INTRODUCTION

Central venous access devices (CVADs) are indispensable in the daily clinical management of many patients. CVADs are routinely placed to provide patients with a wider range of treatment options, such as long-term infusion of anticancer drugs for target treatment; convenient blood collection, long periods of parenteral nutrition management; the delivery of vasopressors or sufficient fluids, or the monitoring of central venous pressure for critically ill patients (Gorski et al., 2021). It is estimated that approximately 8% of hospitalized patients require CVADs during hospitalization, and more than 5 million central venous punctures are performed per year in the United States (Duwadi et al., 2019). Although catheter placement into the central vein is a common procedure performed in many clinical settings, severe insertion and retention complications associated with CVADs, such as bloodstream infections, skin lesions, phlebitis and thrombosis, are still prevalent (Jiang et al., 2020; Mimoz et al., 2015; Pu et al., 2020; Ullman et al., 2019).

BACKGROUND

A multistage research project, organized by the World Congress of Vascular Access (WoCoVA), bridged the obvious gap in the definition of CVAD-associated skin impairment (CASI) in 2017 (Broadhurst et al., 2017). CASI was defined based on the definition of medical
adhesive-related skin injury (MARSII). This definition was also written into the ‘Infusion Therapy Standards of Practice’ in 2021 (Gorski et al., 2021). Skin complications associated with the use of CVADs have been reported to be a frequent occurrence. The prevalence rates of skin impairment as a result of moisture-related dermatitis, local infections, contact dermatitis and MARSII associated with CVAD sites, such as redness, rash, vesicle, itchiness or bruising, ranged from 11.7%-36%, and in China, ranged from 3.23%-19.7% across reported studies (Chan et al., 2017; Ullman et al., 2019; Wang et al., 2019; Zhao et al., 2018). Moreover, the presence of CASI often results in substantial adverse impacts, such as patients’ discomfort, device failure, increased risk of infections and considerable healthcare costs (Ullman et al., 2015; Wall et al., 2014).

The use of assessment tools is associated with improvements in CASI management. Standardized management of CASI consists of systematic evaluation, appropriate (or individualized) prevention and long-term follow-up, with every aspect critical to the overall success (LeBlanc & Baranoski, 2011; McNichol et al., 2013). The systematic evaluation of skin impairment mainly depends on the professional clinical knowledge and the practical skills of healthcare researchers and medical workers, including complete history-taking, thorough examination and exact clinical judgement (Broadhurst et al., 2017). Assessment tools are important for conducting clinical evaluations accurately and completely. Nevertheless, the existing tools used to evaluate CASI are inaccurate and incomplete, according to the literature. Timsit and colleagues (Timsit et al., 2009) reported data results from the randomized controlled trials. Nurses used the International Contact Dermatitis Research Group Scale to describe the skin condition of the catheter site. Although the scoring system consisted of four levels, it can only assess skin redness, swelling, blisters and a spreading reaction (Timsit et al., 2009). This scoring system was also used in subsequent skin condition assessments by other investigators (Buetti et al., 2020; Günther et al., 2016; Mimoz et al., 2015; Timsit et al., 2012), but there were some limitations, such as less detailed and ordinal response format to report the size of blisters. In other studies, unvalidated local institutional grading was used to assess skin status (Curtis et al., 2015; Su et al., 2017). No targeted instruments have been developed to assess the condition of skin impairment at CVAD sites.

Therefore, to improve the quality and safety of CVADs use, we systematically developed a wound assessment tool to evaluate skin conditions. The goal of this instrument is that members of the health care team can easily apply the instrument, which contains only the most relevant information, and evaluate the severity and healing of skin impairment during catheter management reliably and accurately. which was conducted to inform potential domains that could be used to describe CASI. After identifying domains from the literature review, semi-structured interviews were conducted with 10 nurses with experience in vascular access care to ensure that their descriptions were reflected in the assessment instrument. Feedback provided by the nurses was integrated into the instrument to produce the archetypal assessment instrument. Experts from China evaluated the relevance and significance of the items to assess the degree of skin impairment surrounding a CVAD site through two Delphi rounds. A multi-stage, qualitative-method research approach was utilized to produce the content of the evaluation instrument and ensure its appropriateness for clinical settings.

3 | METHODS

The APA Style JARS checklist (Levitt et al., 2018) was followed in reporting on this study (Appendix S1). The following procedures were used to develop a new CASI assessment tool. The content of the instrument was developed through a systematic literature review, A systematic literature search was performed by three reviewers in March 2019. The databases PubMed, Scopus, Web of Science, Embase, Cochrane Central Register of Controlled Trials, Cochrane reviews, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Joanna Briggs Institute Library were searched through database-specific strategies. After the search, the results were imported into a document management software, and the duplicate records were automatically deleted. Two authors independently reviewed the titles and abstracts to retain records that might be relevant. All abstracts selected by the reviewers were then subjected to a full manuscript review. All articles that met the inclusion criteria were included in the systematic review. Disagreements were resolved through discussion with a third researcher. The eligibility criteria for the study included case reports, expert opinions, randomized controlled trials (RCTs), observational studies that described the objective symptoms and signs of CASI. Studies were excluded if the method of assessment was not described or if they were exclusively conducted with children and/or adolescents under 18. Articles about the clinical manifestations and assessment of phlebitis, drug extravasation and dermatoses, such as pyoderma and varicella, were excluded from this review. Additionally, this review also excluded research on non-human subjects and articles not available in English. The domains of the wound assessment tool were extracted from the eligible studies identified in the systematic reviews based on reporting frequency of clinical symptoms and signs of skin injury.

3.2 | Semi-structured interviews

A representative sample of clinical nurses with experience in vascular access care was invited to participate in semi-structured, in-depth, one on one interviews based on a descriptive qualitative research approach (Holt & Hughes, 2021). The aim of the interviews was to determine the most relevant and important categories that characterize CASI in a clinical practice setting. Before the interviews, we formulated several major questions that were continually revised during the interviews. Any interview excerpt describing
CASIs and discomfort was marked as a domain. Each interview was conducted in a quiet, private room and recorded. The transcription was performed after each interview, and was reviewed and coded by a researcher under the support of qualitative data analysis software (NVivo 11). In order to collect data accurately, themes were continuously revised to facilitate the emergence of new content until saturation of data was reached.

3.3 Establishment of the item pool

The drafted indicators were generated according to clinical studies of CASIs, reviews, case reports, expert consensus and the nurses' interview results. These items were integrated into a preliminary instrument to assess key characteristic of skin lesions and develop appropriate rating content. Through detailed and in-depth discussion among the members of experts, the initial instrument was examined for reasonableness, simplicity and redundancy to accommodate the Chinese vascular access care setting, and to improve clinical usability and efficiency.

3.4 Delphi technique

The Delphi technique is considered to be one of the most commonly used research approaches to guide the improvement of content validity of an assessment instrument, which demonstrates its suitability for this study. The Delphi method was used to collect quantitative and qualitative data from an advisory group during two consecutive rounds of questionnaires (McPherson et al., 2018). Purposive sampling methods were used to form an advisory group of multidisciplinary experts. The expert panel recruitment criteria were as follows: (a) they had a Bachelor's degree or above, (b) they had at least 10 years of experience in skin/wound or catheter management and (c) they were willing to participate in the Delphi procedure. To avoid the homogeneity of the expert panel, the panelists were purposively recruited from different district polyclinics and medical universities. A professional and secure survey website was used that sent automated reminders to panelists to complete the questionnaire over a period of 1 week.

The content of the questionnaire included three parts. The first part consisted of the complete instrument with detailed domains and response options. In each round, the experts were instructed to rate each statement according to the degree to which they considered it to be relevant for the assessment of CASIs via a 5-point Likert scale (1 = strongly irrelevant, 2 = irrelevant, 3 = neutral, 4 = relevant and 5 = strongly relevant), and were encouraged to offer additional recommendations in blanks. The second part collected demographic information of the panelists (i.e. age, occupation, work seniority, education level and professional title). The third part was a self-assessment of judgement criteria (Ca) and familiarity (Cs) (Li et al., 2018; Wang & Si, 2011).

3.5 Statistical analysis

The databases were created in Microsoft Office 365 Excel, and the statistical analyses were carried out in IBM SPSS, version 25.0. All comparisons were two-sided, and p values ≤.05 were considered statistically significant.

3.6 Ethical considerations

The study was conducted at the comprehensive Grade 3A hospital in southeastern China, and ethical approval was obtained from the Medical Research Ethical Committee. The research conformed to the Declaration of Helsinki, and all participants voluntarily participated and provided informed consent.

4 RESULTS

4.1 Article selection

The results of literature review are displayed in the PRISMA flow chart (Figure 1). A total of 4,637 articles were originally identified during the searches. After removing the duplicates, the reviewers screened 3,988 titles and 137 abstracts. Subsequently, 64 articles were selected for full-text review, of which 39 were excluded based on the inclusion and exclusion criteria. Three additional full texts were identified by reviewing the references of articles and were added to the analysis. In total, 28 articles were included in the systematic review for the development of the wound assessment tool. These publications included 11 RCTs, 6 observational studies, 4 case reports, 3 expert opinion articles, 3 expert consensus documents and 1 quasi-experiment. All studies described the specific manifestations of skin injury. Ten studies described wound assessment instruments, with 4 utilizing the International Contact Dermatitis Research Group system to assess the severity of contact dermatitis; 3 using MARSI classification criteria; 1 using a grading scale for skin tears and 2 using their local institutional assessment scales to assess skin injury. In most studies, only a few aspects of skin injury were described, which is not all-inclusive. In addition, the terminology of assessing CVAD-associated skin impairment varied widely among studies, and no unified definition could be confirmed.

4.2 Nurse interview

Ten nurses with vascular access care experience participated in semi-structured face-to-face interviews. After interviewing 8 nurses, data saturation was reached. All participants were women with a bachelor's degree, and 80% had more than 10 years of work experience. The demographic characteristics of all participants are summarized in Table 1.
From the articles and interview contents analysed, 15 criteria were selected based on the reporting frequency. After further screening via in-depth discussion with the panel of experts, the CASI-assessment tool was refined to 14 major domains that were considered as the most critical factors in monitoring and evaluating CASI healing. The refined instrument included domains for wound size, position and shape, skin colour, depth, size of vesicle and erythema, swelling and hardness of the catheter exit site, warmth, type/amount of exudate and pruritus and pain degree. Each of these domains had a detailed descriptive subscale. The initial instrument was sent to the advisory group panellists via email.

### 4.4 | Delphi technique

### 4.4.1 | Advisory group

Thirteen experts from general hospitals and universities were recruited to complete the questionnaire and then asked to
recommend questionnaire to colleagues or friends who could participate in the study through a sampling technique called ‘snowball sampling’. Using participants’ personal social network for snowball sampling when contacting difficult-to-reach target groups can shorten the recruitment time and create a sufficient size and heterogeneous sample (Wohl et al., 2017). After this process, the final advisory group consisted of 19 scholars, clinical nurses and doctors from the provinces of Zhejiang, Guangzhou, Shanghai, Chongqing and Yunnan, who had expertise in wound management, vascular access, geriatric care, critical care and oncology care (Table 2).

4.4.2 Initiation coefficient

The expert panel response rate was used to represent the initiation coefficient. The response rate of the questionnaire was 100% (19/19) in round one, and 94.74% (18/19) in round two. According to the literature, a 70% or higher response rate is regarded very good (Li et al., 2018). In the first round, seven panelists presented constructive suggestions for revisions on domains and items. The term ‘pink’ was removed from the colour domain. Panellists recommended changing the content of the ‘amount of exudate’ domain, as the type of dressing may vary from gauze to transparent dressing. Additionally, the panelists suggested that domains like ‘wound size’ should be described in greater detail. The modifications of the initial instrument were adjusted based on the feedback from experts, and then the second round Delphi was conducted.

### Table 2 Characteristics of the Delphi panel experts

| Description                  | Round 1, N (%) | Round 2, N (%) |
|------------------------------|---------------|---------------|
| Age (mean ± SD) (y)          | 45.63 ± 5.34 | 46 ± 5.24     |
| Professional title           |               |               |
| Professor                    | 4 (21.05)     | 4 (22.22)     |
| Associate professor          | 13 (68.42)    | 12 (66.67)    |
| Nurse-in-charge              | 2 (10.53)     | 2 (11.11)     |
| Occupation                   |               |               |
| Teacher                      | 1 (5.27)      | 1 (5.56)      |
| Nurse                        | 14 (73.68)    | 13 (72.22)    |
| Doctor                       | 4 (21.05)     | 4 (22.22)     |
| Education level              |               |               |
| Doctor                       | 4 (21.05)     | 4 (22.22)     |
| Master                       | 4 (21.05)     | 3 (16.67)     |
| Bachelor                     | 11 (57.90)    | 11 (61.11)    |
| Work seniority (mean ± SD) (y) | 24.95 ± 7.02 | 25.44 ± 6.87 |
| <20 years                    | 6 (31.58)     | 5 (27.78)     |
| 20–30 years                  | 7 (36.84)     | 7 (38.89)     |
| ≥30 years                    | 6 (31.58)     | 6 (33.33)     |

4.4.3 Authority coefficient

The authority coefficient (Cr) was used to evaluate the degree of authority of experts’ opinions. Cr usually depends on three factors: the academic level of experts, the judgement criteria (Ca) and familiarity (Cs). Cr = (Ca +Cs)/2 (Wang & Si, 2011). Ca was the sum of clinical experience, theoretical analysis, literature references and intuition. Familiarity (Cs) consisted of 5 levels, that is very familiar, familiar, neutral, unfamiliar and very unfamiliar, which corresponded to values of 1.0, 0.8, 0.6, 0.4 and 0.2, respectively. In general, Cr ≥0.7 is considered to indicate acceptable reliability. Our results showed that the Cr values were 0.879 and 0.886, respectively.

4.4.4 Coefficient of concordance

Kendall’s coefficient of concordance (Kendall’s W) was used to quantify the strength of consensus among the multiple raters of the CASI assessment tool. The value ranges from 0 (no agreement) to 1 (perfect agreement) (Melinosky et al., 2021; Stanhope et al., 2021). In our study, the two rounds of Delphi results showed that Kendall’s W values were 0.394 and 0.402 for the domains and 0.279 and 0.330 for the items. All the results were statistically significant (Table 3).

4.4.5 Level of concentration of expert opinions

The level of concentration of expert opinions is calculated by the arithmetic average (Mj) and full mark ratio (Kj) (Wang & Si, 2011). Mj is the average score of each item based on the evaluations of all experts. Kj is the ratio of the number of experts who evaluate the indicator to be very relevant to the total number of experts. The evaluation indexes are screened by the boundary value method, and Mj, Kj and the coefficient of variation (Vj) are calculated according to the importance (or relevance) of each item (Cui et al., 2018). The coefficient of variation (Vj) refers to the degree of coordination of experts’ evaluation for indicators. The exclusion criteria of the indicators are: Kj and Mj < mean (MD) - standard deviation (SD) and Vj > MD + SD (Hu et al., 2019). To prevent important indicators from being eliminated, the indicators that did not meet the requirements

### Table 3 Kendall’s coefficient of concordance

| Round   | Part          | N   | Kendall’s W | Chi-square | DF  | p    |
|---------|---------------|-----|-------------|------------|-----|-----|
| Round 1 | Dimensions    | 19  | 0.394       | 97.357     | 13  | .000*|
|         | Items         | 19  | 0.279       | 270.440    | 51  | .000*|
|         | Total         | 19  | 0.286       | 353.258    | 65  | .000*|
| Round 2 | Dimensions    | 18  | 0.402       | 86.761     | 12  | .000*|
|         | Items         | 18  | 0.330       | 444.905    | 75  | .000*|
|         | Total         | 18  | 0.318       | 503.246    | 88  | .000*|

Abbreviation: DF, degrees of freedom.
*p ≤ .001
| Abbreviated item content | Kj | Mj | SD  | Vj  | I-CVI | Result |
|--------------------------|----|----|-----|-----|-------|--------|
| **A** Anatomical position of skin impairment | 73.68 | 4.68 | 0.58 | 0.12 | 0.95 | Stay |
| Marking relevant position on the picture. | 57.89 | 4.32 | 0.89 | 0.21 | 0.74 | Stay |
| **B** Wound shape | 26.32 | 3.00 | 1.45 | 0.48 | 0.32 | Remove |
| Irregular | 21.05 | 2.79 | 1.47 | 0.53 | 0.26 | Remove |
| Slender | 10.53 | 2.58 | 1.30 | 0.51 | 0.21 | Remove |
| Round | 10.53 | 2.26 | 1.24 | 0.55 | 0.16 | Remove |
| Square | 10.53 | 2.11 | 1.28 | 0.58 | 0.16 | Remove |
| **C** Size | 84.21 | 4.84 | 0.37 | 0.08 | 0.74 | Stay |
| Intact | 42.11 | 3.74 | 1.45 | 0.39 | 0.63 | Stay |
| <25 cm² | 52.63 | 3.84 | 1.46 | 0.38 | 0.63 | Change |
| 25 cm²< S ≤ 100 cm² | 31.58 | 3.58 | 1.35 | 0.38 | 0.58 | Change |
| >100 cm² | 36.84 | 3.53 | 1.43 | 0.41 | 0.53 | Change |
| **D** Size of vesicle | 84.21 | 4.84 | 0.37 | 0.08 | 1.00 | Stay |
| No | 79.95 | 4.42 | 1.30 | 0.30 | 0.84 | Stay |
| Yes, but limited to the dressing area. | 52.63 | 4.16 | 1.07 | 0.26 | 0.74 | Change |
| Yes, but exceeded the dressing area. | 52.63 | 4.05 | 1.27 | 0.31 | 0.74 | Change |
| **E** Size of erythra | 78.95 | 4.68 | 0.67 | 0.14 | 0.89 | Stay |
| No | 57.89 | 4.05 | 1.35 | 0.33 | 0.68 | Change |
| Yes, but within the dressing area. | 57.89 | 4.10 | 1.20 | 0.29 | 0.68 | Change |
| Yes, but beyond the dressing area. | 52.63 | 3.95 | 1.31 | 0.33 | 0.63 | Change |
| **F** Depth | 78.95 | 4.79 | 0.42 | 0.09 | 1.00 | Stay |
| Intact, or with pigmentation | 73.68 | 4.42 | 1.26 | 0.29 | 0.89 | Stay |
| Intact, but with constant redness | 78.95 | 4.68 | 0.75 | 0.16 | 0.95 | Stay |
| Only epidermis missing | 84.21 | 4.79 | 0.54 | 0.11 | 0.95 | Stay |
| Both the epidermis and dermis are missing | 84.21 | 4.74 | 0.73 | 0.15 | 0.95 | Stay |
| Damage or necrosis of the tissues under the dermis | 89.47 | 4.74 | 0.93 | 0.20 | 0.95 | Stay |
| **G** Colour | 73.68 | 4.63 | 0.68 | 0.15 | 0.89 | Stay |
| Normal | 73.68 | 4.26 | 1.48 | 0.35 | 0.84 | Stay |
| Pink | 26.32 | 3.05 | 1.64 | 0.54 | 0.53 | Remove |
| Red | 78.95 | 4.53 | 1.07 | 0.24 | 0.84 | Stay |
| Purple | 78.95 | 4.47 | 1.26 | 0.28 | 0.89 | Stay |
| Black | 57.89 | 4.00 | 1.45 | 0.36 | 0.73 | Stay |
| **H** Swelling | 84.21 | 4.79 | 0.54 | 0.11 | 0.95 | Stay |
| None | 52.63 | 4.16 | 1.26 | 0.30 | 0.84 | Stay |
| Within 2 cm of catheter exit site | 68.64 | 4.37 | 1.07 | 0.24 | 0.84 | Stay |
| Beyond 2 cm of catheter exit site | 47.37 | 4.16 | 1.12 | 0.27 | 0.84 | Stay |
| **I** Hardness | 57.89 | 4.47 | 0.70 | 0.16 | 0.89 | Stay |

(Continues)
Table 4

| Abbreviated item content | Kj | Mj | SD  | Vj  | I-CVI | Result |
|--------------------------|----|----|-----|-----|-------|--------|
| A Anatomical position of skin impairment | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| Marking relevant position on the picture. | 16.67 | 3.28 | 1.13 | 0.34 | 0.39 | Remove |
| Left neck | 94.44 | 4.94 | 0.24 | 0.05 | 1.00 | Stay |
| Right neck | 94.44 | 4.94 | 0.24 | 0.05 | 1.00 | Stay |
| Left chest | 94.44 | 4.94 | 0.24 | 0.05 | 1.00 | Stay |
| Right chest | 94.44 | 4.94 | 0.24 | 0.05 | 1.00 | Stay |
| Left upper limb | 88.89 | 4.89 | 0.32 | 0.07 | 1.00 | Stay |
| Right upper limb | 88.89 | 4.89 | 0.32 | 0.07 | 1.00 | Stay |
| Left groin | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| Right groin | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| B Size | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| Intact | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| ≤ 1 cm² | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| 1 cm² < S ≤ 4 cm² | 83.33 | 4.78 | 0.55 | 0.11 | 0.94 | Stay |
| 4 cm² < S ≤ 9 cm² | 83.33 | 4.78 | 0.55 | 0.11 | 0.94 | Stay |
| 9 cm² < S ≤ 16 cm² | 77.78 | 4.72 | 0.57 | 0.12 | 0.94 | Stay |
| 16 cm² < S ≤ 25 cm² | 72.22 | 4.67 | 0.59 | 0.13 | 0.94 | Stay |
| 25 cm² < S ≤ 36 cm² | 72.22 | 4.67 | 0.59 | 0.13 | 0.94 | Stay |
| 36 cm² < S ≤ 49 cm² | 55.56 | 4.44 | 0.70 | 0.16 | 0.89 | Stay |
| 49 cm² < S ≤ 64 cm² | 44.44 | 4.28 | 0.75 | 0.18 | 0.83 | Stay |
| 64 cm² < S ≤ 81 cm² | 44.44 | 4.28 | 0.75 | 0.18 | 0.83 | Stay |
| 81 cm² < S ≤ 100 cm² | 50.00 | 4.22 | 1.06 | 0.25 | 0.83 | Stay |
| S > 100 cm² | 50.00 | 4.22 | 1.06 | 0.25 | 0.83 | Stay |
| C Size of vesicle | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| Intact | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| ≤ 1 cm² | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| 1 cm² < S ≤ 4 cm² | 66.67 | 4.56 | 0.70 | 0.15 | 0.89 | Stay |
| 4 cm² < S ≤ 9 cm² | 66.67 | 4.56 | 0.70 | 0.15 | 0.89 | Stay |
| > 16 cm² | 66.67 | 4.56 | 0.70 | 0.15 | 0.89 | Stay |
| D Size of erythra | 77.78 | 4.72 | 0.57 | 0.12 | 0.94 | Stay |
| Intact | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| ≤ 1 cm² | 83.33 | 4.83 | 0.38 | 0.08 | 1.00 | Stay |
| 1 cm² < S ≤ 4 cm² | 83.33 | 4.78 | 0.55 | 0.11 | 0.94 | Stay |
| 4 cm² < S ≤ 9 cm² | 83.33 | 4.78 | 0.55 | 0.11 | 0.94 | Stay |
| 9 cm² < S ≤ 16 cm² | 77.78 | 4.72 | 0.57 | 0.12 | 0.94 | Stay |
| 16 cm² < S ≤ 25 cm² | 72.22 | 4.67 | 0.59 | 0.13 | 0.94 | Stay |
| 25 cm² < S ≤ 36 cm² | 72.22 | 4.67 | 0.59 | 0.13 | 0.94 | Stay |

(Continues)
### Table 4 (Continued)

| Abbreviated item content                                      | Kj  | Mj  | SD   | Vj  | I-CVI | Result |
|---------------------------------------------------------------|-----|-----|------|-----|-------|--------|
| None                                                          | 47.37 | 4.05 | 1.31 | 0.32 | 0.84  | Stay   |
| Within 2 cm of catheter exit site                            | 63.16 | 4.42 | 0.96 | 0.22 | 0.89  | Stay   |
| Beyond 2 cm of catheter exit site                            | 57.89 | 4.42 | 0.84 | 0.19 | 0.89  | Stay   |
| **J Exudate type**                                            |     |     |      |     |       |        |
| None/dry wound                                               | 68.42 | 4.53 | 0.77 | 0.17 | 0.84  | Stay   |
| Bloody                                                       | 78.95 | 4.42 | 1.30 | 0.30 | 0.84  | Stay   |
| Serous                                                       | 73.68 | 4.58 | 0.84 | 0.18 | 0.89  | Stay   |
| J Exudate amount                                             |     |     |      |     |       |        |
| None/dry wound                                               | 63.16 | 4.37 | 0.96 | 0.22 | 0.79  | Stay   |
| Bloody                                                       | 73.68 | 4.58 | 0.84 | 0.18 | 0.89  | Stay   |
| Serous                                                       | 89.47 | 4.68 | 1.00 | 0.21 | 0.89  | Stay   |
| **K Exudate amount**                                         |     |     |      |     |       |        |
| None/dry wound                                               | 52.63 | 4.16 | 1.26 | 0.30 | 0.84  | Stay   |
| <25% dressing saturation                                     | 52.63 | 4.00 | 1.33 | 0.33 | 0.74  | Change |
| 25%–50% dressing saturation                                  | 52.63 | 4.05 | 1.27 | 0.31 | 0.74  | Change |
| 51%–75% dressing saturation                                  | 47.37 | 4.00 | 1.29 | 0.32 | 0.79  | Change |
| 76%–100% dressing saturation                                 | 57.89 | 4.11 | 1.33 | 0.32 | 0.79  | Change |
| **L Warmth**                                                 |     |     |      |     |       |        |
| No                                                           | 15.79 | 3.37 | 1.01 | 0.30 | 0.42  | Remove |
| Yes                                                          | 10.53 | 3.00 | 1.29 | 0.43 | 0.37  | Remove |
| **M Pruritus**                                               |     |     |      |     |       |        |
| None                                                          | 57.89 | 4.16 | 1.17 | 0.29 | 0.68  | Stay   |
| Pruritus without the need to scratch                          | 68.42 | 4.26 | 1.33 | 0.31 | 0.79  | Stay   |
| Pruritus with the need to scratch but without excoriations    | 78.95 | 4.53 | 1.02 | 0.23 | 0.84  | Stay   |
| Pruritus unrelieved by scratching but without excoriations    | 73.68 | 4.53 | 0.90 | 0.20 | 0.84  | Stay   |
| **N Pain**                                                   |     |     |      |     |       |        |
| None                                                          | 57.89 | 4.42 | 0.77 | 0.17 | 0.84  | Stay   |
| Slight                                                       | 73.68 | 4.42 | 1.26 | 0.29 | 0.89  | Stay   |
| **O Odour**                                                  |     |     |      |     |       |        |
| No                                                           | 68.42 | 4.53 | 1.02 | 0.23 | 0.89  | Stay   |
| Yes                                                          | 73.68 | 4.47 | 1.02 | 0.23 | 0.89  | Stay   |
| Heavy                                                        | 73.68 | 4.58 | 0.96 | 0.21 | 0.95  | Stay   |
Results Delphi round 2 (N = 18)

| Abbreviated item content                                      | Kj  | Mj  | SD  | Vj  | I-CVI | Result   |
|--------------------------------------------------------------|-----|-----|-----|-----|-------|----------|
| 36 cm²<5≤49 cm²                                              | 55.56 | 4.44 | 0.70 | 0.16 | 0.89  | Stay     |
| 49 cm²<5≤64 cm²                                              | 44.44 | 4.28 | 0.75 | 0.18 | 0.83  | Stay     |
| 64 cm²<5≤81 cm²                                              | 44.44 | 4.28 | 0.75 | 0.18 | 0.83  | Stay     |
| 81 cm²<5≤100 cm²                                             | 50.00 | 4.22 | 1.06 | 0.25 | 0.83  | Stay     |
| S<100 cm²                                                    | 50.00 | 4.22 | 1.06 | 0.25 | 0.83  | Stay     |
| E Depth                                                      | 77.78 | 4.78 | 0.43 | 0.09 | 1.00  | Stay     |
| Intact, or with pigmentation                                 | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| Intact, but with constant redness                            | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| Only epidermis missing                                       | 88.89 | 4.89 | 0.32 | 0.07 | 1.00  | Stay     |
| Both the epidermis and dermis are missing                    | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| Damage or necrosis of the tissues under the dermis           | 55.56 | 4.44 | 0.70 | 0.16 | 0.89  | Stay     |
| F Colour                                                     | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| Normal                                                       | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| Red                                                          | 83.33 | 4.83 | 0.38 | 0.08 | 1.00  | Stay     |
| White/Gray                                                   | 50.00 | 4.28 | 1.02 | 0.24 | 0.89  | Stay     |
| Purple/Dark red                                              | 50.00 | 4.28 | 1.02 | 0.24 | 0.89  | Stay     |
| Black                                                        | 16.67 | 3.39 | 1.24 | 0.37 | 0.57  | Remove   |
| G Swelling                                                    | 55.56 | 4.44 | 0.70 | 0.16 | 0.89  | Stay     |
| None                                                         | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| Within 2 cm of catheter exit site                           | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| Beyond 2 cm of catheter exit site                           | 50.00 | 4.33 | 0.84 | 0.19 | 0.89  | Stay     |
| H Hardness                                                   | 55.56 | 4.44 | 0.70 | 0.16 | 0.89  | Stay     |
| None                                                         | 50.00 | 4.33 | 0.84 | 0.19 | 0.89  | Stay     |
| Within 2 cm of catheter exit site                           | 50.00 | 4.28 | 1.02 | 0.24 | 0.89  | Stay     |
| Beyond 2 cm of catheter exit site                           | 50.00 | 4.28 | 1.02 | 0.24 | 0.89  | Stay     |
| I Moisture type                                              | 61.11 | 4.50 | 0.71 | 0.16 | 0.89  | Stay     |
| None/dry wound                                               | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| Perspiration                                                 | 33.33 | 3.33 | 1.46 | 0.44 | 0.39  | Remove   |
| Bloody                                                       | 94.44 | 4.94 | 0.24 | 0.05 | 1.00  | Stay     |
| Serous                                                       | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| Purulent                                                     | 94.44 | 4.94 | 0.24 | 0.05 | 1.00  | Stay     |
| J Moisture amount (Frequency of dressing change)             | 66.67 | 4.61 | 0.61 | 0.13 | 0.94  | Stay     |
| None/dry wound                                               | 83.33 | 4.78 | 0.55 | 0.11 | 0.94  | Stay     |
| Less than once a day                                         | 50.00 | 4.33 | 0.84 | 0.19 | 0.89  | Stay     |
| Once a day                                                   | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| More than twice a day                                        | 50.00 | 4.39 | 0.70 | 0.16 | 0.89  | Stay     |
| K Odour                                                      | 22.22 | 2.89 | 1.49 | 0.52 | 0.33  | Remove   |
| No                                                           | 16.67 | 3.17 | 1.10 | 0.35 | 0.28  | Remove   |
| Yes                                                          | 11.11 | 3.11 | 1.08 | 0.35 | 0.33  | Remove   |
| L Pruritus                                                   | 66.67 | 4.61 | 0.61 | 0.13 | 0.94  | Stay     |
| None                                                         | 94.44 | 4.94 | 0.24 | 0.05 | 1.00  | Stay     |
| Pruritus without the need to scratch                         | 77.78 | 4.78 | 0.43 | 0.09 | 1.00  | Stay     |

(Continues)
of the three functions were included. For some unqualified or controversial items, the research group discussed them and determined whether they would be retained in accordance with the principles of comprehensiveness, scientificity and feasibility (Table 4) (Wang & Si, 2011). The first round of Delphi results showed that the Kj, Mj and Vj cut-off values were 43.66, 3.84 and 0.29 for the domains and 35.89, 3.44 and 0.41 for the items, respectively. In the second round, the cut-off values were 50.65, 4.01 and 0.27 for the domains and 45.22, 4.10 and 0.23 for the items, respectively (Table 5).

4.4.6 | Content validity

Content validity refers to the degree of consistency among content measured by the evaluation instrument and the actual domains. The content validity index (CVI) is the most widely used indicator in the quantitative assessment of content validity (Almanasreh et al., 2019). The CVI is divided into two categories: the item-level CVI (I-CVI) and scale-level CVI (S-CVI). The I-CVI was calculated based on the proportion of items rated as 4 or 5 by the experts on a 5-point scale (Li et al., 2018). When there are more than 5 experts, the I-CVI standard should not be <0.78, which indicates that the indicators in the evaluation instrument represent a good degree of consistency regarding the specific areas of concern. Depending on the calculation method, the S-CVI can be divided into two functions: (a) S-CVI/UA (universal agreement), that is, the percentage of items that all experts rate as 4 or 5 points; and (b) average S-CVI (S-CVI/Ave). As the number of experts increases, the possibility for disagreement increases, so the S-CVI/UA is sensitive to the number of experts and is therefore not recommended. Although there are three methods to calculate S-CVI/Ave, the use of the average I-CVI of all items in the scale is recommended. Researchers have suggested that the S-CVI/UA should be more than 0.8 and that the S-CVI/Ave should reach 0.90, indicating that the content validity is good (Almanasreh et al., 2019). After the second Delphi round, the I-CVI values of the items that we retained all exceeded 0.78 (Table 4). In this instance, S-CVI/Ave =0.90, which is the criterion for acceptability.

5 | DISCUSSION

In clinical settings, health workers are increasingly aware that CVADs are not only a simple tool to provide therapies for vulnerable
patients (Broadhurst et al., 2016). Successful insertion and management of CVADs play an important role in improving service quality and ensuring medical safety. During long-term CVAD placement, the skin integrity surrounding catheter sites is a substantial challenge, as the skin is repeatedly in contact with disinfectants, dressings, etc. (Mimoz et al., 2015; Ullman et al., 2019). In 2017, a study provided a literature review found that there was no specialized, targeted tool that had been systematically developed for CASI assessment. In view of the clinical problem of a lack of targeted CASI tools, we began to develop an instrument to fill the existing gap. Healthcare researchers and medical workers could accurately characterize the changes in skin conditions surrounding CVAD sites and assess the severity and healing of the impaired skin quickly via this instrument, which is an adequate and consistent measurement tool, has cultural compatibility and is accessible and affordable.

The Delphi technique is an effective and structured method to refine and collect opinion and expertise on the assessment of CASI from a range of experts (McPherson et al., 2018). In this study, a group of experts that constituted the Delphi panel reached consensus on the content of the CASI assessment tool. After the two Delphi rounds, the response rates exceeded 70%, indicating that the Delphi participants had positive attitudes towards this research (Li et al., 2018). The authoritative coefficients were >0.70 in the two Delphi rounds. Because the expert authority coefficient is related to familiarity and the judgement criterion, our results showed that expert authority was high and reliable (Wang & Si, 2011). Since the representativeness of an expert panel is based on the experts’ ability and the quality of their expertise rather than the number of experts, to ensure the reliability of expert opinions, the Delphi participants who had an abundance of theoretical knowledge and clinical practice experiences in long-term work were invited to participate. They were familiar with the research topics and had professional recognition in CVAD management or wound healing. The increase in the Kendall’s W value indicated the increase in the expert consensus on the CASI assessment tool, and the indicator system was accepted by panellists (Wang & Si, 2011). The excellent content validity indicated that the CASI instrument contained the most relevant content that could be used to identify the severity of skin impairment (Yusoff, 2019). Our research considered the important symptoms and clinical manifestations of CASI, ensuring that the topic was comprehensively analysed.

Clinician might express different insights on wound care due to the variation in their clinical experience and expertise (Erbay Dalli & Kelebek Girgin, 2021). To avoid gaps in inspecting skin conditions surrounding the CVAD site, researchers and clinicians should consider using standardized, validated assessment instruments to examine skin integrity regularly (Broadhurst et al., 2017; Greatrex-White & Moxey, 2015). The contents of our assessment instrument provide clinicians with evidence- and consensus-based guidance to assess the clinical manifestations of CASI qualitatively and quantitatively, including the extent of erythema, swelling, exudation, itching and blisters. Our findings indicated that the panellists’ recommendations for the item descriptions allowed the instrument to describe the relevant symptoms in detail. Overall, the instrument is acceptable and valid and includes an ordinal response format to describe symptom severity and healing for CASI.

In the future, the tool will be applied in CASI clinical assessment of Chinese patients, including inpatients and outpatients. The departments initially planned to carry out an evaluation activity including gastrointestinal surgery, respiratory medicine, breast surgery and PICC clinic. After further validation, it will continue to be extended to the whole hospital. Differences in assessment results can be compared between nurses with different work seniority and between nurses and doctors. Due to the low number of ethnic groups of other skin colours in the clinical setting in China, inter-ethnic comparisons are not yet possible.

### TABLE 4 (Continued)

| Abbreviated item content | Kj | Mj | SD | Vj | I-CVI | Result |
|--------------------------|----|----|----|----|-------|--------|
| Pruritus with the need to scratch but without excoriations | 66.67 | 4.67 | 0.49 | 0.10 | 1.00 | Stay |
| Pruritus unrelieved by scratching but without excoriations | 50.00 | 4.28 | 1.02 | 0.24 | 0.89 | Stay |
| Pruritus accompanied by excoriations | 50.00 | 4.28 | 1.02 | 0.24 | 0.89 | Stay |
| Totally restless | 72.22 | 4.67 | 0.59 | 0.13 | 0.94 | Stay |
| **M Pain** | | | | | | |
| None | 88.89 | 4.89 | 0.32 | 0.07 | 1.00 | Stay |
| Slight | 77.78 | 4.78 | 0.43 | 0.09 | 1.00 | Stay |
| Moderate | 50.00 | 4.39 | 0.70 | 0.16 | 0.89 | Stay |
| Heavy | 61.11 | 4.44 | 0.98 | 0.22 | 0.94 | Stay |
| Severe | 66.68 | 4.44 | 1.04 | 0.23 | 0.89 | Stay |
LIMITATIONS

There were several study limitations. First, most of the members of the expert panel were from the same province, which might have affected the generalizability and heterogeneity of the results. Second, some subjectivity was required when analysing some skin impairment domains, so this tool is more suitable for professional personnel. Third, we have yet to validate the tool in clinical practice. Further investigation is required to assess the validity and reliability.

CONCLUSION

The CASI assessment instrument is an important, targeted tool to guide clinicians in identifying and diagnosing the severity and healing of skin injury around CVAD sites. More prospective clinical studies are needed to verify the feasibility and stability of the tool.

ACKNOWLEDGEMENTS

The authors appreciate all the nurses’ and experts’ participation and contributions to this project. We are also very grateful to those not listed as authors who provided support in this study.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

LM and YYQ contributed to the study design, the data collection, data interpretation and writing of the manuscript. ZP contributed to the study design and writing of the manuscript. KZW and GXY contributed to the statistical analysis, data interpretation. ZCH contributed to writing of the manuscript. All authors contributed to the preparation of the manuscript and approved the final submitted version.

DATA AVAILABILITY STATEMENT

Author elects to not share data.

ORCID

Ye Qin Yang https://orcid.org/0000-0003-1039-7219

REFERENCES

Almanasreh, E., Moles, R., & Chen, T. F. (2019). Evaluation of methods used for estimating content validity. Research in Social and Administrative Pharmacy, 15(2), 214–221. https://doi.org/10.1016/j.sapharm.2018.03.066

Broadhurst, D., Moureau, N., & Ullman, A. J. (2016). Central venous access devices site care practices: An international survey of 34 countries. The Journal of Vascular Access, 17(1), 78–86. https://doi.org/10.5301/jva.5000450

Broadhurst, D., Moureau, N., & Ullman, A. J. (2017). Management of central venous access device-associated skin impairment: An evidence-based algorithm. Journal of Wound, Ostomy & Continence Nursing, 44(3), 211–220. https://doi.org/10.1097/won.0000000000000322

Buetti, N., Ruckly, S., Schwebel, C., Mimoz, O., Souweine, B., Lucet, J. C., & Timsit, J. F. (2020). Chlorhexidine-impregnated sponge versus chlorhexidine gel dressing for short-term intravascular catheters: Which one is better? Critical Care, 24(1), 458. https://doi.org/10.1186/s13054-020-03174-0

Chan, R. J., Northfield, S., Larsen, E., Mihala, G., Ullman, A., Hancock, P., Marsh, N., Gavin, N., Wyld, D., Allworth, A., Russell, E., Choudhury, M. A., Flynn, J., & Rickard, C. M. (2017). Central venous access device SeCurement and dressing effectiveness for peripherally inserted central catheters in adult acute hospital patients (CASCADE): A pilot randomised controlled trial. Trials, 18(1), 458. https://doi.org/10.1186/s13063-017-2207-x

Cui, K., Shen, F., Han, B., Liu, H., & Chen, J. (2018). Establishment and application of an index system for prevention of coal workers’ pneumoconiosis: A Delphi and analytic hierarchy process study in four state-owned coal enterprises of China. Occupational and Environmental Medicine, 75(9), 654–660. https://doi.org/10.1136/oemed-2017-104909

Curtis, K., Ockery, C., Bennett, P., Heywood, E., & Marshall, L. (2015). Peripherally inserted central catheter cushioning: A pilot study comparing gauze with silicone foam. Clinical Journal of Oncology Nursing, 19(3), 253–256. https://doi.org/10.1188/15.CJn.253-256

Dwadi, S., Zhao, Q., & Budal, B. S. (2019). Peripherally inserted central catheters in critically ill patients - complications and its prevention: A review. International Journal of Nursing Sciences, 6(1), 99–105. https://doi.org/10.1016/j.jins.2018.12.007

Erbay Dalli, Ö., & Kelebek Girgin, N. (2021). Knowledge, perception and prevention performance of intensive care unit nurses about medical device-related pressure injuries. Journal of Clinical Nursing, 1–8, online ahead of print. https://doi.org/10.1111/jocn.16104

Gorski, L. A., Hadaway, L., Hagle, M. E., Broadhurst, D., Clare, S., Kleidon, T., Meyer, B. M., Nickel, B., Rowley, S., Sharpe, E., & Alexander, M. (2021). Infusion therapy standards of practice, 8th Edition. Journal of Infusion Nursing, 44(15), S1–S224. https://doi.org/10.1097/NAN.0000000000000396

Greatrex-White, S., & Mooney, H. (2015). Wound assessment tools and nurses’ needs: An evaluation study. International Wound Journal, 12(3), 293–301. https://doi.org/10.1111/iwj.12100

Günther, S. C., Schwebel, C., Hamidfar-Roy, R., Bonadona, A., Lugosi, M., Ara-Somohano, C., Minet, C., Potton, L., Cartier, J.-C., Vésin, A., Chautemps, M., Styfaloava, L., Ruckly, S., & Timsit, J.-F. (2016). Complications of intravascular catheters in ICU: Definitions, incidence and severity. A randomized controlled trial comparing usual transparent dressings versus new-generation dressings (the ADVANCED study). Intensive Care Medicine, 42(11), 1753–1765. https://doi.org/10.1007/s00134-016-4582-2

Holt, G., & Hughes, D. (2021). A study using semi-structured interview and Delphi survey to explore the barriers and enabling factors that influence access and utilisation of weight management services for people living with morbid obesity: A patient and professional perspective. Journal of Human Nutrition & Dietetics, 34(1), 215–223. https://doi.org/10.1111/jhn.12832

Hu, Q., Qin, Z., Zhan, M., Wu, B., Chen, Z., & Xu, T. (2019). Development of a trigger tool for the detection of adverse drug events in Chinese geriatric inpatients using the Delphi method. International Journal of Clinical Pharmacy, 41(5), 1174–1183. https://doi.org/10.1007/s11096-019-00871-x

Jiang, M., Li, C. L., Pan, C. Q., Cui, X. W., & Dietrich, C. F. (2020). Risk of venous thromboembolism associated with totally implantable venous access ports in cancer patients: A systematic review and meta-analysis. Journal of Thrombosis and Haemostasis, 18(9), 2253–2273. https://doi.org/10.1111/jth.14930

LeBlanc, K., & Baranoski, S. (2011). Skin tears: State of the science: Consensus statements for the prevention, prediction, assessment, and treatment of skin tears©. Advances in Skin & Wound Care, 24(9 Suppl), 2–15. https://doi.org/10.1097/01.Asw.0000405316.99011.95

Levitt, H. M., Bamberg, M., Creswell, J. W., Frost, D. M., Josselson, R., & Suárez-Orozco, C. (2018). Journal article reporting standards for
qualitative primary, quantitative qualitative meta-analytic, and mixed methods research in psychology: The APA Publications and Communications Board task force report. American Psychologist, 73(1), 26–46. https://doi.org/10.1037/amp0000151

Li, J., Oakley, L. D., Li, Y., & Luo, Y. (2018). Development and initial validation of a clinical measure to assess early symptoms of post-stroke depression in the acute stroke patient. Journal of Clinical Nursing, 27(3–4), 784–794. https://doi.org/10.1111/jocn.14099

McNichol, L., Lunn, C., Rosen, T., & Gray, M. (2013). Medical adversities and patient safety: State of the science: Consensus statements for the assessment, prevention, and treatment of adverse-related skin injuries. Journal of Wound, Ostomy & Continence Nursing, 40(4), 365–380. https://doi.org/10.1097/01.won.00003182995516

McPherson, S., Reese, C., & Wendler, M. C. (2018). Methodology update: Delphi studies. Nursing Research, 67(5), 404–410. https://doi.org/10.1097/nmr.000000000000297

Melinovsky, C., Kincaid, H., Claassen, J., Parikh, G., Badjatia, N., & Morris, N. A. (2021). The modified fisher scale lacks interrater reliability. Neurocritical Care, 35(1), 72–78. https://doi.org/10.1007/s12028-020-01142-8

Mimoz, O., Lucet, J.-C., Kerforne, T., Pascal, J., Souweine, B., Goudet, V., Mercat, A., Boudama, L., Lasocki, S., Alfandari, S., Friggeri, A., Wallet, F., Allou, N., Ruckly, S., Balayn, D., Lepape, A., & Timsit, J.-F. (2015). Skin antisepsis with chlorhexidine-alcohol versus povidone iodine-alcohol, with and without skin scrubbing, for prevention of intravascular-catheter-related infection (CLEAN): An open-label, multicentre, randomised, controlled, two-by-two factorial trial. Lancet, 386(10008), 2069–2077. https://doi.org/10.1016/s0140-6736(15)00244-5

Pu, Y.-L., Li, Z.-S., Zhi, X.-X., Shi, Y.-A., Meng, A.-F., Cheng, F., Ali, A., Li, C., Fang, H., & Wang, C. (2020). Complications and costs of peripherally inserted central venous catheters compared with implantable port catheters for cancer patients: A meta-analysis. Cancer Nursing, 43(6), 455–467. https://doi.org/10.1097/ncc.0000000000007472

Stanhope, V., Baslock, D., Tondora, J., Jessell, L., Ross, A. M., & Marcus, S. C. (2021). Developing a tool to measure person-centered care in service planning. Frontiers in Psychiatry, 12, 681597. https://doi.org/10.3389/fpsyt.2021.681597

Su, D., Tao, L., Kong, J., & Li, C. (2017). Study on the application of alginate dressing in PICC-related allergic dermatitis. Chinese General Practice Nursing, 15(3), 297–298. https://doi.org/10.3969/j.issn.1674-4748.2017.03.015

Timsit, J.-F., Mimoz, O., Mourvillier, B., Souweine, B., Garrouste-Orgeas, M., Alfandari, S., Plantefève, G., Bronchard, R., Troche, G., Gauzit, R., Antona, M., Canet, E., Bohe, J., Lepape, A., Vesin, A., Arrault, X., Schwebel, C., Adrie, C., Zahar, J.-R., ... Lucet, J.-C. (2012). Randomized controlled trial of chlorhexidine dressing and highly adhesive dressing for preventing catheter-related infections in critically ill adults. American Journal of Respiratory and Critical Care Medicine, 186(12), 1272–1278. https://doi.org/10.1164/rccm.201206-1038OC

Timsit, J.-F., Schwebel, C., Boudama, L., Geoffroy, A., Garrouste-Orgeas, M., Pease, S., Herault, M.-C., Hausuache, H., Calvino-Gunther, S., Gstin, B., Armand-Lefèvre, L., Leflon, V., Chaplain, C., Benali, A., Français, A., Adrie, C., Zahar, J.-R., Thuong, M., Arrault, X., ... Dressing Study Group (2009). Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically ill adults: A randomized controlled trial. JAMA, 302(12), 1231–1241. https://doi.org/10.1001/jama.2009.376

Ullman, A. J., Cooke, M. L., Mitchell, M., Lin, F., New, K., Long, D. A., Mihala, G., & Rickard, C. M. (2015). Dressings and securement devices for central venous catheters (CVC). Cochrane Database Systematic Review, 2015(9), Cd010367. https://doi.org/10.1002/14651858.CD010367.pub2

Ullman, A. J., Mihala, G., O’Leary, K., Marsh, N., Woods, C., Bugden, S., Scott, M., & Rickard, C. M. (2019). Skin complications associated with vascular access devices: A secondary analysis of 13 studies involving 10,859 devices. International Journal of Nursing Studies, 91, 6–13. https://doi.org/10.1016/j.ijnurstu.2018.10.006

Wall, J. B., Divito, S. J., & Talbot, S. G. (2014). Chlorhexidine gluconate-impregnated central-line dressings and necrosis in complicated skin disorder patients. Journal of Critical Care, 29(6), 1130.e1131–1134. https://doi.org/10.1016/j.jcc.2014.06.001

Wang, C., & Si, Q. (2011). A study of data statistical processing method of Delphi method and its application. Journal of Inner Mongolia University of Finance and Economics, 9(4), 92–96. https://doi.org/10.13895/j.cnki.jmufe.2011.04.019

Wang, L., Wen, P., Xue, M., Tao, Y., Guan, Z., Li, Y., & Mao, J. (2019). Investigation on dressing-related tension injuries among patients with peripherally inserted central catheters. Shanghai Nursing, 19(1), 23–27. https://doi.org/10.3969/j.issn.1009-8399.2019.01.007

Wohl, A. R., Ludwig-Barron, N., Dierst-Davies, R., Kulkarni, S., Bendetson, J., Jordan, W., Bolan, R., Smith, T., Cunningham, W., & Pérez, M. J. (2017). Project engage: Snowball sampling and direct recruitment to identify and link hard-to-reach HIV-infected persons who are out of care. Journal of Acquired Immune Deficiency Syndromes, 75(2), 190–197. https://doi.org/10.1097/qaids.0000000000001312

Yusoff, M. S. B. (2019). ABC of content validation and content validity index calculation. Resource, 11(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6

Zhao, H., He, Y., Wei, Q., & Ying, Y. (2018). Medical adhesive-related skin injury prevalence at the peripherally inserted central catheter insertion site: A cross-sectional, multiple-center study. Journal of Wound, Ostomy & Continence Nursing, 45(1), 22–25. https://doi.org/10.1097/won.0000000000000394

**SUPPORTING INFORMATION**

Additional supporting information may be found in the online version of the article at the publisher’s website.

**How to cite this article:** Liu, M., Zheng, C., Guan, X., Ke, Z., Zou, P., & Yang, Y. (2022). Development of central venous access device-associated skin impairment assessment instrument. Nursing Open, 9, 2095–2107. https://doi.org/10.1002/nop2.1220