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Nurse Knowledge and Attitude Scale on Blood and Blood Product Transfusion Safety

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ABSTRACT:
Purpose: Blood transfusion is a critical clinical intervention for replacing deficient blood or blood components in patients with acute or chronic conditions. Ensuring transfusion safety is essential to minimize complications and optimize patient outcomes. This study aimed to develop a psychometrically validated scale to evaluate nurses' knowledge and attitudes regarding the safety of blood and blood product transfusions.
Material and Methods: This methodological study was conducted with 684 nurses, of whom 374 comprised the EFA sample and 310 comprised the CFA sample. The scale's validity and reliability were assessed using Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), item analysis, Cronbach's alpha coefficient, and test-retest reliability evaluation.
Results: EFA, performed with 374 participants, identified a four-factor structure explaining 65.88% of the total variance. The Kaiser–Meyer–Olkin (KMO) value was 0.836, indicating sampling adequacy. CFA with 310 participants confirmed this four-factor model. The 15-item model demonstrated good fit indices: $\chi^2/df = 1.453$ (<3), GFI = 0.953 (>0.90), IFI = 0.977 (>0.95), TLI = 0.970 (>0.95), CFI = 0.976 (>0.97), and RMSEA = 0.038 (<0.05). All standardized factor loadings exceeded 0.50, supporting construct validity. Internal consistency was acceptable, with a Cronbach's alpha of 0.786.
Conclusion: "The Blood and Blood Products Transfusion Safety Knowledge and Attitude Scale," with its strong psychometric properties, is a reliable assessment tool for both research and clinical practice, and can be effectively used in nursing education and quality improvement initiatives.
Keywords: *Blood transfusion; nursing; transfusion practices; patient safety; psychometrics*

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INTRODUCTION

Blood transfusion is a critical, life-saving clinical intervention aimed at restoring lost blood volume or blood components in patients with acute or chronic medical conditions. Each year, millions of individuals worldwide undergo this procedure, which is widely recognized as safe and effective (Sadani et al., 2006; Mohd Noor et al., 2021). The blood transfusion process is a complex, critical procedure encompassing multiple stages, including donor blood collection, relevant laboratory testing, proper storage and preservation, delivery to clinical units, monitoring for adverse reactions post-transfusion, and accurate completion of transfusion follow-up documentation. This process is essential for ensuring patient safety. Errors may occur at any stage due to operational activities across different hospital departments or as a result of human factors inherent to the procedure (Karabela et al., 2019). Consequently, although blood transfusion is a therapeutic and life-saving intervention, it inherently carries certain risks (Kalyoncuo & Ceyhan, 2022). Preventable errors related to the transfusion of blood and blood products can lead to significant

morbidity and mortality. Studies have reported that approximately 87% of preventable hazards associated with blood transfusion are attributable to human error (Bolton-Maggs, 2017; Mohd Noor et al., 2021). Given the inherent risks associated with transfusion, it is crucial to rigorously evaluate nurses' knowledge and attitudes regarding blood and blood product transfusions. An attitude is a learned predisposition that shapes what an individual thinks, feels, and is inclined to do in response to a given stimulus (Altmann, 2008). Knowledge in nursing is a dynamic and subjective learning process that integrates an individual's personal experience with objective facts, acquired through awareness and reflection (Bonis, 2009). In the context of blood transfusion safety, nurses' knowledge and attitudes are critical for ensuring correct practices and enhancing patient safety; adequate knowledge supports accurate decision-making and practice, while a positive attitude strengthens nurses' commitment to safe transfusion procedures. Such assessments are essential for guiding and implementing improvements in clinical practice, thereby ensuring the safe and reliable administration of transfusions (Mohd Noor et al., 2021). Both national (Gün et al., 2019) and international (Hijji et al., 2012; Hijji et al., 2013; Mohd Noor et al., 2021) studies have attempted to assess nurses' knowledge and attitudes toward the safe administration of blood and blood products. However, it has been noted that all of these studies, conducted both globally and within our country, relied on researcher-developed questionnaires, underscoring the lack of validated and reliable measurement instruments in this domain. Studies indicate that in-service training programs on the safe administration of blood and blood products should be systematically planned and conducted at regular intervals (Göray & Peker, 2022; Gün et al., 2019; Günüşen et al., 2018; Hijji et al., 2012; Hijji et al., 2013; Kavaklıoğlu et al., 2017; Mohd Noor et al., 2021). The use of valid and reliable objective measurement tools to assess nurses' knowledge and attitudes toward blood transfusion safety is essential for identifying educational needs and gaps. Such evaluations inform the development of targeted in-service training aimed at addressing deficiencies in knowledge and clinical practice. This study represents the first psychometrically validated scale developed to assess transfusion safety among Turkish nurses. Within this context, the present study aims to develop a measurement tool to assess nurses' knowledge and attitudes regarding blood and blood product transfusion safety, evaluate the scale's validity and reliability, and determine the knowledge and attitudes of participating nurses toward safe transfusion practices. It is anticipated that the developed scale will enhance nurses' awareness of safe transfusion procedures, guide the planning and implementation of in-service training programs, and serve as a reliable quantitative instrument for future research in this area. The research questions addressed in this study are as follows:

1. Does the "Nurse Knowledge and Attitudes Scale on Blood and Blood Product Transfusion Safety" constitute a valid and reliable measurement instrument?
2. What are the levels of nurses' knowledge and attitudes regarding blood and blood product transfusion safety?

MATERIAL and METHODS

Purpose and Type of the Study

The study was designed as a methodological research.

Sampling and participant

According to the literature, when the number of variables is relatively small and the factors are strong and well-defined, a sample size of 100 to 200 is considered sufficient for Exploratory Factor Analysis (EFA) (Büyüköztürk, 2015). Additionally, it is recommended that the sample size be at least five times the number of items or observed variables for the application of factor analysis techniques (Child, 2006).

In this study, the initial item pool comprised sixty-two (62) items. Accordingly, the minimum sample size for EFA was determined to be 310 participants, and a total of 374 participants were ultimately recruited. Although there is no unanimous consensus in the literature regarding the required sample size for Confirmatory Factor Analysis (CFA),

Kline (2011) recommends a minimum sample size of 200. Consequently, the sample size for CFA was set above this threshold, resulting in a total of 310 participants. The study population consisted of 724 nurses employed at a university hospital and 186 nurses working at a state hospital. Data were collected through face-to-face interviews using a structured survey form between May and December 2023. The final sample comprised 684 nurses who voluntarily participated and completed the survey in full.

Data Collection Tools

Development of the Item Pool

The "Nurse Knowledge and Attitudes Scale on Blood and Blood Product Transfusion Safety" was developed by the researchers through an extensive literature review (Gün et al., 2019; Hijji et al., 2012; Hijji et al., 2013; Ministry of Health, Republic of Turkey, 2016; Ministry of Health, Republic of Turkey, 2020; Mohd Noor et al., 2021) to generate the initial item pool. This pool was subsequently evaluated by a panel of experts for content validity. Twelve experts were consulted, including three hematology specialists, two faculty members from the Nursing Fundamentals Department, one instructor from the Midwifery Department, five clinical nurses, and one clinical midwife. The item pool evaluation form, prepared by the researchers, was distributed to the experts via email. Each expert was asked to categorize each item as "Appropriate," "Should be removed," or "Should be revised," and to provide suggestions for items requiring modification. The researchers collectively reviewed the expert feedback in a dedicated session, incorporating the necessary revisions. The finalized version of the scale was then established. To ensure clarity and adherence to linguistic norms, a draft version of the scale was also submitted to a language expert for further evaluation and feedback.

Scale Structure and Scoring

The draft scale, finalized based on the literature review and expert feedback, comprises 62 items. It is designed to assess nurses' knowledge and attitudes toward blood and blood product transfusion safety using a seven-point Likert-type scale. The response options are scored as follows: "7 = Strongly Agree, 6 = Agree, 5 = Partially Agree, 4 = Undecided, 3 = Partially Disagree, 2 = Disagree, and 1 = Strongly Disagree." Scores approaching seven indicate a high level of agreement with the statement, whereas scores near one indicate low agreement. Items reflecting negative attitudes toward the subject are reverse-scored during the evaluation process. Following the completion of language and content validity assessments, a pilot study was conducted with 10 nurses representative of the target population to evaluate the scale's clarity and comprehensibility. Subsequent analyses were then initiated based on the results of this pilot study.

Statistical Analysis

In this study, the following procedures were undertaken to perform reliability and validity analyses, which are essential components of scale development research (Kartal & Bardakçı, 2018; Tavşancıl, 2018):

- EFA and CFA to assess construct validity,
- Item analysis,
- Calculation of Cronbach's Alpha coefficient to evaluate internal consistency and reliability,
- Test-retest reliability assessment to determine the scale's stability over time.

For EFA, principal components analysis was employed to extract factors, and the Varimax rotation method was applied. The Kaiser criterion was used to determine the number of factors to be included in the scale; specifically, factors with eigenvalues greater than 1 were retained (Büyüköztürk, 2015). IBM SPSS 25.0 software was used for EFA, and IBM AMOS 25.0 software was used for CFA. The data obtained from the participants were coded in IBM SPSS 25.0, and it was confirmed that there were no missing data or outliers.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Sivas Cumhuriyet University Non-Interventional Clinical Research Ethics Committee (Approval No: 2023-05/06, Date: 17.05.2023). Informed consent was obtained from all participants.

RESULTS

Factor Structure and Construct Validity of the Scale

To determine the factor structure of the developed scale, EFA was conducted using data from a sample of 374 participants. The Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett's test of sphericity were employed to assess the suitability of the data for factor analysis. The KMO statistic was 0.836, indicating that the sample size was more than adequate for factor analysis (Tavşancıl, 2018). Additionally, Bartlett's test was statistically significant ($p < 0.001$), confirming that the sphericity assumption was met and the data were suitable for factor analysis. The factor structure identified through EFA is presented in Table 1. The naming of the extracted subscales was guided by existing literature and expert evaluations.

As shown in Table 1, EFA revealed that the "Nurse Knowledge and Attitude Scale on Blood and Blood Product Transfusion Safety" comprises four subscales with eigenvalues greater than one. The variance contributions of the subscales were 35.045% for Factor 1, 12.384% for Factor 2, 11.623% for Factor 3, and 6.827% for Factor 4, respectively, resulting in a cumulative variance explained of 65.879% (Table 1).

The scale, consisting of four subscales and 15 items as identified through EFA, was then subjected to CFA to validate its factor structure, using data from a separate sample of 310 participants. The CFA results, presented in Table 2, indicated the following model fit indices: $\chi^2/df = 1.453$ (<3); GFI = 0.953 (>0.90); IFI = 0.977 (>0.95); TLI = 0.970 (>0.95); CFI = 0.976 (>0.97); and RMSEA = 0.038 (<0.05). The path diagram showing the standardized factor loadings for the one-factor structure derived from CFA is presented in Figure 1. Standardized factor loadings, a key indicator of construct validity, all exceeded 0.50 in this study (Table 3).

Reliability Analysis of the Scale

Internal Consistency of the Scale

The internal consistency of the scale was evaluated by calculating Cronbach's Alpha coefficients for the entire scale and for each subscale. The results were as follows:

- "Transfusion Reaction" subscale (five items): 0.732
- "Transfusion Preparation" subscale (four items): 0.806
- "Pre-Transfusion" subscale (three items): 0.634
- "Transfusion Control" subscale (three items): 0.773
- Entire scale (15 items): 0.786

"Transfusion Reaction" subscale*:* Evaluates the early detection of adverse reactions during transfusion and the appropriate management of the reaction process (patient monitoring, documentation of reactions, and timely reporting to the physician).

"Transfusion Preparation" subscale: Evaluates the appropriateness of pre-transfusion preparation procedures (verification of blood orders, appropriate transport of products, testing of blood samples, and confirmation of informed consent).

"Pre-Transfusion" subscale: Assesses the appropriateness of procedures carried out prior to the initiation of transfusion (ensuring correct patient-product matching, safe return of unused products, and sequential management of multiple transfusions).

"Transfusion Control" subscale: Evaluates the correct administration of blood products to the right patient and the safe management of transfusion duration according to protocol (performing checks in the appropriate setting and adherence to transfusion duration protocols).

Test-Retest Reliability

In the test-retest procedure, paired-sample t-tests were performed to assess the consistency of the scale scores across different measurement occasions. As shown in Table 4, no statistically significant differences were observed between the pre-test and post-test mean scores for the total scale or any of its subscales ($p > 0.05$).

Participant Characteristics

Among the nurses who participated in the study, 49.6% were aged 20–29 years, 75.3% were female, and 61.8% held a bachelor's degree in nursing. Additionally, 34.9% had 0–5 years of professional experience, and 57.6% reported working 40 hours per week. The lowest and highest mean scores obtained by nurses for the subscales of the scale were 5.4566 ± 1.76676 for "Transfusion Control" and 6.9015 ± 0.29840 for "Transfusion Preparation," respectively. The overall mean score for the scale was 6.0544 ± 0.41766 (Table 5).

Table 1. Exploratory factor analysis results

Scale Subscale	Items	Factor Load Value	Eigenvalue	Variance (%)	Cumulative Variance (%)
Factor 1 (Transfusion Reaction)	Item 53	0.786	5.257	35.045	35.045
	Item 43	0.757			
	Item 48	0.751			
	Item 50	0.724			
	Item 41	0.619			
Factor 2 (Transfusion Preparation	Item 3	0.828	1.858	12.384	47.429
	Item 2	0.821			
	Item 4	0.792			
	Item 1	0.736			
Factor 3 (Before Transfusion)	Item 26	0.851	1.743	11.623	59.052
	Item 20	0.720			
	Item 21	0.567			
Factor 4 (Transfusion Control)	Item 29	0.834	1.024	6.827	65.879
	Item 25	0.768			
	Item 36	0.767			

Table 2. Critical values for model fit indices

Model Fit Indices	Good Fit	Acceptable Fit	Scale Values
χ2/sd	≤ 3	≤ 5	1.453
GFI	≥ 0.90	≥ 0.85	0.953
IFI	≥ 0.95	≥ 0.90	0.977
TLI	≥ 0.95	≥ 0.90	0.970
CFI	≥ 0.97	≥ 0.95	0.976
RMSEA	≤ 0.05	≤ 0.08	0.038

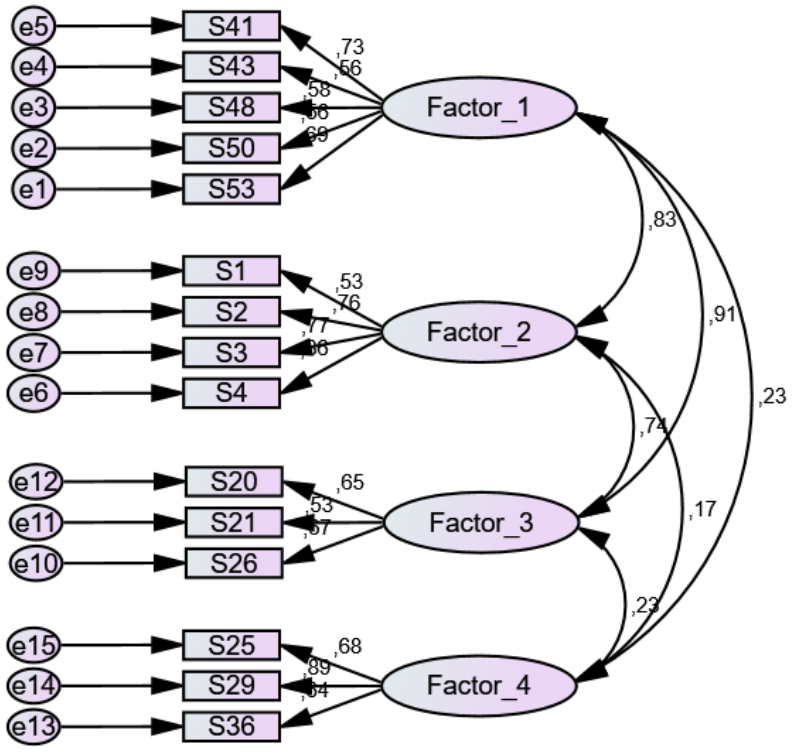

Figure 1. First-order confirmatory factor analysis model including four subscales.

Table 3. Standard regression coefficients of the items from confirmatory factor analysis

Items	Factor 1	Factor 2	Factor 3	Factor 4
53. In the event of a transfusion-related adverse reaction, the transfusionist is responsible for documenting the process and all interventions performed.	0.695			
43. During the first 15 minutes of blood and blood product transfusion, the flow rate is deliberately set to a slow pace.	0.565			
48. Throughout the transfusion process, the patient is continuously monitored for any transfusion-related adverse reactions.	0.584			
50. In the event of a transfusion-related adverse reaction, the transfusionist promptly reports the observed reaction to the patient's physician.	0.561			
41. The transfusionist records the start time of the transfusion.	0.730			
3. The blood component order is verified prior to initiating the transfusion.		0.774		
2. The blood component is transported under appropriate conditions, using designated blood transport containers.		0.763		
4. The informed consent form is reviewed and confirmed before initiating the transfusion.		0.535		
1. A blood sample is collected from the patient for pre-transfusion testing, along with the blood request form.		0.864		
26. The identity check at the initiation of the transfusion is performed at the patient's bedside.			0.667	
20. If the requested blood or blood product is not to be used, it must be returned to the transfusion center within 30 minutes.			0.653	
21. If more than one blood or blood product is to be transfused to the patient, all products are not delivered simultaneously from the transfusion/blood center to the patient's bedside (the arrival of the next product is ensured at the end of each transfusion).			0.528	
29.Checks to be performed before starting the transfusion can be carried out in the treatment room or the nurses' station.				0.887
25. In cases of heavy workload, it is sufficient for the checks to be performed by a single healthcare professional.				0.678
36. If the transfusion time exceeds 4 hours, the transfusion may be continued until the blood component is completely administered (to prevent wastage of the blood component).				0.637

Table 4. Test-retest results

Subscales of the scale	Practice	N	Mean	ss	t	p
Transfusion Reaction	**Pre-test**	41	34.76	0.92	-1.125	0.268
	Post-test	41	34.93	0.35		
Transfusion Preparation	**Pre-test**	41	27.61	1.22	-1.889	0.066
	Post-test	41	27.98	0.16		
Before Transfusion	**Pre-test**	41	20.63	1.26	-0.666	0.509
	Post-test	41	20.80	0.98		
Transfusion Control	**Pre-test**	41	7.61	3.56	0.681	0.500
	Post-test	41	6.80	3.17		
Total	**Pre-test**	41	90.61	6.19	0.059	0.954
	Son Test	41	90.54	6.17		

Table 5. Nurse knowledge and attitude scale for blood and blood product transfusion safety (n = 684)

Subscales of the scale	Subscale Items	Min.	Max.	Mean ± MD
Transfusion reaction	53, 43, 48, 50, 41	3.60	7.00	6.8711 ± .35291
Transfusion preparation	3, 2, 4, 1	4.50	7.00	6.9015 ± .29840
Before transfusion	26, 20, 21	3.00	7.00	6.8231 ± .48306
Transfusion control	29, 25, 36	1.33	7.00	5.4566 ± 1.76676
Total		4.60	7.00	6,0544 ± .41766

DISCUSSION

Discussion of the Scale's Psychometric Properties

EFA is a multivariate statistical technique used to identify a smaller set of meaningful, summary-based variables, known as factors (subscales), from the relationships among a larger set of variables (Karagöz, 2016). In this study, indicators of construct validity for the developed scale included the eigenvalues of the subscales, the variance explained by these subscales, the standardized factor loadings of the items, and the total variance explained by the scale. These indicators were evaluated by comparing the results with established criteria in the literature. During the EFA process, items that failed to achieve sufficient factor loadings on any factor, were deemed "unnecessary," or negatively impacted the total variance explained were iteratively removed, with the analysis repeated after each removal. According to the literature, factor loadings above 0.45 are considered sufficient for establishing construct validity (Büyüköztürk, 2015). The factor loadings of the items in the developed scale ranged from 0.567 to 0.851 (Table 1), indicating adequate construct validity. Eigenvalues also serve as an important indicator for determining the appropriate number of subscales. According to the Kaiser criterion, factors with eigenvalues equal to or greater than one are typically retained in the measurement structure of the scale (Kartal & Bardakçı, 2018). As shown in Table 1, the EFA results indicated that the developed scale comprised four subscales with eigenvalues exceeding one, explaining a total variance of 65.879%. This level of explained variance is considered sufficient in the literature to support the construct validity of a scale (Karagöz, 2016; Kartal & Bardakçı, 2018). In scale development studies, validating the factor structure identified through EFA using CFA is essential for assessing construct validity, as CFA examines whether the measurement model derived from EFA fits data obtained from a different sample, thereby confirming the generalizability of the proposed structure (Kartal & Bardakçı, 2018). Model fit in CFA is evaluated using several indices, including χ^2/df, GFI, IFI, TLI, CFI, and RMSEA. In this study, the CFA yielded the following fit index values: $\chi^2/df = 1.453$ (<3); GFI = 0.953 (>0.90); IFI = 0.977 (>0.95); TLI = 0.970 (>0.95); CFI = 0.976 (>0.97); and RMSEA = 0.038 (<0.05) (Table 2), indicating a good fit between the model and the data across all assessed indices. Standardized factor loadings obtained from CFA are also a critical indicator of construct validity, with loadings above 0.50 generally considered satisfactory (Karagöz, 2016; Kartal & Bardakçı, 2018). In the CFA results for the developed scale, all items demonstrated standardized factor loadings exceeding 0.50, supporting adequate construct validity (Table 3). Internal consistency reflects the extent to which individual items within a scale align with the overall construct and is widely recognized as an important measure of reliability (Karagöz, 2016; Kartal & Bardakçı, 2018). Accordingly, the reliability of the developed scale was evaluated by calculating Cronbach's Alpha coefficients for the entire scale and its subscales. The obtained coefficients indicate a high level of internal consistency (Özdamar, 2010). To assess stability-based reliability, the draft scale was administered twice to 41 nurses with a three-week interval between administrations. Paired-sample t-tests confirmed that the scale produced consistent results across the two time points, indicating satisfactory test-retest reliability (Table 4).

Discussion of the Study Findings

In our study, nurses demonstrated knowledge gaps regarding blood and blood product transfusion control processes (5.4566 ± 1.76676), despite showing a high level of knowledge in transfusion preparation (6.9015 ± 0.29840) (Table 5). These gaps in transfusion control knowledge pose significant risks to patient safety. Insufficient knowledge in this area may lead to adverse outcomes, including improper transfusion practices (Hijji, et al., 2012; Hijji et al., 2013; Mohd Noor et al., 2021; Kalyoncuo & Ceyhan, 2022), allergic reactions, infections (Sadani et al., 2006; Hijji et al., 2012; Hijji et al., 2013; Mohd Noor et al., 2021; Kalyoncuo & Ceyhan, 2022), inadequate monitoring, and failure to detect complications (Sadani et al., 2006; Hijji et al., 2012; Hijji et al., 2013; Mohd Noor et al., 2021; Bediako et al., 2021; Kalyoncuo & Ceyhan, 2022). Such deficiencies can compromise patient safety, generate substantial legal and ethical challenges,

increase healthcare costs, and negatively affect the professional reputation and credibility of nurses. To mitigate these risks, it is essential that nurses receive comprehensive training on transfusion procedures, adhere to established protocols, and comply with current guidelines. Furthermore, promoting effective teamwork and ensuring continuous monitoring are critical strategies for improving transfusion practices. In this context, the high level of knowledge regarding transfusion preparation observed among nurses in our study represents a key competency for safe blood transfusion. Nevertheless, addressing the identified gaps in transfusion control knowledge is expected to further enhance the quality and safety of transfusion practices.

CONCLUSION

The developed "Nurse Knowledge and Attitude Scale on Blood and Blood Product Transfusion Safety" was found to possess adequate psychometric properties in accordance with established scientific recommendations. It can be concluded that the nurses included in this study demonstrated a sufficient level of knowledge regarding the blood and blood product transfusion process. In future studies, testing the scale in different clinical settings and with larger, more diverse samples will contribute to the verification of its generalizability and robustness.

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Conflict of Interest

The authors declare that they have no competing interests.

Authors Contributions

İY: Conceptualization, methodology, formal analysis, investigation, resources, writing original draft, review and editing, visualization. ŞK: Conceptualization, methodology, formal analysis, writing original draft, review and editing, visualization, supervision, project administration. SB: Conceptualization, methodology, formal analysis, writing original draft, review and editing, visualization, supervision, project administration.

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