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Assessing 21st Century Skills: Development and Validation of a Multidimensional Tool for College Students

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HIGHLIGHTS

- A standardized assessment tool for college students in the 21st century was finalised, consisting of 54 items.
- Confirmatory factor analysis indicated a seven-factor structure to assess 21st century skills.
- The tool was aimed to assess 21st century skills in college students precisely.

ARTICLE INFO

Keywords: Transversal skills, Factor analysis, Holistic development, Item analysis, Skill assessment.

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ABSTRACT

This study endeavours to develop and validate a multidimensional tool for the assessment of 21st century skills among college-going students during 2024-25 at Banaras Hindu University (BHU), Varanasi. Initially, 120 items were identified through a comprehensive literature review. Experts from the teaching and research domains reviewed these items, and their feedback was incorporated to refine the tool, resulting in 56 items. The refined tool was administered to 350 respondents. The construct validity was established through exploratory factor analysis (EFA) and subsequently confirmed through confirmatory factor analysis (CFA) to ascertain the adequacy of the model fit. EFA revealed that the seven-factor structure accounted for a substantial proportion of the total variance. The CFA of the 54-item 21st-century skills assessment tool identified seven factors with good internal consistency. CFA indicated that items were loaded on the relevant factors and evidenced satisfactory model fit indices. The reliability of the tool was established by the Cronbach's alpha coefficient, which yielded a value of 0.81. Thus, the tool was indicated to be relevant for college students and served as a valuable metric to assess college students' 21st century skills.

INTRODUCTION

The 21st century has such dynamic demands that require a sound combination of skills to enable students excel in their academic, career and personal life. The importance of leadership skills, communicative skills, decision-making, and the role of financial literacy cannot be underestimated because they make it possible to cope with the complexities. With the ethos of the 21st century education, students need the four key competencies of critical thinking, creativity, communication, and collaboration (Erdogan, 2019), and they are essential to success. These skills include other advanced skills and learning methods vital in surviving in the information age (Karadas et al., 2021). Graduates should have skills of the 21st century to handle complex information and keep up with the changing professional requirements (van Laar et al., 2017, Tight, 2022; Kaya et al., 2023). Based on this, educators should integrate such skills in their instruction methods. It is worth noting that critical thinking is existentially required in order to promote high-order intellectual pursuits, enhance cognition, and enable students to audit their own position and solve problems in a competent manner (Tuzlukova et al., 2018). A standardised tool should be created to measure the acquisition of these foundational skills by students in order to execute this. The measurement of

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21st century competencies can provide insight into the development of the skills in students and, hence, inform the course design as well as the ability to incorporate these skills in the curriculum (Koretz, 2017). However, these competencies are difficult to measure, especially in the case of monitoring the student progress throughout the duration (Holec & Marynowski, 2020). The need to have accurate and reliable assessment tools has been generated owing to the insistence on inculcating skills in the curricula. In order to translate abstract ideas into measurable skills, creativity, critical thinking, and cooperation need to be assessed in reference to certain conceptual frameworks. Factor analysis has become one of the common tools used in educational research to ensure validity and reliability (Kumar et al., 2015; Kline, 2023). To measure the 21st century skills, recent studies have proposed a diverse array of instruments indicating that the different scales might be needed in different disciplines and cohorts of students (Cevik, 2019; Huang, 2023). Even despite the spread of theoretical frameworks that claim to describe these competencies, it has proven difficult to agree on the specific list of skills that they entail (van Laar et al., 2017; Tight, 2021; Saleem et al., 2024). Partnership for 21st century skills provides an extensive framework in which the essential skills are listed that cannot be ignored in order to be successful in the modern age. The competencies in this framework will be divided into three main areas, namely; learning and innovation skills, information, media, and technology skills, and life and career skills (Kennedy & Sundberg, 2020). The research study aimed at developing and validating a tool to assess 21st century skills for college students, relying on the Partnership for 21st century skills framework.

METHODOLOGY

The development of the standardized tool in this study adhered to the widely accepted Likert summated rating scale methodology. The tool was constructed meticulously and stepwise, as recommended in the procedures by Likert (1932). A set of 120 statements was initially collected and narrowed down using the 14-point criteria described by Edward (1959). Experts were consulted to assess the relevance of every item that was retained (Junger et al., 2017; Shitu et al., 2018; Gupta et al., 2022; Kademani et al., 2025). The relevance assessment was conducted by 35 experts in the fields of education, psychology, and extension education. The suitability of each item was measured with the help of two indicators, Mean Relevance Score (MRS) and Relevancy Percentage (RP). The selection followed the criteria that an item has a mean relevancy score higher than the overall mean score (≥ 2.00) and a relevancy percentage greater than 80%.

$$\text{Mean Relevancy Score (MRS)} = \frac{(\text{MRR } 3) + (\text{RR } 2) + (\text{LRR} \times 1)}{\text{Number of judges}}$$

(MRR= most relevant response, RR= relevant response, LRR= least relevant response)

$$\text{Relevancy Percentage (RP)} = \frac{\text{FS}}{\text{Number of respondents}} \times 100$$

(FSS= frequency of MRR and RR score)

The Exploratory Factor Analysis (EFA) was used to determine construct validity of the instrument (Watkins, 2018). The analyses were conducted on responses from 350 undergraduate students across multiple academic streams at Banaras Hindu University, selected through purposive sampling. The degree of sampling adequacy was measured using the Kaiser-Meyer-Olkin (KMO) measure and the test of sphericity of Bartlett. The EFA was used to explain the underlying factor construct of the tool (Winters, 2016). Items with primary factor loadings of 0.40 or higher and cross-loadings below 0.30 were retained, whereas items with factor loadings below 0.40 or cross-loadings of 0.30 or higher were eliminated (Howard, 2016). Confirmatory Factor Analysis (CFA) was conducted to validate the factor structure using R (version 4.5.0). Model fit was assessed using multiple indices, Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) with thresholds ≥0.90, Root Mean Square Error of Approximation (RMSEA) with 90% confidence interval, and Standardised Root Mean Square Residual (SRMR≤0.08). Convergent validity was examined using Average Variance Extracted and composite reliability (CR ≥0.70). Discriminant validity was evaluated via the Fornell-Larcker criterion, comparing the square root of each construct's AVE with inter-construct correlations. Cronbach's alpha was computed for each dimension. An internal consistency value exceeding 0.8 was deemed satisfactory.

RESULTS

Established approaches, such as relevancy testing, item analysis, reliability assessment, and validity checking, were followed in the development of 21st century skills assessment tool intended for assessing college students' 21st century skills.

Relevancy and item analysis

The mean relevancy score and relevancy percentage were calculated by analyzing the responses from 35 subject experts as presented in Table 1. As part of the item analysis, final statements (comprising 40 positive and 14 negative statements) that confirmed the predefined criteria, mean relevancy scores exceeding 2.0, and a relevancy percentage greater than 80% were retained. Additionally, to enhance the precision and coherence of the tool, redundant and duplicate statements were systematically reviewed and refined based on expert recommendations.

Exploratory factor analysis

EFA was conducted on data from 350 respondents using the full item pool of 56 items. The initial step involved assessing data suitability with the Kaiser-Meyer-Olkin (KMO) (Ledesma et al., 2021). The KMO test evaluates sampling adequacy for each variable, where a higher KMO value (>0.6) indicates greater variance among variables, confirming data appropriateness for factor analysis. The Bartlett's test of sphericity was significant (χ^2= 4958.56, df = 1953, p .000), implying that the intercorrelation matrix contained adequate common variance. The correlation matrix, anti-image correlation matrix and measures of sampling adequacy were analysed to ensure that the application of the factor analysis to the data set was appropriate. A total number of two items indicated a consistently low correlation and were excluded from

Table 1. Mean relevancy score and relevancy percentage of selected items

S.No.	Items	MRS	RP
	Communication		
1.	I always pronounce words confidently.	2.37	85.71
2.	I find it challenging to easily connect with others.	2.43	88.57
3.	I can use nonverbal gestures to convey my messages effectively.	2.43	94.29
4.	I am hesitant to express my opinions in a group.	2.49	88.57
5.	I am able to observe people's body language.	2.17	77.14
6.	I am able to understand other viewpoints.	2.29	91.43
7.	I usually pay attention when others are speaking.	2.11	82.86
8.	My words are often misunderstood by people.	2.20	88.57
9.	I regularly share and receive constructive feedback.	2.46	97.14
10.	I often hesitate to ask for clarification when I don't understand something in conversation.	2.31	94.29
	Creative Thinking		
11.	I prioritise continuously learning and expanding my knowledge and skills.	2.46	97.14
12.	I try new things and step out of my comfort zone to learn and grow.	2.31	94.29
13.	I find it hard to challenge my existing beliefs and assumptions	2.63	98.15
14.	I seek opportunities to unlearn outdated assumptions and relearn new knowledge to stay relevant and up to date.	2.31	85.71
15.	I am able to seek out different perspectives and consider alternative viewpoints.	2.54	97.00
16.	I am able to explore creative solutions and think outside the box.	2.31	88.57
17.	I can identify multiple ways to solve a problem.	2.40	91.43
18.	I find it hard to think of creative and useful solutions for problems.	2.46	91.43
	Critical thinking		
19.	I can accept criticism gracefully and use it to improve my skills and knowledge.	2.34	94.29
20.	I find it difficult to generate innovative ideas and approaches to challenges.	2.54	94.29
21.	I have the ability to identify and avoid logical fallacies in arguments or discussions.	2.17	90.91
22.	I enjoy solving difficult problems and finding solutions.	2.40	97.14
23.	When I encounter a problem, I am unable to think about anything else.	2.31	88.57
24.	I visit websites with a clear purpose and within preset time limits	2.23	91.43
25.	I reflect on situations and learn from them.	2.66	97.14
	Digital Literacy		
26.	I am confident in using various digital devices, such as computers, smartphones, and tablets.	2.63	98.01
27.	I can manage and organize digital files and documents in a systematic manner.	2.31	85.71
28.	I generally solve common digital issues.	2.34	94.29
29.	I create and share content online using digital tools, including editing images, recording sounds, and producing videos.	2.54	94.29
30.	I often make use of software like Photoshop, SPSS, or Microsoft Word.	2.17	90.91
31.	I am familiar with controlling apps' access to my personal information.	2.09	85.71
	Financial Literacy		
32.	I can manage my personal finances effectively.	2.31	88.57
33.	I am capable of making decisions about borrowing money and managing debt.	2.31	88.57
34.	I can interpret financial statements, such as income statements and balance sheets.	2.40	91.43
35.	I regularly check my bank statements and transactions.	2.46	91.43
36.	I find it hard to create and follow a realistic and effective budget.	2.23	91.43
37.	I am unable to distinguish between needs and wants in financial decision-making.	2.11	82.86
38.	I always look for financial education and resources to improve my financial literacy.	2.20	88.57
	Information & Media Literacy		
39.	I use social media platforms responsibly and ethically.	2.57	97.14
40.	I am able to quickly get rid of outdated or incorrect information and adopt new and accurate knowledge.	2.57	97.14
41.	I find it difficult to determine how useful the information is for my purpose.	2.31	88.57
42.	I often search for information online using search engines and databases.	2.40	91.43
43.	I prioritize gathering information to make better decisions.	2.46	91.43
44.	I am able to identify and discard irrelevant or outdated information.	2.23	91.43
	Leadership		
45.	I can positively influence a group of individuals.	2.43	88.57
46.	I do consider the individual opinions of group members.	2.37	88.57
47.	I generally express appreciation for the achievements of others.	2.54	94.29
48.	In my studies, I enjoy helping others with their questions and concerns.	2.46	94.29
49.	I can manage conflicts and disagreements within the team fairly and constructively.	2.43	94.29
50.	I find it hard to build relationships with others to reach a mutual goal.	2.49	94.29
51.	I can reflect on situations and learn from them.	2.66	97.14
52.	I am not able to make decisions quickly under pressure.	2.31	80.00
53.	I cannot convince others of my opinions.	2.23	88.57
54.	I can collaborate with others to share and manage information collectively.	2.54	97.00

Table 2. Factor loadings for the EFA with varimax pattern matrix

S.No.	Matrix	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Communality
	Communication								
1.	COMM 1		.815						.669
2.	COMM 2		.795						.662
3.	COMM 3		.857						.691
4.	COMM 4		.828						.657
5.	COMM 5		.833						.661
6.	COMM 6		.811						.694
7.	COMM 7		.809						.703
8.	COMM 8		.798						.659
9.	COMM 9		.847						.646
10.	COMM 10		.779						.675
	Creativity								
11.	CreatT 1			.811					.672
12.	CreatT 2			.814					.677
13.	CreatT 3			.825					.680
14.	CreatT 4			.841					.721
15.	CreatT 5			.833					.695
16.	CreatT 6			.806					.669
17.	CreatT 7			.805					.667
18.	CreatT 8			.814					.653
	Critical Thinking								
19.	CritT 1					.833			.698
20.	CritT 2					.810			.675
21.	CritT 3					.830			.685
22.	CritT 4					.842			.711
23.	CritT 5					.833			.690
24.	CritT 6					.834			.682
25.	CritT 7					.779			.222
	Digital Literacy								
26.	DL 1							.797	.631
27.	DL 2							.812	.635
28.	DL 3							.817	.654
29.	DL 4							.834	.665
30.	DL 5							.830	.667
31.	DL 6							**.77**4	.692
	Financial Literacy								
32.	FL 1				.811				.665
33.	FL 2				.808				.657
34.	FL 3				.841				.702
35.	FL 4				.829				.703
36.	FL 5				.849				.713
37.	FL 6				.822				.670
38.	FL 7				.803				.642
	Information and Media Literacy								
39.	IML 1						.817		.655
40.	IML 2						.814		.673
41.	IML 3						.825		.679
42.	IML 4						.808		.637
43.	IML 5						.809		.655
44.	IML 6						.815		.647
	Leadership								
45.	LEAD 1	.815							.695
46.	LEAD 2	.795							.670
47.	LEAD 3	.857							.752
48.	LEAD 4	.828							.704
49.	LEAD 5	.833							.702
50.	LEAD 6	.811							.683
51.	LEAD 7	.809							.660
52.	LEAD 8	.798							.663
53.	LEAD 9	.847							.738
54.	LEAD 10	.779							.672

further analysis. Factors were extracted with Principal Component Analysis (PCA) and 54 items converged into seven factors with >65% of total variance. Parallel analysis was used to determine number of factors to retain compared to use of eigenvalues and scree plots. Table 2 outlines the findings, indicating a seven-factor structural solution consisting of 54 items as follows: communication (10 items, loadings 0.63-0.8); creativity (7 items, loadings 0.63-0.8); critical thinking; (6 items, loadings 0.63-0.8); digital literacy (6 items, loadings 0.63-0.8); financial literacy; (7 items, loadings 0.63-0.8); information and media literacy (6 items, loadings 0.63-0.8); leadership (10 items, loadings 0.63-0.8).

Confirmatory factor analysis

CFA confirmed the factor structure using a dataset of 350 respondents. 21st century skills assessment questionnaire demonstrated a good overall fit. The results demonstrated that the hypothesized model provided a satisfactory representation of the data as illustrated in Figure 1. The chi-square statistic was statistically significant (χ^2 = 1507.37, p = .002). The Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) were well above the recommended threshold of .95, indicating satisfactory model fit. Similarly, the Root Mean Square Error of Approximation

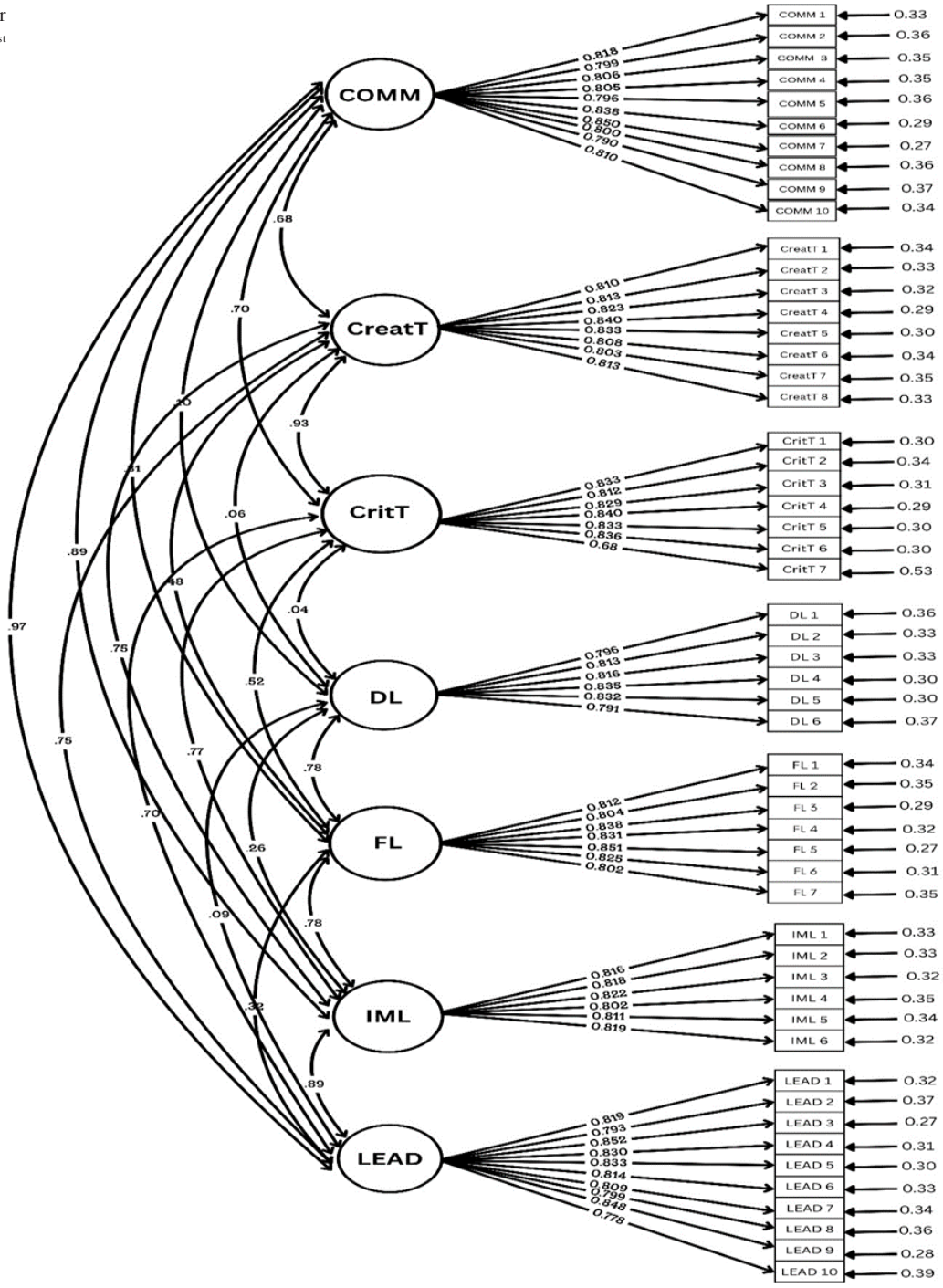

Figure 1. Confirmatory factor analysis path diagram for 21st century skills assessment tool

(RMSEA = .017; 90% CI (.011, .022) was within the range indicative of close fit (< .05), and the Standardized Root Mean Square Residual (SRMR = .036) was below the cut-off value of .08, confirming the adequacy of the model. These indices surpass conventional benchmarks (CFI/TLI≥0.90; RMSEA≤0.08; SRMR≤0.08), indicating that the proposed seven-factor structure closely reproduces the observed covariance matrix and is suitable to retain for subsequent reliability and validity analyses.

Realiability analysis

The internal consistency of the instrument was evaluated using Cronbach's Alpha. As Cronbach's alpha serves as a measure of reliability, reflecting how well the particulars inclusively assess the same underpinning dimension (Revelle & Condon, 2019). The reliability analysis was conducted for both the entire tool and its 7 dimensions separately. The Cronbach's Alpha values for each dimension ranged from 0.80 to 0.82, indicating acceptable to good internal consistency. The overall reliability for the complete scale was 0.81, confirming the robustness of the instrument for assessing the targeted constructs.

DISCUSSION

In the modern context, cognitive and emotional abilities to a great extent are associated with the ability to make evidence-based decisions and adequately adjust to the complex and dynamic environment (Adeoye et al., 2024). These seven factors, communication, critical thinking, creativity, digital literacy, financial literacy, information and media literacy and leadership, all act as a tool of assessment that gives a chance to understand how well learners can adapt, think creatively and make a difference in a variety of environments. Communication is the core of the knowledge sharing, relationship building, and effective collaboration. It includes the ability to deliver clear ideas, to be an active listener, and to tune the messages to a variety of people (Pepe et al., 2025). As a student, communication allows to collaborate, engage in academic dialogues, and argue over relevant causes and critical thinking refers to the capacity to use logic, evidence and reasoning to make decisions and resolve issues. It is an art of questioning assumptions, taking into account several positions, and making sensible conclusions (Yagci, 2019). Critical thinking equips students with clear mindedness in order to deal with work-related issues professionally. Creativity is the ability to be innovative, and find new solutions to problems. Development and implementation of novel approaches indicate an overlap of the creativity and critical thinking (Korkmaz et al., 2017). Digital literacy is defined as the competent and responsible utilization of digital tools, devices and technology. It is about the technical expertise to include ethical internet use and data safety (Falloon, 2020). The digital literacy of navigation, evaluation, and utilization of digital resources is essential becoming not only to educational success but also to lifelong learning (Saxena, et al., 2018; Chandra, et al., 2024). With potent digital skills, young people are better able to maintain balanced screen use and navigate digital spaces responsibly (Gupta & Vatta, 2025). Financial literacy is the ability of people to obtain, analyze, and interpret financial data and make wise economic choices as well as manage resources effectively (Goyal & Kumar, 2021). Information and media literacy have changed their definitions with the changing media technologies. Media literacy, in its simplest sense, relates to media message access, analysis, critique, and production (Yamaguchi et al., 2023). This opinion is supported by the conceptual model developed by Potter (2022), which pays attention to the interconnection with information literacy and emphasizes the manner in which people process and create information in the digital and media space. Its dimensions are information seeking, source evaluation, and ethical media use. This ability is crucial to the academic education of students, their digital citizenship, and decision-making. Media literacy protects against misinformation and makes people responsible citizens in a world full of information (Jones-Jang et al., 2021; Chen et al., 2025). The process of leadership can be characterized as the capacity to see the path ahead, make rational choices, and leveraging interpersonal power to influence and motivate other people to achieve common goals (Northouse, 2021). Its dimension includes mindfulness, strategic vision, and resilience (Durnali, 2022). Within the student milieu, leadership provides an opportunity to do business together, motivate others, and attain group outcomes (Stewart, 2017; Smith et al., 2022).

CONCLUSION

In the contemporary, rapidly evolving educational and professional environment, the acquisition of potent 21st century competencies needs to be an essential element. Furthermore, learners' attitudes and desire to participate in pertinent educational initiatives are increasingly essential for producing significant outcomes. The assessment tool may result in very specific foundational assessments that serve as the basis for data-driven decisions pertaining to skills enhancement programs and policy formulation. The tool offers explicit insights into strengths and areas for enhancement, thereby enhancing the evidential basis for decision-making and establishing a strategic framework for the curriculum and regulations that can facilitate students' continued success and intellectual growth.

DECLARATION

Ethical approval and consent to participate: Informed consent was sought from the respondents.

Availability of supporting data: Supporting data are available upon request.

Competing interests: No competing interests were declared.

Conflict of interest: No conflicts of interest among the authors.

The authors declare that during the preparation of this work, thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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