(75.5)	13(21.3)/12(24.5)	0.693
Age, years ± SD	60.92 ± 19.17	56.84 ± 18.89	74.80 ± 12.64	< 0.001
Source, n (%)				0.041
Appendix	27 (24.5)	25 (29.4)	2 (8.0)	
Hepatobiliary system	26 (23.6)	20 (23.5)	6 (24.0)	
Stomach/duodenum	24 (21.8)	18 (21.2)	6 (24.0)	
Colon/Rectum	18 (16.4)	10 (11.8)	8 (32.0)	
Small intestine	2 (18.)	1 (1.2)	1 (4.0)	
Gynecological	7 (6.4)	7 (8.2)	0 (0)	
Others	6 (5.5)	4 (4.7)	2 (8.0)	
Peritonitis, *n* (%)				0.016
Local	40 (36.4)	36 (42.4)	4 (16.0)	
Diffuse	70 (63.6)	49 (57.6)	21 (84.0)	
Exudate, *n* (%)				0.007
Serous	21 (19.1)	19 (22.4)	2 (8.0)	
Purulent	84 (76.4)	65 (76.5)	19 (76.0)	
Feculent	5 (4.5)	1 (1.2)	4 (16.0)	
Comorbidity, *n* (%)				
High blood pressure	44 (40.0)	32 (37.6)	12 (48.0)	0.353
Malignancy	16 (14.5)	7 (8.2)	9 (36.0)	0.002
Diabetes	13 (11.8)	10 (11.8)	3 (12.0)	1.000
Chronic renal failure	9 (8.2)	3 (3.5)	6 (24.0)	0.004

Table 4. Scoring systems.

Variable	Total population	Survivors ($n = 85$)	Non-survivors ($n = 25$)	p value
SIRS ≥ 2, *n* (%)	36 (32.7)	25 (29.4)	11 (44.0)	0.172
SIRS, *n* (%)				0.057
0	26 (23.6)	21 (24.7)	5 (20)	
1	49 (44.5)	39 (45.9)	10 (40)	
2	25 (22.7)	21 (24.7)	4 (16)	
3	9 (8.2)	4 (4.7)	5 (20)	
4	1 (0.9)	0 (0)	1 (4)	
qSOFA ≥ 2, *n* (%)	11 (10.0)	3 (3.5)	8 (32.0)	< 0.001
qSOFA, *n* (%)				< 0.001
0	77 (70.0)	66 (77.6)	11 (44.0)	
1	22 (20.0)	16 (18.8)	6 (24.0)	
2	6 (5.5)	3 (3.5)	3 (12.0)	
3	5 (4.5)	0 (0)	5 (20.0)	
MPI, points (IQR)	21 (18.8-30)	21 (16-25)	30 (26-35.5)	< 0.001
MPI > 25, *n* (%)	39 (35.5)	19 (22.4)	20 (80.0)	< 0.001
WSES SSS, points (IQR)	3 (0-7)	3 (0-5)	7 (5-8)	< 0.001
WSES SSS > 4, *n* (%)	50 (45.5)	27 (31.8)	23 (92.0)	< 0.001

Abbreviation: MPI, Mannheim Peritonitis Index; WSES SSS, World Society of Emergency Surgery Sepsis Severity Score; qSOFA, quick sequential (sepsis-related) organ failure assessment; SIRS, systemic inflammatory response syndrome; IQR, interquartile range.

score ≥ 2 points (AUROC = 0.698, 95% CI = 0.566–0.829), and positive SIRS (AUROC = 0.583, 95% CI = 0.447–0.720) showed poor prognostic value (Figure 1) (Table 5).

Correlations

The strongest correlation was found between MPI and outcome ($r = 0.500$); however, the Spearman's coefficient value was low ($r = 0.483$) between WSES SSS and outcome. We observed a weak correlation between qSOFA and outcome ($r = 0.356$, $p < 0.001$) and a very weak correlation with no significance between SIRS and outcome ($r = 0.128$, $p = 0.181$) (Table 6).

DISCUSSION

Complicated intra-abdominal infections represent a major healthcare challenge globally and are associated with significant morbidity, mortality, and healthcare costs. Early prognosis and timely management improve outcomes, which indicates that reliable tools are needed to identify patients at a higher risk of complications and mortality. A number of factors have already proven their association with a fatal outcome, such as comorbidity, immunosuppression, advanced age, prolonged hospital

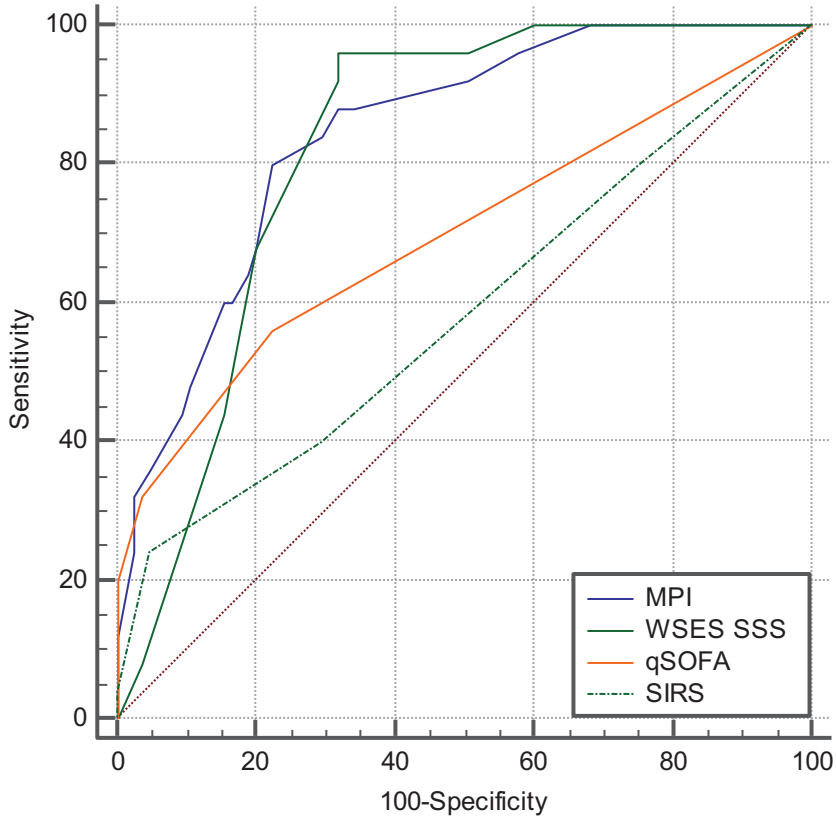

Figure 1. Comparison of ROC curves.

Table 5. Sensitivity, Specificity and AUROCs.

Variable	Sensitivity, %	Specificity, %	AUROC
SIRS ≥ 2	40.0	70.6	0.583 (0.447–0.720)
qSOFA ≥ 2	32.0	96.5	0.698 (0.566–0.829)
WSES SSS > 4	92.0	68.2	0.825 (0.749–0.902)
MPI > 25	80.0	77.6	0.844 (0.763–0.924)

Abbreviation: MPI, Mannheim Peritonitis Index; WSES SSS, World Society of Emergency Surgery Sepsis Severity Score; qSOFA, quick sequential (sepsis-related) organ failure assessment; SIRS, systemic inflammatory response syndrome; AUROC, area under receiver operating characteristics.

Table 6. Correlations.

		MPI	WSES SSS	qSOFA	SIRS
Outcome	Correlation coefficient	$r = 0.500$	$r = 0.483$	$r = 0.356$	$r = 0.128$
	Significance	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p = 0.181$

Abbreviation: MPI, Mannheim Peritonitis Index; WSES SSS, World Society of Emergency Surgery Sepsis Severity Score; qSOFA, quick sequential (sepsis-related) organ failure assessment; SIRS, systemic inflammatory response syndrome.

stay before treatment, diffuse peritonitis, organ dysfunction, septic shock, poor source control, and nosocomial infections[7]. Determining the criteria with the greatest impact on the final outcome to be included in a prognostic score is not an easy task. However, researchers are trying to solve these challenges by developing novel scoring systems or validating already existing ones.

APACHE II and SOFA scales are scoring systems used in ICUs worldwide. APACHE II could make a current assessment of the patient at any time during the disease; however, it is clearly cumbersome to be used routinely in clinical practice outside ICUs. Furthermore, several researchers revealed a few weaknesses in its prognostic performance in patients with sepsis and acute peritonitis[17-19]. The SOFA score showed reliable characteristics over the years and is now a part of the new sepsis 3 definitions[11].

This score has a better prognostic accuracy than SIRS or qSOFA in adult patients with suspected infection admitted to the ICU[20]. However, like APACHE II, SOFA is not a simple score requiring numerous clinical and laboratory parameters for its calculation and being difficult to use in everyday practice outside ICUs. As simplified version of SOFA, the sepsis-3 group introduced the qSOFA score for easier identification of patients with infection and higher risk of death in ED.

Three studies (to the best of our knowledge) investigated the prognostic performance of qSOFA in surgical patients with cIAIs exclusively. Tolonen et al.[21] investigated qSOFA $\geq$ 2 in patients with severe cIAIs and identified sensitivity of 37% and specificity of 95%. A Chinese study[15] with 453 surgical patients showed better sensitivity of 46%, but worse specificity of 86%. Raimondo et al.[16] observed the lowest sensitivity (14.3%), and the highest specificity (98.3%). All the three studies reported similar ability of qSOFA to predict the fatal outcome: Tolonen et al.[21] AUROC = 0.723, Jung et al.[15] AUROC = 0.717, and Raimondo et al.[16] AUROC = 0.722. We obtained comparable data about qSOFA $\geq$ 2 as a mortality predictor AUROC = 0.698, sensitivity and specificity of 32% and 96.5%, respectively.

We also found that qSOFA is a better predictor of death than SIRS (AUROC = 0.698 vs. AUROC = 0.583). Other studies with surgical patients showed the same; Jung et al.[15] AUROC = 0.717 vs. AUROC = 0.672 and Raimondo et al.[16] AUROC = 0.722 vs. AUROC = 0.692, respectively. Better prognostic performance of qSOFA than SIRS in patients from ED was reported by Freund et al.[12] AUROC = 0.80 vs. AUROC = 0.65 and Osatnik et al.[13] AUROC = 0.65 vs. AUROC = 0.53.

Each novel scoring system is developed to improve the prognostic assessment of certain diseases and aims to replace the already existing scores. In this regard, in 2014, the World Society of Emergency Surgery designed a new clinical score, the WSES SSS, that showed an excellent ability to prognosticate the fatal outcome and could be used everywhere[6]. The WISS study[7] in 2015 confirmed this result and demonstrated that the best cut-off point for predicting mortality was WSES SSS > 5 with a sensitivity of 89.2 % and a specificity of 83.5 %. The same threshold with a sensitivity of 85.7% and a specificity of 75.9% was reported by Raimondo et al.[16] in 65 patients with cIAIs. In our study, the identified cut-off value was WSES SSS > 4 points with a sensitivity and specificity of 92% and 68.2%, respectively. An identical threshold was reported by Sazhin et al.[22] and Godinez-Vidal et al.[9]. For cut-off value >4 points, Sazhin et al.[22] observed a sensitivity of 78.6% and a specificity of 84.7% in 153 patients with diffuse peritonitis, and Godinez-Vidal et al.[9] observed a sensitivity of 76.47% and specificity of 90.48% in 185 patients with cIAIs. A Kenyan study[8] including 173 patients with cIAIs reported a cut-off value >6 with a sensitivity of 80% and a specificity of 20.9%. The highest cut-off value of WSES SSS $\geq$ 8 with a sensitivity of 73% and a specificity of 76% was reported by Tolonen et al.[21] in 93 patients with severe cIAIs. Except Tolonen et al.[21] (AUROC = 0.809), all other studies Godinez-Vidal et al.[9] (AUROC = 0.931), Raimondo et al.[16] (AUROC = 0.887), Mwenda et al.[8] (AUROC = 0.874), and Sazhin et al.[22] (AUROC = 0.851) revealed a higher AUROC of WSES SSS than our study (AUROC = 0.825).

MPI was based on a retrospective analysis of 1,253 patients with acute peritonitis and includes eight proven risk factors that were selected according to their prognostic ability[3]. In the original study, the authors determined a threshold value of MPI = 26 points with a sensitivity of 84% and a specificity of a 79%. We identified the same threshold in our study; MPI > 25 points with similar sensitivity and specificity, 80% and 77.6%, respectively. Threshold MPI = 26 was set by Demmel et al.[23] and Billing et al.[24] too. Demmel et al.[23] found a sensitivity of 88% and a specificity of 78%, and Billing et al.[24] observed a sensitivity of 86% and a specificity of 74%. Lower threshold was reported by Godinez-Vidal et al.[9] MPI $\geq$ 18 points with a sensitivity of 82.35% and a specificity of 79.17%, Salamone et al.[25] MPI = 20 with a sensitivity of 78% and a specificity of 89%, Neri et al.[26] MPI = 21 with a sensitivity of 86% and a specificity of 59%, and Sazhin et al.[22] MPI $\geq$ 25 with a sensitivity of 85.7% and a specificity of 87.4%. Higher cut-off values were observed in the studies of Koppad et al.[27] MPI $\geq$ 29 with a sensitivity of 87.21% and a specificity of 78.57%, Tolonen et al.[21] MPI $\geq$ 30 with a sensitivity of 51% and a specificity of 79%, and Budzyński et al.[5] MPI = 32 with a sensitivity of 66.7% and a specificity of 97.9%.

Our study showed a very good ability of MPI to predict mortality (AUROC = 0.844, $p < 0.0001$). Godinez-Vidal et al.[9] reported the same prognostic ability of MPI (AUROC = 0.843). Better prognostic value of MPI was observed by Koppad et al.[27] (AUROC = 0.945), Salamone et al.[25] (AUROC = 0.89), and Sazhin et al.[22] (AUROC = 0.885); whereas Budzyński et al.[5], Tolonen et al.[21] and Neri et al.[26] reported a lower value in their studies (AUROC = 0.81, 0.774 and 0.759, respectively).

In our study, MPI was found to be a better mortality predictor than WSES SSS (AUROC = 0.844 vs AUROC = 0.825). Sazhin et al.[22] observed the same result (MPI vs. WSES SSS: AUROC = 0.885 vs.

AUROC = 0.851); however, Tolonen et al.[21] and Godinez-Vidal et al.[9] reported opposite findings (MPI vs. WSES SSS: AUROC = 0.774 vs. AUROC = 0.809 and MPI vs. WSES SSS: AUROC = 0.843 vs. AUROC = 0.931, respectively).

We found prognostic superiority of MPI not only to WSES SSS, but also to qSOFA and SIRS (AUROC = 0.844 vs. 0.825 vs. 0.698 vs. 0.583). The bivariate correlation analysis performed showed a very weak correlation between SIRS and outcome ($r = 0.128$), a weak correlation between qSOFA and outcome ($r = 0.356$), a stronger correlation between WSES SSS and outcome ($r = 0.483$), and the strongest between MPI and outcome ($r = 0.500$). No other study (to the best of our knowledge) has investigated the correlations between SIRS, qSOFA, WSES SSS, MPI, and outcome or compared the prognostic performance of these four scores in patients with cIAIs.

Our study had a few limitations, including being a single-center, retrospective study and the small sample size.

CONCLUSION

In patients with cIAI, qSOFA score and SIRS seem to be ineffective for the prediction of a fatal outcome. Although they are simple to perform and easy to calculate, these scores show a lack of prognostic accuracy. WSES SSS has proven to be reliable, practical, and with comparable performance to MPI in predicting mortality among patients with cIAIs. However, it does not show a better ability to recognize the patients at a higher risk of death. The 40-year-old MPI score is one of the best and relevant tools to prognosticate mortality in patients with cIAIs nowadays.

Conflict of Interest Statement

The authors did not report any conflicts of interest and received no financial support for the preparation of this manuscript.

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