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Development and initial psychometric testing of the Intrahospital Transport Safety Scale in intensive care

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ABSTRACT

Objective To develop and evaluate the psychometric properties of a scale measuring patient safety during the intrahospital transport process for intensive care.

Design The scale was developed based on a theoretical model of the work system and patient safety, and items generated from participant observations. A Delphi study with international experts was used to establish content validity. Next, a cross-sectional study was undertaken to inform item reduction and evaluate construct validity and internal consistency.

Setting The questionnaire was distributed to healthcare practitioners at 12 intensive care units in Sweden.

Participants A total of 315 questionnaires were completed. Eligible participants were healthcare practitioners in the included units that performed an intrahospital transport during the study period. Inclusion criteria were (1) transports of patients within the hospital to undergo an examination or intervention, and (2) transports performed by staff from the intensive care unit. We excluded transports to a step-down unit or hospital ward.

Outcome measures Psychometric evaluation, including item analysis, validity and reliability testing.

Results Items were reduced from 55 to 24, informed by distributional statistics, initial reliabilities, factor loadings and communalities. The final factor model consisted of five factors, accounting for 59% of variance. All items loaded significantly on only one factor (>0.35). The original conceptual model of teamwork, transport-related tasks, tools and technologies, environment, and organisation was maintained with regrouping of items. Cronbach's alpha ranged from 0.72 to 0.82 for each subscale (ie, factor).

Conclusions The present study provides a self-report questionnaire to assess patient safety during intrahospital transport of patients in intensive care. The results indicate acceptable validity and reliability of the scale among a sample of Swedish healthcare practitioners. If further confirmatory testing supports the present results, this scale could be a useful tool to better understand safety prerequisites and improve clinical practice.

Strengths and limitations of this study

- This is the first study to evaluate the psychometric properties of a newly developed instrument for measuring patient safety during intrahospital transport (IHT) of patients in intensive care.
- Development of the IHT Safety Scale was informed by theory and previous research, and content validity was tested among a group of international experts using modified Delphi techniques.
- Exploratory factor analysis was performed to achieve a parsimonious set of items and identify the underlying structure among the items.
- Internal consistency reliability of the IHT Safety Scale was evaluated using interitem and item-to-total correlations and Cronbach's alpha.
- Future research is needed to test the IHT Safety Scale using confirmatory factorial analytical approaches and to assess additional aspects of reliability.

INTRODUCTION

During intensive care treatment, patients frequently require examinations and interventions that cannot be undertaken in the intensive care unit (ICU). Yet intrahospital transport (IHT) is a potentially dangerous process for patients; respiratory, haemodynamic and neurological alternations are common.[1–3] International observational studies have reported adverse events rates from 1.7% to 80% during IHTs.[1 4–6] This wide variation might be explained by discrepancies in definitions of transport-related adverse events used across studies, but this also means that the real safety risks faced by patients are not clear. Thus, there is a need to standardise and validate procedures regarding how safety is measured and evaluated during IHTs to better understand clinical risks and improve practices. Furthermore, the IHT process has been associated with system failures and safety hazards. For example, several studies have reported that equipment errors, lack of staff resources, time pressure and environmental disturbances during IHTs are factors contributing to adverse incidents, which may or may not result in patient harm.[7–9] Despite IHT-related risks, to the best of our knowledge, no instrument exists for measuring patient safety during IHTs. The present study therefore aimed to develop a scale, informed by a

human factors engineering model, as a new approach to measure and evaluate IHT safety.

Most studies evaluating safety during IHT measure either patient-related outcomes (eg, physiological changes, mortality and morbidity) or rates of adverse incidents (ie, adverse events, mishaps and near misses).[1 6] However, acknowledging that most errors in healthcare do not arise from the actions of individuals but rather from conflicting, incomplete or suboptimal systems has led to increased attention given to human factors engineering approaches. Human factors engineering is a scientific discipline concerned with understanding the interactions among humans and other elements of a system, to optimise human well-being and overall system performance.[10] Hence, increased understanding of how the structure (ie, healthcare delivery system) influences the IHT process might bring about important insights regarding factors contributing to IHT-related patient safety incidents.

Over 50 years ago, Donabedian[11] presented the structure, process and outcome model for evaluating the quality of healthcare. These concepts remain the foundation for quality assessment in healthcare today.[12] Building on Donabedian's seminal work, the Systems Engineering Initiative for Patient Safety (SEIPS) model was published in 2006.[13–15] It expands on the concept of structure (referred to as the work system) to emphasise the system in which practitioners work rather than their individual performance.[13] The model describes the specific work system components and their relationship. A *person* (or team) performs several *tasks* using various *tools and technologies*. These performances occur within a specific physical *environment* influenced by *organisational* conditions.[13–15] Furthermore, design or redesign of the work system components can contribute to acceptable or unacceptable care processes. Thus, to inform a redesign of the IHT process, there is a need to understand how the work system components influence the care process and outcomes (ie, patient safety).

Aims and questions

The aim of the present study was to develop and evaluate the psychometric properties of a scale measuring patient safety during the IHT process in intensive care. The study addressed the following research questions: (1) To what extent do the items in each of the subscales together represent the underlying dimension of IHT safety? (2) What is the construct validity of the IHT Safety Scale? (3) Is the a priori hypothesised model of IHT safety appropriate for the scale? (4) What is the internal consistency reliability of the IHT Safety Scale?

MATERIALS AND METHODS

Study design

This study included three phases informed by a framework by Boateng *et al*[16] for scale development in healthcare settings. Phase 1, item development, included conceptualisation of dimensions and item identification. Phase 2 involved scale development, including item refinement and content validation using a modified Delphi study with 18 international experts,[17] subsequent translation into Swedish using back-translation techniques[18] and pretesting among six critical care nurses. Phase 3 involved item reduction, and evaluation of construct validity and internal consistency using a cross-sectional study design among a sample of Swedish healthcare practitioners in the ICU. Figure 1 shows each phase, including the activities undertaken and the main results.

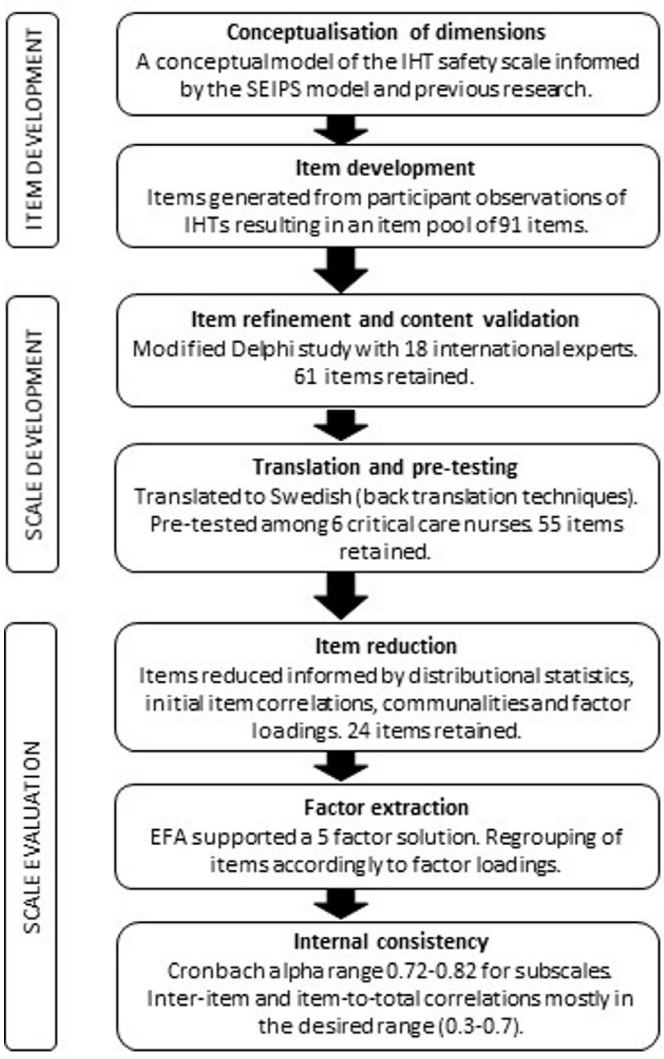

Figure 1 Outline and main results in the development of the IHT Safety Scale. EFA, exploratory factor analysis; IHT, intrahospital transport; SEIPS, Systems Engineering Initiative for Patient Safety.

Conceptual model

In the present study, patient safety is defined as an attribute of the healthcare delivery system that minimises the incidence and impact of adverse events and maximises the recovery from such events.[19 20] The conceptual model for the IHT Safety Scale was based on the SEIPS model's five components of the work system. Thus, we hypothesised that the construct of patient safety during IHTs

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Table 1 Work system components, definitions and characteristics of each dimension in the IHT Safety Scale

Work system components in the SEIPS model	Conceptual definition	Dimension in the IHT Safety Scale	Characteristics
Person(s)	Individuals such as patients, clinicians or teams of healthcare professionals acting and performing tasks.	Teamwork.	Team structure (ie, size, norms, roles, status, cohesiveness). Knowledge, skills and attitudes among team members.
Tasks	Activities or actions performed during a process.	Transport-related tasks.	Task complexity, difficulty, ambiguity and sequence. Perceived workload.
Tools and technologies	Objects used to assist persons in performing tasks.	Tools and technologies.	Usability, functionality, accessibility and familiarity with objects.
Environment	Physical work setting where tasks are performed that influences the care process.	Environment.	Physical layout, available space and workplace design. Factors that might cause sensory disruptions.
Organisation	The structure that provides and coordinates time, space, resources and activities.	Organisation.	Supervision and management support. Attitudes towards safety.

IHT, intrahospital transport; SEIPS, Systems Engineering Initiative for Patient Safety.

has five dimensions: teamwork, transport-related tasks, tools and technologies, environment, and organisation. Each of these dimensions was conceptualised for the IHT Safety Scale based on research in human factors engineering,[13–15 21–26] patient safety literature from related healthcare settings (such as ICU and anaesthesia),[27–29] and previous conceptual work on teamwork and team processes.[30–32] Table 1 presents the work system components in the SEIPS model, conceptual definitions and characteristics of each dimension of the IHT Safety Scale.

Item development

Items in the IHT Safety Scale were generated from participant observations of the IHT process (n=51)[7] and were informed by previous research aiming to measure aspects of patient safety in hospital settings.[29 33–37] The initial item pool, which was written in English, was critically assessed by members in the research group prior to content validity testing. The item pool consisted of 91 items according to the five domains, as follows: 27 teamwork items, 12 transport-related task items, 19 tools and technologies items, 13 environment items, and 20 organisation items.

Item refinement and content validation

A modified Delphi study was conducted to refine items and evaluate content validity of the IHT Safety Scale. The Delphi technique collects experts' opinions to achieve consensus on the relevance of items and clarity of wording.[17] A total of 18 international experts in intensive care from Europe, North America and Australasia participated in the first Delphi round. Of these, 15 experts completed the second round. The group of experts included critical care nurses, physicians and researchers with an average of 22 years of previous experience in intensive and/or acute care. Data were collected from February to April 2019 using an online questionnaire (Webropol Oy, Linköping, Sweden). The experts were asked to rate each item's relevance (not relevant to highly relevant) and clarity of wording (very unclear to very clear) on a 4-point scale. They were also asked to provide comments and/or suggest additional items to ensure that the items covered the construct. The proportion of agreement was assessed using a content validity index (CVI), where the criteria of item-CVI ≥0.78 was used to retain items.[38] The overall scale content validity was calculated using the average method, where ≥0.9 provides evidence of strong content validity.[38] Items were revised and new items were added based on experts' comments and item-CVI values for clarity of wording. Items that did not meet the predetermined criteria of item-CVI ≥0.78 for relevance were omitted. In the first Delphi round, 27 items were accepted for the final item set, 35 items revised, 4 new items added and 29 items omitted. After the second Delphi round, 13 additional items were accepted, 20 items revised and accepted, 1 new item added and 6 items omitted. Thus, the English item set consisted of 61 items.

Translation and pretesting of the Swedish version

The IHT Safety Scale was developed and items generated in English. The English version of the IHT Safety Scale was thereafter translated into Swedish using back-translation techniques.[18] First, one professional translator translated the items from English into Swedish. Second, another professional translator independently translated the Swedish version back into English. Third, the two English versions were compared by the researchers to establish accuracy of the translation. Thereafter, the

Swedish version of the IHT Safety Scale was pretested among six experienced critical care nurses to assess clarity of wording, accuracy and appropriateness. Minor revisions of the item set were made to adapt the scale to a Swedish context. This included omission of six additional items from the English item set.

Questionnaire

The questionnaire had two components: (1) the IHT Safety Scale and (2) generic safety and demographic questions. The IHT Safety Scale was constructed as a self-reported paper-and-pencil questionnaire including 55 items reflecting the five domains of the work system, as follows: 16 teamwork items, 9 transport-related tasks items, 12 tools and technologies items, 9 environment items, and 9 organisation items. The IHT Safety Scale used a bipolar Likert rating scale with descriptors measuring five levels of agreement (strongly disagree to strongly agree). Participants were instructed to reflect on their own IHT experience in answering each statement (item), with higher scores indicating higher agreement on patient safety. In addition, four single generic questions measuring the usability of the checklist and IHT protocol, adverse incidents and patient complications, as well as seven questions regarding participant and transport characteristics, were added to the questionnaire. These questions were added to collect information about existing safety routines and complication rates in our sample.

Setting and sample

The main study (phase 3) used a two-stage sampling approach.[39] First, every ICU in the region of Västra Götaland and Stockholms Läns Landsting in Sweden was invited to participate (n=26). The ICU leaders and directors received written and verbal information about the study and its purpose. An invitation to participate was sent via email and followed up by two reminders. A total of 12 ICUs accepted the invitation and were enrolled in the study. University, tertiary and regional hospitals were represented. The included ICUs had the capability of providing full spectrum of monitoring and life support technologies and had between 5 and 14 beds.

Second, a consecutive sampling approach was used by inviting all staff performing an IHT in the included units to participate during a predetermined time interval. Eligible participants were healthcare practitioners (ie, critical care nurses, physicians, assistant nurses or registered nurses undertaking their specialisation in the ICU) who performed an IHT during the study period. Inclusion criteria were (1) IHTs for a patient undergoing examination and/or intervention within the hospital (such as to the MRI or radiology department, or the operation theatre) and (2) IHTs performed by staff from the ICU. We excluded (1) IHTs to a step-down unit or hospital ward. These transfers were excluded because patients transported to a step-down or hospital ward are no longer critically ill and would not require the same level of surveillance, equipment and therapies and they are not routinely performed by personnel from the ICU. That is, patient and transport characteristics differ from ICU IHTs. Potential participants (ie, staff at the included units) received information about the study design, including that participation was voluntary, prior to data collection. Data were collected anonymously and the return of a completed questionnaire implied consent. Sample calculation using the recommended five participants per item (5×55=275) and a minimum number needed to support factor analysis yielded a target sample size of 300.[40]

Data collection

Data were collected for 6 weeks (from May to the end of June 2019). At each participating ICU, a research assistant was responsible for recruitment and data collection. The questionnaire was available for participants at the units to complete after they had performed an IHT during the study period. All members of the transport team were invited to participate, and thus multiple questionnaires could be filled in from the same IHT. Also, staff at the included units could participate more than once if they performed several IHTs during the data collection period. To avoid recall bias, participants were asked to complete the questionnaire within 72 hours of performing an IHT. Data on IHTs performed during the study period were collected from the Swedish Intensive Care Registry.[41] In total, 325 healthcare practitioners completed the questionnaire regarding their IHT experience. However, 10 questionnaires were excluded on the basis that they did not meet the inclusion criteria (n=4) or were unusable surveys (n=6).

Data analysis

Item analysis was performed with the aim to achieve a parsimonious set of items for each dimension of the IHT Safety Scale. The decision for item reduction was informed by (1) poor distributional statistics, that is, items did not have full variance, were endorsed for extreme values (criteria <75% endorsement of extreme options), were extremely skewed (criteria >2.0) and missing data (criteria <5%); (2) demonstrated redundancy or had low corrected item-to-total correlations; and (3) items with non-significant factor loadings or cross loadings, and communalities <0.5.[42 43] However, if an item did not meet all of the predetermined criteria, the items' theoretical contribution to the construct being measured was further evaluated, informed by the conceptual definition presented in table 1. The selection of items was an iterative process performed by the researchers.[42 43] Missing data were imputed using linear interpolation.

Exploratory factor analysis (EFA) was performed using common factor analysis (principal axis rotation) to further inform item reduction and to identify the factor structure.[40] A Pearson product-moment correlation matrix was used as the basis for the factor analysis. The choice of using Pearson correlation was based on that

data from rating scales can be treated as interval without introducing severe bias and that Pearson correlation is robust in respect of ordinal measurements and non-normality.[43–45] Appropriateness of the data set for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) index (criteria >0.8) and Bartlett's test of sphericity (p<0.05). Factor extraction was informed by the latent root criterion (eigenvalue >1), total variance explained (>60%) and visual examination of the scree plot.[40] The factor solution was rotated using oblique rotation as correlations between factors were expected.[40] A variety of EFAs were performed to identify the final factor solution explaining the highest percentage of variance and that had a clear interpretation. Subsequently, factor loadings of each item were reviewed. Factor loadings of >0.35 were considered significant based on the sample size.[40]

Internal consistency reliability of each subscale was evaluated with Cronbach's alpha (criterion >0.70). Further, interitem correlations and corrected item-to-total correlations (criterion >0.3, with >0.7 indicating possible redundancy) were assessed. Finally, distributional statistics for each dimension, including floor and ceiling effects (criteria ≥15%), were calculated.[42 43] Statistical analysis was performed using IBM SPSS V.25/26.

Patient and public involvement

There was no patient or public involvement in the present study.

RESULTS

Demographics of the sample

A total of 315 questionnaires were included in the analysis. Table 2 presents the characteristics of participants and IHTs. We were unable to determine the response rate owing to an unknown number of (1) questionnaires distributed, (2) IHTs performed on the included units during the study period and (3) staff involved in each IHT.

For seven of the participating units, data on IHTs performed during the study period were available (either provided by the unit or collected from the Swedish Intensive Care Registry). During the study period, 298 IHTs were performed at these seven units. Based on the time, day and destination of the completed questionnaire, we estimated that our questionnaire was completed by at least one participant in 132 of 298 IHTs (44%).

Content validity of the item set

The English set of 61 items had a scale-CVI/average of 0.90 for relevance (range 0.78–1.00) and scale-CVI/average of 0.88 for clarity of wording (range 0.60–1.00).

Item reduction

All items had missing values less than <5% (range 0.3%–3.2%). The iterative process of assessing the contribution of each item to the scale led to identification of a final factor model consisting of 24 items. The items omitted, including the reasons for deletion, are presented in online supplemental table 1. Distributional statistics for the original 55-item version of the IHT Safety Scale are presented in online supplemental table 2.

Table 2 Participant and transport characteristics (N=315)

Characteristics	Frequency	%
Profession		
Critical care nurse	217	69
Nurse assistant	86	27
Physician	8	3
Other	4	1
Number of members on the transport team		
1–2 persons	75	24
3–4 persons	231	73
5 or more	9	3
Transport destination		
CT	219	69
MRI	27	9
Operating theatre	22	7
Other	46	15
Missing	1	0
Time of day		
Day	204	65
Afternoon	86	27
Night	22	7
Missing	3	1
Day of the week		
Monday–Friday	249	79
Saturday, Sunday (or public holiday)	59	19
Missing	7	2
	Median	**IQR**
Years of experience of intensive care	8	3–19
Years employed at current intensive care unit	5	2–12

Factor extraction

The revised 24-item scale data set met the assumptions for EFA with a KMO index value 0.860 and a significant Bartlett's test of sphericity (p<0.001). A five-factor solution was extracted based on the latent root criterion (eigenvalue >1), accounting for 59% of the variance. The rotated solution revealed a discrepancy between how the items performed in the a priori hypothesised structure of the IHT Safety Scale and the final factor solution. Hence, items initially identified for each dimension of the IHT Safety Scale loaded together differently than expected. However, the original conceptual model with the five dimensions of organisation (factor 1), tools and technologies (factor 2), transport-related tasks (factor

3), environment (factor 4), and teamwork (factor 5) was maintained with regrouping of some items.

The first factor (organisation) accounted for 29% of the total variance and included six items. These items had factor loadings ranging from 0.488 to 0.780 and communalities ranging from 0.338 to 0.580. The second factor (tools and technologies) explained 10% of the total variance. It consisted of five items with factor loadings of 0.473–0.792 and communalities of 0.350–581. The third factor (transport-related tasks) had four items, explaining 8% of total variance, with factor loading from 0.483 to 0.901 and communalities between 0.341 and 0.693. The fourth factor (environment) accounted for 7% of variance and consisted of five items. The items had factor loadings ranging from 0.374 to 0.887 and communalities ranging from 0.318 to 649. Finally, the fifth factor (teamwork) explained 5% of the total variance. It comprised four items with factor loadings of 0.513–0.713 and communalities of 0.320–0.682. Table 3 shows the rotated factor matrix for the 24-item version of the IHT Safety Scale.

Table 3 Rotated factor matrix for common factor analysis of the 24-item IHT Safety Scale (promax rotation; N=315)

		Factor loadings				
Dimension	**Item**	**1**	**2**	**3**	**4**	**5**
Organisation	We had sufficient staff resources to prepare for the transport.	**0.780**	−0.022	0.104	−0.029	−0.147
	We had enough time to prepare for the IHT.	**0.770**	−0.063	−0.052	−0.060	−0.020
	We had sufficient staff resources to settle the patient back in the ICU.	**0.666**	0.034	−0.100	0.054	0.088
	I was able to perform IHT-related tasks without being interrupted.	**0.593**	0.151	0.075	−0.119	0.008
	We had enough time to settle the patient back in the ICU.	**0.540**	−0.041	−0.035	0.015	0.136
	IHT preparation in the ICU was well coordinated.	**0.488**	−0.109	0.291	0.158	0.030
Tools and technologies	The transport equipment met the requirements needed to perform the transport safely.	−0.127	**0.792**	0.111	0.002	−0.069
	The transport equipment was reliable.	−0.059	**0.764**	0.058	−0.024	−0.090
	It was easy to monitor the patient throughout the IHT.	0.116	**0.670**	−0.012	0.009	0.029
	Audible alarms supported my work in monitoring the patient.	0.195	**0.483**	−0.174	0.005	0.139
	Medical tools (IV lines, tubes, cords and so on) were suited to the intended purpose.	−0.035	**0.473**	−0.019	0.081	0.190
Transport-related tasks	The skills of staff on our IHT team overlapped sufficiently so that work could be shared when necessary.	−0.097	0.131	**0.901**	−0.020	−0.112
	Individual team members knew what tasks they had to perform.	0.043	−0.050	**0.722**	0.038	0.108
	We had a shared understanding of the task sequence during the IHT.	0.111	−0.073	**0.646**	−0.024	0.140
	I felt supported by the other team members.	0.118	0.024	**0.483**	−0.076	0.077
Environment	Hallways were free from obstacles.	0.004	−0.167	0.011	**0.887**	−0.102
	The physical layout of the hospital facilitated safe performance of the transport.	−0.003	0.068	−0.189	**0.727**	0.120
	Rooms at the destination sites were designed for ICU patients.	−0.133	0.171	0.095	**0.564**	−0.067
	The physical layout of the ICU facilitated preparation for the transport.	0.268	0.143	0.130	**0.380**	−0.138
	We were able to maintain the patient's privacy during the transport.	−0.021	0.148	0.027	**0.374**	0.186
Teamwork	We confirmed each other's responsibilities.	−0.188	−0.097	0.317	0.009	**0.713**
	We gave each other feedback throughout the transport.	0.022	−0.050	−0.065	0.093	**0.655**
	A team leader was clearly recognised.	0.097	0.103	−0.014	−0.157	**0.521**
	All team members were present when transfer information was shared.	0.070	0.112	0.036	−0.034	**0.513**

Bold values: items loading significant to a factor.
ICU, intensive care unit; IHT, intrahospital transport.

Table 4 Descriptive and reliability statistics of the 24-item version of the IHT Safety Scale (N=315)

	Organisation	Tools and technologies	Transport-related tasks	Environment	Teamwork	Total scale
Number of items	6	5	4	5	4	24
Number of subscale levels	24	20	16	20	16	96
Theoretical range	6–30	5–25	4–20	5–25	4–20	24–120
Observed range	8–30	9–25	8–20	5–25	5–20	49–120
Mean (SD)	26.0 (4.5)	22.0 (3.4)	18.5 (2.3)	18.7 (4.9)	16.1 (3.5)	101.2 (13.4)
Skewness	−1.31	−1.40	−2.25	−0.58	−0.74	−0.93
Floor effect (% lowest score)	0.0	0.0	0.0	0.3	0.0	0.0
Ceiling effect (% highest score)	30.2	30.5	49.2	10.2	21.3	2.2
Corrected item-to-total correlations	0.51–0.68	0.51–0.66	0.51–0.73	0.46–0.62	0.47–0.62	n/a
Interitem correlations	0.31–0.58	0.34–0.63	0.43–0.66	0.30–0.57	0.28–0.57	n/a
Cronbach's alpha	0.82	0.79	0.82	0.77	0.72	0.88

IHT, intrahospital transport; n/a, not applicable.

Internal consistency and scale properties

The Cronbach's alpha for each dimension ranged from 0.72 to 0.82. Interitem and item-to-total correlations were mostly within the desired range (0.3–0.7). All items had corrected item-to-total correlations >0.3. No significant improvement in Cronbach's alpha was detected if any additional item had been deleted. Table 4 shows the descriptive and reliability statistics of the 24-item version of the IHT Safety Scale.

Distributional statistics showed that the observed range for the environment dimension covered the theoretical range. For this dimension, 0.3% of scores were at the floor and 10.2% of scores were at the ceiling. Thus, this dimension meets the predetermined criteria of ≤15% proportion of scores at extreme endpoints of the scale. For the four remaining dimensions (ie, organisation, tools and technologies, transport-related tasks, and teamwork), the observed range did not fully cover the theoretical range. Further, ceiling effects were detected, with the subscale of transport-related task showing the highest effect; 49.2% of the scores were at the ceiling. Results also showed that the scores for all five dimensions were negatively skewed. For the total scale, the observed range did not fully cover the theoretical range, but no floor or ceiling effects were observed (0% respectively; 2.2% proportion of scores at extreme endpoints of the total scale).

DISCUSSION

The present study aimed to develop an instrument informed by a theoretical model from human factors engineering as a new approach to measure and evaluate IHT safety. To date, there is increasing evidence suggesting that IHTs are a dangerous process for ICU patients.[1 5] Yet factors contributing to adverse incidents are known to be multifactorial.[46] Therefore, an understanding of how system factors influence the IHT process is needed. Our findings provide evidence of construct validity and internal consistency for the IHT Safety Scale. Thus, the present study provides a preliminary instrument that can be used to assess safety prerequisites during the IHT process for ICU patients.

The IHT Safety Scale was developed based on the SEIPS model framework of the structure of the work system[13–15] and comprised the five dimensions of organisation, tools and technologies, transport-related tasks, environment, and teamwork. Organisation refers to the structure that provides resources and coordinates activities (ie, supervision and management support).[14 22] This dimension highlights the importance of time and staff resources in order to perform the transfer safely. Limited resources, time pressure and workload are known to compromise patient safety in intensive care settings,[47] and it has previously been acknowledged that IHTs require time and resources and are perceived as a stressful and demanding activity.[48] Our findings show that organisational characteristics such as availability of resources were an important safety prerequisite, especially during the pretransport phase as well as when resettling the patient back in the ICU.

Second, the dimension of tool and technologies refers to objects used to assist task performance and is dependent of characteristics such as usability and functionality.[14 26] In terms of IHT safety, the dimension encompasses aspects of the transport equipment used. Importantly, our study findings showed that IHT equipment needs to be reliable and meet the requirements needed for safe task performance. These findings concur with previous research finding that technical errors are a common contributing factor to IHT-related adverse events.[7–9]

The third dimension of the IHT Safety Scale is transport-related tasks. Tasks refer to activities and actions performed during the IHT process. Professional skills and attributes during IHTs have previously been described and include knowledge and experience in performing transport-related tasks and appropriate

level of competence among team members.[48 49] To facilitate safe task performance, our findings identified that technical skills and knowledge about task performance and sequence were important. Furthermore, task performance was enhanced by a shared understanding and support among team members.

The fourth dimension of the IHT Safety Scale, the IHT environment, refers to the physical work setting.[14] Environmental safety hazards during IHTs have previously been described.[7] However, we suggest that environmental deficiencies might be under-reported in the IHT literature as healthcare practitioners tend to adapt their work to cope with system design flaws.[50] Importantly, our findings show that the physical layout and design of the hospital setting, including the ICU setting and rooms and the destination site, were important to perform transfers safely. Finally, teamwork includes attributes such as knowledge, skills and attitudes among team members and the team structure.[31] This dimension encapsulates important aspects of teamwork, such as team leadership, information transfer, confirmation of team roles and feedback among team members. Notably, the association between effective teamwork and clinical performance has previously been described.[51] Moreover, research has demonstrated positive effects of IHT-related teamwork on patient safety.[52 53]

The items developed for the IHT Safety Scale showed good content validity among a group of international experts. Furthermore, we hypothesised that the construct of IHT patient safety was multidimensional, consisting of five independent but related dimensions accordingly to the SEIPS models work system.[13–15] Because this was a newly developed instrument, we used an exploratory approach to identify the factor structure as a first step to assess construct validity. This was because we had no prior empirical knowledge of which items would load to each factor and whether (or to what extent) the factors would be interrelated.[54] We applied common factor analysis for factor extraction.[53] Common factor analysis is recommended when developing new scales and when little previous knowledge exists about specific and error variance among items.[40 55] Moreover, the complex interrelationships among the above-described dimensions have previously been highlighted.[14] Therefore, we assumed that our dimensions would be correlated and oblique rotational method was applied.[40] The findings from the EFA resulted in a parsimonious set of items measuring patient safety during IHTs and yielded a five-factor model with each item significantly loading (>0.35) on only one factor. These findings need to be confirmed and cross-validated in future evaluation studies. Furthermore, our results showed that the IHT Safety Scale was reliable (ie, internally consistent) in our sample, with interitem and item-to-total correlations mostly within the desired range of 0.3–0.7 and Cronbach's alpha ranging from 0.72 to 0.82 for subscales. An alpha coefficient of 0.70 is considered acceptable for newly developed scales and indicates that items on each subscale fit together conceptually.[56] However, our findings showed ceiling effects for all subscales except for the environment subscale. Moreover, subscale scores were negatively skewed, indicating that the healthcare practitioners in our sample agreed on statements concerning patient safety. Interestingly, these findings indicate that safety prerequisites were satisfactory. Yet previous research highlights IHTs as a risky and demanding process.[1 6 48] The discrepancy between the present findings and previous research might be attributed to response bias in our sample using the 55-item questionnaire, and the 24-item version of the IHT Safety Scale therefore needs further testing. Further work is also needed to assess whether the IHT Safety Scale can predict other patient safety outcomes, such as adverse events or incidents (ie, criterion validity). Nevertheless, the IHT Safety Scale offers an easy to administer paper-and-pencil questionnaire to collect healthcare professionals' perceptions about patient safety during the IHT process.

The scale may be used as an indicator of healthcare practitioners' perceptions of safety; low scores indicate system deficits in relation to safe practices. Further, using subscale scores, safety improvements can be targeted to specific areas of the work system. Thus, the IHT Safety Scale might be a useful tool to identify system strength and limitations, which could further inform safety improvements.

Strengths and limitations

The present study has several methodological strengths. First, we used an existing theory and empirical research (participant observations) for identification of items. Second, international experts from North America, Europe and Australia assessed the content validity using modified Delphi techniques. This resulted in a set of items applicable in different countries and settings. Third, in translating the instrument to Swedish, professional translators performed translation and back translation independent of each other. To further ensure accuracy of the translated questionnaire, it was pretested among a sample of nurses experienced in critical care.

However, there were also some limitations to the present study. First, the questionnaire was not pilot-tested among a sample of the relevant population. This might have resulted in items that were perceived as difficult to interpret, that is, resulting in poor distributional statistics. Second, the questionnaires in our study were not coded. Therefore, we were unable to assess inter-rater reliability or calculate an accurate response rate. This was a pragmatic choice enabling the questionnaires to be easily distributed and completed right after participants performed an IHT (ie, avoiding recall bias) and allowing the data to be collected completely anonymously. Because the questionnaires were anonymous, the same participant may have completed more than one questionnaire during the data collection period. However, as the questionnaires reflect different IHTs, each with differing IHT staff, different experiences would be expected. Third, we achieved a sample size just above the minimum recommended ratio of 1:5 for EFA. Although our sample was

appropriate for psychometrical evaluation, we were unable to apply split-sample techniques and thus test the dimensionality of our exploratory identified structure by confirmatory factor analysis. Fourth, our cross-sectional study design did not enable us to assess test–retest reliability (ie, stability over time). Hence, some aspects of validity and reliability were not addressed in the present study; the IHT Safety Scale therefore needs to be further psychometrically evaluated.

CONCLUSION

The present study offers a self-report questionnaire to assess patient safety during IHTs of patients in intensive care. The results provide evidence of acceptable initial psychometric properties of the IHT Safety Scale among a sample of Swedish healthcare practitioners. In our study, EFA yielded evidence of construct validity for a five-factor model of the IHT Safety Scale, including organisation, tools and technologies, transport-related tasks, environment, and teamwork. Further work is needed to validate our exploratory factor structure using confirmatory factor analysis approaches. Nevertheless, the findings from the present study offer a preliminary instrument to measure patient safety during IHTs that can be used to better understand and improve clinical practice.

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