Safety hazards during intrahospital transport: a prospective observational study

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ABSTRACT

Objective: To identify, classify, and describe safety hazards during the process of intrahospital transport of critically ill patients.

Design: A prospective observational study. Data from participant observations of the intrahospital transport process were collected over a period of 3 months.

Setting: The study was undertaken at two intensive care units in one university hospital.

Patients: Critically ill patients transported within the hospital by critical care nurses, unlicensed nurses, and physicians.

Interventions: None.

Measurements and Main Results: Content analysis was performed using deductive and inductive approaches. We detected a total 365 safety hazards (median 7; IQR 4–10) during 51 intrahospital transport of critically ill patients, 80% of whom were mechanically ventilated. The majority of detected safety hazards were assessed as increasing the risk of harm, compromising patient safety (n= 204). Using the System Engineering Initiative for Patient Safety, we identified safety hazards related to the work system, as follows: team (n=61), tasks (n=83), tools and technologies (n=124), environment (n=48), and organization (n=49). Inductive analysis provided an in-depth description of those safety hazards, contributing factors, and process-related outcomes.

Conclusions: Findings suggest that intrahospital transport is a hazardous process for critically ill patients. We have identified several factors that may contribute to transport-related adverse events, which will provide the opportunity for the redesign of systems to enhance patient safety.

INTRODUCTION

Intrahospital transport (IHT) of critically ill patients is required for diagnostic and therapeutic procedures that cannot be performed in the intensive care unit (ICU). IHT is a potentially dangerous process for a critically ill patient. Adverse events (AEs) and mishaps occur frequently, with an overall rate of up to 70% (1-3). AEs are defined as injuries or complications resulting from medical intervention, caused by the healthcare management rather than by the patient's underlying disease (4). IHT can lead to various complications in critically ill patients such as hemodynamic instability (2, 5), increased intracranial pressure (6, 7), ventilator-associated pneumonia (8, 9), respiratory alterations (2, 9, 10), hyper- and hypoglycemia (9), and blood gas abnormalities (5, 10). IHT has also been linked to longer ICU and hospital lengths of stay (9, 11).

Previous research has identified patient-related risk factors that contribute to the onset of AEs during IHT, such as high severity of illness score (5, 12), ventilation with positive-end-expiratory pressure (PEEP) >6 (2), and sedation before IHT (2). Furthermore, human- and system-based risk factors have been investigated (13-16). Guidelines, checklists, and recommendations have been developed on the basis of existing evidence and expert opinions (17-20). However, IHT continues to pose considerable risks for transport-related AEs among critically ill patients (5, 21, 22).

To improve safety, the identification and mitigation of safety hazards is important (23). Hazards (known as risk factors in epidemiological terms) are anything that increases the probability of errors and injuries (24). Most previous studies on risk factors during IHT have been either retrospective—often from self-reported audits—or focused on outcomes. The objective of this study was to prospectively identify, classify, and describe safety hazards during the process of IHT of critically ill patients.

MATERIALS AND METHODS

Study Design

We performed an ethnographic study using semi-structured observations. Ethnography allows the researcher to immerse themselves in a setting, which generates a rich understanding of actions in different contexts (25). The System Engineering Initiative for Patient Safety (SEIPS) model (26, 27), a framework for proactively improving patient safety by focusing on the design of the work system, was used to guide data analysis. This model has previously been used to identify safety hazards in hospital settings (28, 29). The study was approved by the Ethical Review Board at the University of Gothenburg (DNR 1030-15).

Setting and Sample

This study was undertaken in one intensive care department located at a university hospital in Sweden. The department had two ICUs, one specializing in general and trauma intensive care (18 beds) and the other specializing in neurological intensive care (8 beds). During 2016, the units had 2209 (general ICU) and 316 (neurological ICU) admissions. Together they performed 1483 transports (30). The staff consisted of critical care nurses (CCN), unlicensed nurses (UN), and physicians who were either specialists or residents in anesthesia or acute care. In Sweden, CCN are registered nurses that have undertaken one additional year of specialized university critical care coursework. At both ICUs, each CCN cared for two patients (nurse:patient ratio 1:2) with assistance from one UN. The hospital had no specialized transport team.

We selected a purposive sample of IHTs for observation, aiming for maximum diversity (31) among the different kinds of transports, teams, and patients. The inclusion criterion was that IHT was performed by healthcare professionals (HCP) from the ICU. Observation began during the pre-transport phase (i.e. the time from when HCP began preparing for IHT to departure from the ICU); continued through the intra-transport phase (i.e. the time from departure from the ICU to the patient either returned to the ICU or was handed over to

another medical team); and ended with the post transport phase (i.e. the time from when the patient returned to the ICU until regular care was resumed).

Data Collection

Data were collected Monday to Friday during three month (February–May 2016). The first author, an experienced CCN, performed all observations and was present at the study site during the fieldwork period. Participant observations (32) of the IHT process were conducted and field notes recorded. The field notes contained detailed descriptions of the process and interactions within the team, as well as verbatim quotes. Characteristics of the IHT process were recorded in case report forms and reflective notes were taken. Field notes were transcribed by the observer immediately after observation was completed. During fieldwork, emerging findings were confirmed with HCP in the units, and local guidelines were reviewed in order to gain a fully understanding of the IHT process. Data collection continued until saturation occurred.

Data Analysis

Qualitative content analysis was performed (33) using deductive and inductive approaches to identify safety hazards and analyze their patterns. On the basis of the SEIPS model's work system components (26, 27) and the three transport phases, an analytic matrix was designed.

After reading and rereading the data and reflective notes, data were first coded for safety hazards and a quasi-quantitative approach was used to count hazard frequencies. Identified hazards were assessed to evaluate its impact on patient safety (34). Second, safety hazards were deductively classified, using the analytic matrix. Safety hazards within each domain and transport phase were then inductively analyzed. Hazard categories were identified, reviewed and revised to find similarities and differences. Third, factors contributing to safety hazards and process-related outcomes were identified and described. The analysis was performed by the research team, including experienced qualitative researchers and former ICU staff, to

establish the validity of the categories and classifications, and to finalize the results. A reflexive approach (31), constantly recognizing the influence of the researcher on the process, and the relationship between the researcher and the participants, was maintained throughout the research process. NVivo (Version 11, QSR International Pty Ltd., Melbourne, Australia) was used for data management.

RESULTS

During the study period, 51 IHTs were observed, resulting in 44 hours of observation. Transport teams had between two and four members, and 86% consisted of CCNs and UNs without physicians (Table 1). Most transported patients were mechanically ventilated (80%), had continuous intravenous sedation (61%), and stable vital signs before departure (Table 2).

A total of 365 safety hazards were detected (median 7; IQR 4–10). The majority of these were assessed as increasing the risk of harm, compromising patient safety (Table 3).

Table 4 displays all hazard categories related to the five work system domains. One third of all hazards were related to tools and technologies (34 %). Factors contributing to observed safety hazards and process-related outcomes are shown in Supplement Table 1 (Supplemental Digital Content 1).

Team

We detected 61 team-related safety hazards, forming in seven hazard categories (Table 4). In the pre-transport phase, limited communication, poor team management, and a lack of shared situational awareness (i.e., common understanding of the situation) affected team performance. During the intra-transport phase, cooperation problems within the transport team or limited cooperation between teams from different units resulted in mishaps, extended transport time, or ineffective teamwork. In those cases when a physician also attended the transport, uncertainties regarding team roles and responsibilities sometimes arose, which affected the overall team performances. During the post-transport phase, the team became

assimilated with the workforce in the ICU and few team-related safety hazards were seen.

Examples of contributing factors for detected safety hazards included: high turnover of team members in the pre-transport phase, the absence of routine use of structured communication tools, and overlapping and/or conflicting responsibilities between teams from different units.

Tasks

Tasks are specific activities or actions performed by the team during the IHT process. We detected 83 task-related safety hazards, forming seven hazard categories (Table 4). In the pre-transport phase, disturbances and interruptions commonly occurred. For example, when colleagues or another patient required the CCN's attention, transport-related tasks were interrupted. Ambiguities or uncertainties regarding task performance or sequences were present during all transport phases. Notably, tasks such as transporting the patient's bed or moving the patient to the exam table were complex and often resulted in mishaps, such as accidental disconnection of ventilation tubes or power cords. Moreover, when patient handover was required, oral reports were often given as patient care was ongoing. This sometimes resulted in interrupted handovers or incomplete reports. Examples of factors contributing to task-related safety hazards included lack of user-friendly checklists, and limited experience among task providers.

Tools and Technologies

Tools and technologies are the objects used by the team to perform transport-related tasks. As shown in Table 4, 124 safety hazards were detected and seven hazard categories identified. Poor usability of the transport equipment was observed across all transport phases. Notably, it became evident that the equipment did not fulfill all the requirements needed during transport. One example of poor equipment design was that tubes and cords were often too short or inflexible, requiring full attention and exact positioning of the transport equipment to avoid mishaps during exams. Moreover, equipment errors, such as non-functioning surveillance

monitors and false alarms, occurred frequently. Examples of contributing factors included technical problems, poor equipment design, and poor attachment arrangements for transport equipment.

Environment

Environment refers to the physical setting, which in this case consisted of the overall hospital setting including the ICUs and destination sites. We detected 48 safety hazards related to environment, resulting in five hazard categories (Table 4). Before and after transport, a lack of physical space led to workarounds and difficulties in preparing for the transport. After transport had begun, the team had to navigate narrow hallways with various obstacles such as laundry trolleys, chairs, people, and stretchers blocking passage. Rooms at the destination site were often too small to accommodate the bed and equipment, causing additional problems in providing patient care. Contributing factors included poor workplace design and poor planning of the overall hospital setting, including transport routes.

Organization

Organization refers to local management of the ICU and overall hospital organization in providing structure and resources for transport-related tasks and activities. A total of 49 safety hazards and six hazard categories were identified (Table 4). Limited resources and high workload in the ICU departments resulted in failure to prepare the patient for transport or to properly reestablish them in the ICU after transport. These also contributed to stress and unhealthy working conditions. For example, on several occasions, HCPs had to interrupt their breaks to hastily assist with IHT. Poorly coordinated time schedules between units and unclear transport routes could result in either delayed or hastily-prepared IHT. For example, uncertainties about the route, or where the exam or intervention would be performed, resulted in the transport team going the wrong way. Lack of coordination of hospital resources, such as delays at the destination site, resulted in longer transport time. Limited staff resources, lack

of communication between hospital units, and unclear transport routes were examples of contributing factors.

DISCUSSION

To our knowledge, this is the first study using a human factors engineering approach to investigate safety hazards during the IHT process. In addition to previous studies that have investigated system- and human-based risk factors (13-16), we have provided an in-depth description of safety hazards, contributing factors, and process-related outcomes.

Team performance affects quality of care and patient outcomes (4, 35). We therefore investigated which safety hazards could be related to the patient transport team. We found that safety hazards such as cooperation problems, unclear team roles, and a lack of shared situational awareness affected team performance. These findings are consistent with previous research exploring teamwork in a critical care setting (36, 37). Zimmerman et al. emphasized the importance of skills such as strong leadership, coordination, communication, collaborative problem solving, and conflict management to improve performance in the ICU (38). In those cases when a physician attended the transport, we noted that uncertainties regarding team roles and responsibilities sometimes arose. Alexanian et al. found that interprofessional teamwork in the ICU was characterized by medical dominance, concluding that most interprofessional interactions could be described as different professionals collaborating rather than teamwork (36). Our results also imply that a potential barrier for effective teamwork during IHT could be that team roles are constantly changing depending on the team's composition. Therefore, we suggest that general teamwork skills and specific team roles during IHT for critically ill patients should be developed and/or improved.

We identified several task-related safety hazards such as disturbances and interruptions, and task complexity. To our knowledge, these findings have not been previously described in the published literature on risk factors during the IHT process. Our findings suggest that IHT-

related tasks should be evaluated to reduce their complexity. Moreover, disturbances and interruptions that may affect transport-related tasks must be limited.

We identified most safety hazards during the IHT process were related to tools and technologies. Equipment errors represent a well-known safety hazard during IHTs (1, 13, 39). However, our results shows equipment is often not designed to fulfill all requirements for the transport of critically ill patients (i.e., poor usability), resulting in workarounds and equipment-related mishaps. Improving human performance includes designing systems to support the needs of clinicians, which may involve designing tools and technologies (40). Our findings imply a need for suitable and usable transport equipment to support teams during the IHT process.

Our results revealed the ITH's surrounding environments hindered the team's ability to provide care. Previous studies have reported physical environment infrastructure as a factor contributing to incidents during IHT (13, 16). However, we suggest that environmental safety hazards might be underreported because factors that contribute to transport-related AEs could be attributed to other causes (such as human error). Our results suggest that greater attention should be paid to environmental safety hazards in clinical practice and research.

Workload, time pressure, and limited resources are known to adversely affect the quality of care and patient safety in a critical care environment (41, 42). Therefore, we hypothesized that these may also affect the IHT process. We identified various organization-related risk factors, including limited resources and a lack of coordination between hospital units. These findings are supported by Fanara et al., who reported organization-related risk factors as among the most common (15). Furthermore, it has previously been acknowledged that the IHT process requires time and resources and is often perceived as a stressful task by HCP (43, 44). Improving the transport process may therefore involve actions to mitigate organizational safety hazards.

In our study, the majority of detected safety hazards were classified as increasing the risk of harm, compromising patient safety. One possible explanation might be that HCP intervene before hazards cause patient harm, but this study was not primarily designed to investigate patient outcome. However, many of the safety hazards seen (e.g., equipment errors, cooperation and communication problems within the team, and lack of communication between hospital units) have previously been associated with errors and adverse outcomes (1, 13, 16, 39). Therefore, we have provided a list of potential solutions for identified safety hazards to be used in clinical practice (Table 5).

Our results support the usability of the SEIPS framework and ethnographic observations to investigate complex care processes in critical care and may provide guidance for those undertaking Root Cause Analysis (45) to understand the contributing factors to AE. That is, using the work systems components of team, task, tools and technologies, environment and organization provides a structured approach to exploring contributing factors.

The following limitations should be acknowledged. Observations were made at a single hospital site; therefore, the results may not be representative of other sites. Yet, our methods and findings may inform others who examine IHT safety. Data were collected by one observer during weekdays. Further studies in multiple sites by several independent observers might bring additional understanding of IHT risks. However, the potential benefits of ethnographic observations include its usefulness in capturing in-depth information about complex care situations to enhance understanding of the incidence and scope of AEs (46, 47). Finally, it is possible that observation of HCP during IHT changed their performance (47); however, other research suggests that such study participants become accustomed to being observed over time (48).

This study provides the foundation to design future interventions, which then can be implemented and evaluated. To improve quality and safety during transportation of critically

ill patients future studies needs to determinate various systems impact on patient outcomes (49). Careful consideration of the risks of IHTs needs to be compared to the potential benefits for the patient.

CONCLUSION

Findings suggest that IHT is a hazardous process for critically ill patients. We have identified several factors that may contribute to transport-related AEs. In our study, one third of all hazards were related to tools and technologies and the majority of detected hazards did not resulted in observable patient harm. Assessing hazards related to the IHT process and each unique local context is important and necessary for the redesign of systems to enhance patient safety.

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TABLE 1. Characteristics of observed intrahospital transports

Intrahospital transports (n=51)	Frequency	(%)
Transport origin		
CICU	29	(57)
Neuro ICU	22	(43)
Transport destination		
Computed tomography	32	(62)
Angiography catheterization lab	8	(16)
Operating theater	7	(14)
Magnetic resonance imaging	4	(8)
Transport team		
CCNs and UNs	28	(55)
CCNs only	16	(31)
CCNs, UNs, and physicians	7	(14)
Observational data	Mdn	(IQR)
Intrahospital transport time, min ^a	50	(35-65)
Number of safety hazards per transport	7	(4-10)

Abbreviations: CICU, central intensive care unit; Neuro ICU, neurological intensive care unit; CCN, critical care nurse; UN, unlicensed nurse; Mdn, median; IQR, interquartile range.

^a Pre-, intra-, and post-transport included.

TABLE 2. Clinical characteristics of transported patients

Patients transported (n=51)	Frequency	(%)
Medical treatment		
Mechanical ventilation	41	(80)
Continuous intravenous sedation	31	(61)
Vasopressor support	26	(51)
Equipment		
Cardio/respiratory monitoring	51	(100)
Infusion pump(s)	45	(88)
Arterial line	45	(88)
Urinary catheter	44	(86)
Central venous catheter	37	(73)
Nasogastric tube	32	(63)
Endotracheal tube	29	(57)
Ventricular drain	18	(35)
Tracheostomy tube	12	(24)
Other drain(s)	7	(14)
Central dialysis catheter	7	(14)
	Mdn	(IQR)
Respiratory parameters (before transport)		
Respiratory rate (breaths/min)	17	15-22
Oxygen saturation (%)	98	97-100
FiO ₂ ^a	0.35	0.30-0.45
PEEP (cm H ₂ O) ^b	10	10-12
Oxygen (L/min) ^b	3	1- 7.5
Circulatory parameters (before transport)		
Heart rate (beats/min)	77	67-94
Systolic blood pressure (mm Hg)	129	112-142
Diastolic blood pressure (mm Hg)	61	53-66
Mean arterial pressure (mm Hg)	81	68-90

Abbreviations: FiO₂, fraction of inspired oxygen; PEEP, positive end-expiratory pressure.

^aOf those with mechanical ventilation (n=41)

^bOf those without mechanical ventilation (n=10)

TABLE 3. Identified safety hazards impact on patient safety^a

Identified hazards (n=365)	Frequency	(%)
Hazards resulting in observable adverse events	3	(1)
Hazards resulting in no harm events or near misses	77	(21)
Hazards increasing the risk of harm (dangerous situations)	204	(56)
Minor hazards foremost resulting in process-related outcomes	81	(22)

^a Categories modified from Battles and Lilford's definition of patient safety event types (34)

TABLE 4. Identified hazard categories during the intrahospital transport process, based on the System Engineering Initiative for Patient Safety model

Transport phase	Team Hazards n=61 (17%)	Tasks Hazards n=83 (23 %)	Tools and Technologies Hazards n=124 (34 %)	Environment Hazards n=48 (13%)	Organization Hazards n=49 (13%)
Pre-transport phase	<ul style="list-style-type: none"> - Limited communication - Poor team management - Lack of shared situational awareness 	<ul style="list-style-type: none"> - Disturbances and interruptions - Ambiguities regarding tasks or task sequences - Transport-related tasks not performed 	<ul style="list-style-type: none"> - Unreliable functioning of transport equipment - Poor usability of transport equipment 	<ul style="list-style-type: none"> - Limited workspace and poor workplace design 	<ul style="list-style-type: none"> - Limited resources and high workload - Limited communication between hospital units
Intra-transport phase	<ul style="list-style-type: none"> - Cooperation problems within the team - Limited cooperation between teams - Uncertainties regarding team roles and responsibilities 	<ul style="list-style-type: none"> - Disturbances and interruptions - Uncertainties regarding the performance of tasks - Task complexity 	<ul style="list-style-type: none"> - Equipment errors - Equipment-related mishaps - Poor usability of transport equipment - Limited surveillance 	<ul style="list-style-type: none"> - Unsuitable hospital setting and long physical distances - Obstacles in the surroundings - Environmental disturbances 	<ul style="list-style-type: none"> - Lack of coordination between hospital units - Unclear transport routes - Lack of human resources or competences
Post-transport phase	<ul style="list-style-type: none"> - Lack of teamwork 	<ul style="list-style-type: none"> - Transport-related tasks not prioritized 	<ul style="list-style-type: none"> - Poor usability of transport equipment 	<ul style="list-style-type: none"> - Limited workspace and poor workplace design 	<ul style="list-style-type: none"> - Lack of resources and last minute changes

TABLE 5. Examples of potential solutions for identified safety hazards

Work system component	Potential solutions
Team	<ul style="list-style-type: none"> - Develop and define task-oriented team roles and responsibilities - Assign and communicate team roles before departure from the ICU (especially important for the team leader). - Implement and use standardized communication tools (e.g. situation, background, assessment, recommendation; loop- communication) within the transport team as well as between different teams involved in patient care - Enhance collaboration between HCP from different units within the hospital involved in patient care during IHT - Specific team-training (e.g. CRM) to develop team non-technical skills - Implement a “time-out” before departure and, if necessary, during IHT - Triage patients that needs to be transported to decide required level of competence
Tasks	<ul style="list-style-type: none"> - Develop checklist together with end-users to ensure that all transport-related tasks are performed - Minimize disturbances and interruptions while performing transport-related tasks - Map the task processes in order to reduce complexity - Provide all HCP involved in the IHT process with sufficient practice and training to ensure familiarity of transport-related tasks.
Tools and Technologies	<ul style="list-style-type: none"> - Develop transport equipment in collaboration with end-users to ensure they fulfill all requirements needed - Develop and implement technical solutions for attachment of equipment to beds - Enhance availability of transport equipment - Limit technical errors (e.g. non-function beds etc.) - Enable sufficient surveillance at all destination sites
Environment	<ul style="list-style-type: none"> - Provide safe transport passages - Provide resources to ensure a sufficient quality of maintenance - Re-plan hospital setting to shorten transport routes
Organization	<ul style="list-style-type: none"> - Map all resources at a hospital level to enhance cooperation and coordination between units within the hospital to minimize transport time - Define clear transport routes and provide information to involved staff at the clinic - Provide human resources to enable task performance during all phases of the IHT process

Abbreviations: ICU, intensive care unit; SBAR, Situation, Background, Assessment, Recommendation; HCP, healthcare professional; IHT, intrahospital transport; CRM; crew resource management.