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Reminding staff of diligence during the medication process is not enough to ensure safety: Learning from wrong fluid product selection incidents in the care of critically ill patients

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ABSTRACT

Background and objectives: Wrong fluid product selection may cause harm to patients. This study aimed to describe voluntarily reported wrong fluid product selection incidents, including their consequences, the reported latent conditions and active failures leading to these and the suggested safeguards to prevent their occurrence, and to compare the suggested and literature-based safeguards to improve the fluid therapy safety within the intensive care (ICU) environment.
Methods: All voluntarily and anonymously reported wrong fluid product selection incidents in all Finnish ICUs during 2007–2017 were reviewed. The incident reports included categorized data that were analyzed quantitatively, and narratives that were analyzed qualitatively, using content analysis. The results were reported as frequencies and percentages and described by using Reason's model of human error.
Results: Over the eleven years, one wrong fluid product selection incident was reported every six days (n = 663; 584 errors, 79 near misses); most were reported to have occurred during the dispensing/preparing phase (92%). Of the 584 reported selection errors, a quarter (26%) was reported to have caused consequences to patients, and one third (35%) to have required corrective or monitoring actions. The main reported latent conditions to the incidents were *Working environment and resources* (*e.g. workload and time pressure*) (*29%*), *Similar-looking and -sounding names or shared features of the product containers* (i.e. the *LASA phenomenon*) (28%) and *Working methods* (22%); and the main reported active failures were a lack of concentration, or forgetfulness (26%). Some usable suggestions of safeguards were made, e.g. optimizing fluid storage (15%) or utilizing checking practices (21%). While requiring accuracy, i.e. reminding staff of diligence and to be more attentive to detail during the whole medication process, was emphasized in most reports (71%), involving manufacturers in redesigning labels of fluid products, utilizing technology and strengthening pharmacy services are advocated existing literature.
Conclusions: Wrong fluid product selection incidents with various latent conditions and active failures were reported more than once a week. To minimize the serious *LASA phenomenon*, multi-professional collaboration, coordinated international discussion and agreements of solutions with manufacturers, regulators and end-users, are needed. However, work is also needed to reduce the other latent factors, such as *Working environment and resources* as well as cognitive biases in daily work that may contribute to the occurrence of LASA related errors.

1. Introduction

For more than a century, fluid therapy has been in clinical use.[1,2] In the treatment of a critically ill patient, different fluid products are used to correct intravenous volume deficiency or acute hypovolemia, to compensate for existing or developing deficiencies, and to maintain daily needs. They are also used to dilute medicines and, in small amounts, to keep vascular catheters open. Improper fluid selection cause to contribute to the patient: changes in blood glucose[3] electrolyte disturbances; hyperchloremic metabolic acidosis; and renal failure requiring dialysis, increasing morbidity and mortality.[1] To provide optimal care for patients, intravenous fluids should be treated with the same intensity as other medications, as they have specific indications, contraindications and adverse effects.[1,2] Medical expertise is required to select the right treatment, considering individual patient factors and other treatments. Moreover, critical care nurses have an important role in implementing and monitoring safe fluid therapy[4] and pharmacists have unique expertise to optimize fluid therapy.[1,2,5] In Finnish intensive care units (ICUs), physicians are responsible for prescribing and nurses for dispensing/preparing and administering fluid therapy. While in some ICUs pharmacists mainly maintain medicine stocks and

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prepare medicines, they are gradually gaining specialist roles in clinical pharmacy in multidisciplinary teams to improve medication safety.[6]

Only some cases of fluid product selection errors have been reported.[3] Similar-looking and -sounding names (Look-Alike and Sound-Alike or LASA) or shared features of the product containers may contribute to selection errors; up to 33% of reported medication errors may be caused by packaging and labelling confusion and up to 25% by name confusion, all of which poses a significant threat to patient safety.[7] The current guidelines of the Finnish Medicines Agency[8] and European Commission[9] for the naming, packaging and labelling of medicines consider some patient safety factors, such as instructions for the naming of the medicine and the information content of the labels. However, they do not appear to consider all human factors, which the then National Patient Safety Agency, which merged with the National Health Service (NHS) NHS in 2019, drew attention to while making recommendations to the healthcare industry for the designing, labelling, and packing of injectable drugs, including fluid products[10]. Recently in the US, The Institute for Safe Medication Practices (ISMP, 2021) has voiced concerns about recurring incidents involving confusion about similar appearances of labelling and packaging of premixed and base solutions, in which manufacturers have a key role to improve fluid therapy safety.[11] Protective structures for this and other factors, contributing to wrong fluid product selection incidents, should be developed, so that the World Health Organization's (WHO 2021) Global Patient Safety Action Plan to eliminate avoidable risks and harms to patients in healthcare,[12] is also applied to fluid therapy.

The use of voluntary incident reporting systems to aggregate incident reports at the national level enables identifying, and learning from, the risks and contributing factors of rare incidents, which may not be easily identifiable at the local level.[13] Indeed, the Council of Europe recommends establishing a national focal point for developing safe medication practices. In Finland, voluntary and anonymous Reporting System for Safety Incidents in Health Care Organizations (national reporting system) has been employed since 2007[14] while a national focal point for developing safe medication practices has yet to be established.

Reason's model of human error (2000), is widely used in patient safety research to analyze the causes of errors.[15] According to the model, every organization has safeguards to prevent errors, but the safeguards may have weaknesses. The safeguards are in constant motion, and, thus, their weaknesses are also shifting their location. Sometimes, the weaknesses momentarily line up to permit an error to progress past the safeguards, leading to an incident. The model approaches human error from two perspectives: an organizational/system perspective (the conditions in which individuals work (i.e. latent conditions)); and the individual perspective (mistakes, slips and lapses (i.e. active failures)). According to Reason, almost all incidents are caused by these two factors and, therefore, both perspectives should be considered while designing safeguards to be the most reliable in healthcare. Latent conditions, such as a lack of knowledge, poor training and communication errors, workload, staff shortages, complexity of tasks, stress and interruptions and disruptive work environment as well as cognitive biases may lead to medication errors.[7,16,17]

Firstly, the study aimed to describe the voluntarily reported fluid selection incidents, the fluid products involved, the reported consequences of these incidents, the actions taken to alleviate or monitor the consequences, and the phases of medication process at which the incidents had been reported to have occurred. Secondly, the aim was to describe the reported latent conditions and active failures of incidents, the safeguards the members of staff had suggested to be implemented to improve medication safety, and to compare these suggestions with existing literature. To our knowledge, there are no previous studies concerning wrong fluid product selection incidents within the ICU environment at the national level.

2. Methods

This retrospective mixed-methods study examined all wrong fluid product selection incidents including both errors and near misses, reported voluntarily and anonymously by healthcare professionals (rapporteurs) to the national reporting system from all adult and paediatric intensive care and high dependency units (ICUs) in all healthcare districts ($n = 20$) in mainland Finland during 2007–2017. In this study, wrong fluid product selection incident means prescribing (physicians), dispensing/preparing (mainly nurses and in some ICUs pharmacists during office hours) or administering (mainly nurses and sometimes physicians) of a wrong fluid product.

To obtain the data from the administrator, research permissions were obtained separately from each healthcare district for the 2007–2014 data set (2007 was a pilot year), and centrally from the Finnish Patient Safety Association for 17 districts and separately from three others that are not members of the Association for the 2015–2017 data set. An ethical review was not required as no identifiable patient information is included in the reports.

The administrator of the national reporting system, Awanic Ltd., provided all medication related incident reports of the ICUs in Microsoft Excel® spreadsheets to the first author (MK). In the national reporting system, structured reporting of medications involved in incidents has been possible since 2015[18]; previously, they had been reported in the narratives that were used to identify medications involved in the incidents by the first author (MK) who discussed unclear cases with the second author (SS). All incident types related to fluid products were identified manually, and after which the wrong selection of fluid product incidents were identified manually and included in this study. The incident reports included categorized data reported voluntarily by rapporteurs and completed locally by classifiers, mainly head nurses in ICUs, and narrative descriptions of the incidents reported by the rapporteurs.

The study employed both quantitative and qualitative analysis. Quantitative descriptive analyses were performed to the categorized data, such as the fluid products involved, nature of incidents (both errors and near misses), consequences to the patients, the phases of the medication process at which the incidents had been reported to have occurred, and latent conditions. The first author (MK) reviewed the original categorizations of the incidents independently and used the narrative descriptions of the incidents to supplement the categorizations, and both were described separately in the results. All unclear reports were discussed with the second author (SS) to reach consensus. Categorized latent conditions, and active failures within the medication process were illustrated onto Reason's model by all authors.

For this study, the fluid products involved in the incidents were categorized according to the Anatomical Therapeutic Chemical (ATC) Classification system: Electrolyte solutions; Electrolytes with carbohydrate solutions, Blood substitutes and plasma protein fractions (Colloids), Other blood products (Blood products) and IV solution additives (e.g. Electrolyte concentrates, vitamins). The following groups were added: parenteral and enteral nutritions were combined and named as *Nutritions*; Peritoneal dialysis, haemodialysis and haemofiltrates were combined and named *Dialytics;* and the *Special fluids* group contained e.g. ready-to-use heparinized solution only used in the cannula flush system, sterile water, and sodium bicarbonate.

The classifiers had categorized the consequences of the incidents to patients as *minor* (a mild harm demanding little or no treatment), *moderate* (a harm demanding treatment) and *major* (a harm impairing the patient's quality of life or requiring life-sustaining care). They had also categorized the latent conditions of the incidents (Table 1) as well as proposed prevention measures or safeguards in the following categories: informing others or discussing what had happened; involving management at a higher level required; planning a development measure required; or no action required. Multiple latent conditions or safeguards could have been reported for each fluid selection incident.

Descriptive statistical analyses were conducted using Microsoft Excel®; the results are reported as frequencies, percentages and medians.

Additionally, qualitative abductive content analysis[19] of the narratives was performed to identify and categorize the described consequences to patients; actions taken to alleviate or monitor them; any external or local latent conditions, and active failures; as well as safeguards to prevent similar incidents from occurring. The first author (MK) read repeatedly all

Table 1
Categorized latent conditions of the incidents and examples of them.

Working methods
Working methods and procedures
Availability and use of instructions related to the task
Clarity of the task
Decision making tools
Working environment and resources
Workload, shift arrangements, time pressure
Number and qualification of staff
Physical working environment
Problems with the operation and use of patient and other information systems
Communication
Insufficient use of available information
Verbal or written communication incomplete or unclear
Education, induction and competence
Knowledge, skills and competence
Availability and adequacy of training and guidance
Medications
Generic medicines
Teamwork
Work supervision
Cooperation, division of work and support
Equipment and supplies
Availability and placement of a device
Availability of equipment and supplies (ergonomics)
Organization and management
Operating principles and management practices
Patient and relatives
Severity of the disease
Unknown or no categorized factors

narrative descriptions, analyzed and preliminarily categorized them, all of which were discussed with all authors to reach consensus. Thereafter, the first author performed the final categorizations independently and consulted the second author (SS) about any unclear reports. The safeguards described in the narrative data were compared with the safeguards identified existing literature and were illustrated onto Reason's model by all authors.

3. Results

A total of 7623 medication related incident reports, of which 2089 concerned fluid therapy, including errors (reached the patient) and near misses (did not reach the patient), were voluntarily reported by healthcare professionals in ICUs during 2007–2017. Duplicated reports ($n = 5$) and inadequate reports (reports did not describe an actual incident) ($n = 34$) were excluded, and reports, in which more than one incident had been reported, were divided into separate reports ($n = 151$), resulting in 2201 incident reports: on average, one fluid therapy incident was reported every other day. Of these, 663 (30%) were related to *wrong fluid selection* (Fig. 1): on average, one incident was reported every six days; most had reached the patient ($n = 584$, 88%). During the first pilot year, only four wrong fluid selection incidents were reported. Thereafter, the median was 59 (IQR 41.0–66.5) wrong fluid product selection incident reports annually during the first five years (2008–2012), and 78 (IQR 67.5–86.0) during the last five years (2013–2017) of data collection, respectively.

3.1. Wrong fluid product selection incidents by fluid groups

The most frequently reported selection incidents occurred *between Electrolyte solutions* ($n = 116$, 18%) (Table 2); most often between Sodium chloride 9 mg/ml and Ringer's acetate solutions ($n = 81$). The second most commonly reported selection incidents occurred *between IV solution additives* ($n = 78$, 12%); mostly between Potassium chloride and Potassium phosphate concentrates ($n = 30$) and between Potassium and Sodium chloride concentrates ($n = 25$), and *between Nutritions* (n = 78, 12%); mostly between *Nutritions* with an identical brand name but different specific characteristics ($n = 68$) (Fig. 2).

3.2. Reported consequences and correcting actions of fluid product selection errors

Almost one fifth ($n = 110$, 19%) of the 584 reported *errors* had been categorized to have caused consequences to patients (Table 2). While the classifiers had recorded "*no consequences*" or consequences "*not known*" to patients in 39 incident reports, the rapporteur had described consequences to patients in the narrative of these reports. Thus, at least one quarter ($n = 149$, 26%) of the reported errors had resulted in consequences to patients, of whom one died. According to the narratives, the most common consequences of the errors to patients were blood glucose changes ($n = 49$), electrolyte disturbances ($n = 38$) and haemodynamic changes ($n = 13$). Furthermore, a third of the incidents ($n = 202$, 35%) had been reported to have required some corrective action to alleviate the consequences (i.e. additional treatments or medicines, or monitoring of, patients). to alleviate the consequences to the patient.

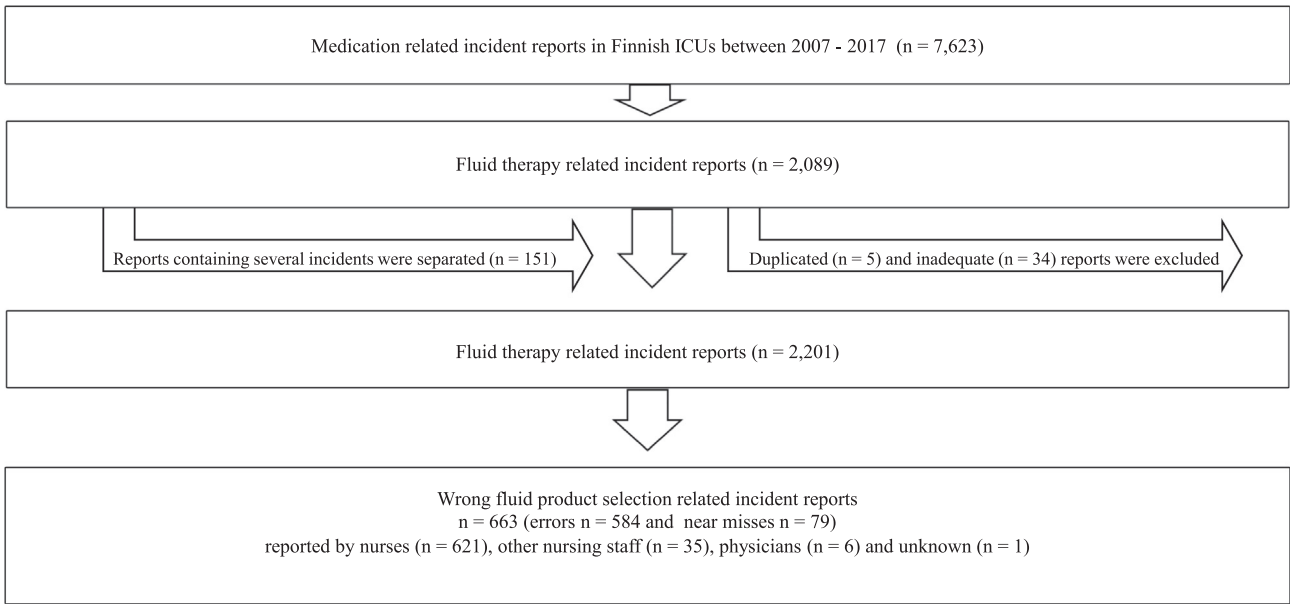

Fig. 1. Flowchart of identifying the voluntarily reported wrong fluid product selection incidents in all ICUs in Finland (2007–2017) and their rapporteurs by profession.

Table 2
Reported wrong fluid selection incidents by fluid groups (n = 663) with the nature of the incidents, the categorized consequences to patients, the described consequences to patients, and the described correcting and monitoring actions.

Reported selection incidents by fluid groups	Nature of the incident, n			Categorized consequences to the patients, n						Consequences to the patients described in the narratives, n	Correcting and monitoring actions taken after the incident described in the narratives, n			
	Error	Near miss	Total	Major	Moderate	Minor	None	Not known	Total	Total	Treatment*	Monitoring with additional laboratory test(s)	Administering additional medicine(s)	Total
Between Electrolyte solutions	112	4	116	0	0	11	80	25	116	8	0	10	3	13
Between IV solution additives	65	13	78	1	0	11	53	13	78	12	1	19	0	20
Between Nutritions	76	2	78	0	1	9	53	15	78	6	1	4	1	6
Between Carbohydrate solutions	70	4	74	0	4	17	40	13	74	25	0	32	18	50
Between Electrolyte solutions and Electrolytes with carbohydrate solutions	60	5	65	0	1	14	41	9	65	22	0	23	12	35
Between Blood products	15	35	50	1	0	3	39	7	50	2	2	3	2	7
Between Electrolytes with carbohydrate solutions	44	3	47	0	0	3	33	12	47	3	0	7	0	7
Between Fluid Products and Drug infusions	44	1	45	1	2	13	21	8	45	19	0	10	14	24
Between Special fluids and Fluid Products	29	3	32	0	0	2	8	22	32	2	0	4	1	5
Between Dialytics	19	1	20	0	0	4	15	1	20	7	0	11	2	13
Between Carbohydrate and Electrolytes with carbohydrate	19	1	20	0	0	2	16	2	20	4	0	5	2	7
Between Electrolyte solutions and IV solution additives	6	6	12	0	0	3	9	0	12	3	0	4	4	8
Between Electrolyte solutions and Carbohydrate solutions	9	1	10	0	0	1	8	1	10	1	0	1	0	1
Between Colloids	8	0	8	0	0	3	5	0	8	1	0	0	1	1
Between Others**	8	0	8	0	0	3	2	3	8	4	0	3	2	5
Total	584	79	663	3	8	99	422	131	663	119	4	136	62	202

* Treatments included cannula-related procedures, administration of excess oxygen, haemodialysis and resuscitation.
** Between Others included wrong selection of fluids between Colloid and electrolyte solutions ($n = 2$), Colloid and Electrolytes with carbohydrates ($n = 1$), Nutrition and Electrolyte solution (n = 1), Nutrition and Electrolytes with carbohydrates (n = 1) and between Citrates and IV solution additives (n = 3).

LASA, similarities in fluid product names

Enteral nutritions:
Brand name
Brand name advanced cubison
Brand name advanced diason
Brand name energy
Brand name energy multi fibre
Brand name multi fibre
Brand name pre
Brand name protein multi fibre
Brand name protein plus
Brand name protein plus multi fibre

Carbohydrates
Glucos Manufacture´s name 50mg/ml
Glucos Manufacture´s name 100mg/ml
Glucos Manufacture´s name 200mg/ml
Glucos Manufacture´s name 300mg/ml
Glucos Manufacture´s name 500mg/ml

Crystalloids:
Brand name
Brand name glucos
Natr.klorid Manufacture´s name c. gluc 3/50 mg/ml
Natr.klorid Manufacture´s name c. gluc 9/50 mg/ml
Natriumklorid Manufacture´s name 9 mg/ml
Natriumklorid Manufacture´s name 4,5 mg/ml

Parenteral nutritions:
Brand name lipid peri
Brand name lipid plus
Brand name lipid special
Brand name peri
Brand name plus

I.V. solution additives:
Brand name -Kalium
Brand name -Kaliumklorid
Brand name- Magnesiumsulfaatti
Brand name- Natriumklorid
Brand name- Tham

LASA, the appearance of fluid bags or bottles

Fig. 2. The names and the appearances of fluid products mentioned most often in the incident reports to have contributed to selection errors, i.e. they looked too similar with another fluid product. LASA (Look-Alike and Sound-Alike) similar-looking and sounding names or shared features of the product containers. Photographs taken by Minna Kurttila on 1st July 2020 in Kuopio University Hospital Pharmacy.

3.3. Reported latent conditions in wrong fluid selection incidents and safeguards to prevent them

The manufacturers (n = 183, 28%) as the designers of the fluid product names, labels and packaging (i.e. the LASA phenomenon), and hospital pharmacies (n = 22, 3%) responsible for the procurement of medicinal products, were identified to be responsible for the *external* latent conditions for wrong fluid selection incidents (Fig. 3). Similar names or packaging of fluids had explicitly been mentioned in 144 (21%) narratives of the reports. In addition to that, in another 43 reports, the problem with similar names or packaging had implicitly been described through recommending optimizing the safe storage of fluids to prevent the occurrence of mix-ups between fluid products. Thus, the LASA phenomenon was involved in almost one third of the reported incidents (n = 187, 28%); the median was 14 (IQR 8.5–19.0) LASA phenomenon reports annually during the first official five years (2008–2012), and 25 (IQR 18.0–28.5) during the last five years (2013–2017) of data collection, respectively. As a safeguard, some rapporteurs proposed that the names and appearances of the fluid products should be redesigned (n = 58).

The most typical categorized *local* latent conditions for wrong fluid product selection incidents were *Working methods* (n = 147, 22%), followed by *Working environment and resources* (n = 62, 9%), *Communication* (n = 57, 9%) and *Education, induction and competence* (n = 48, 7%) Additionally, in another 129 narratives conditions related to the *Working environment and resources*, such as time pressure, workload, staff shortages, multitasking, interruptions, insufficient lighting were described, so the *Working environment and resources* accounted for almost one third of the reported incidents (n = 191, 29%). Similarly, in another 77 narratives conditions related to *Education, induction and competence* were described, increasing its share to almost one-fifth (n = 125, 19%). Finally, descriptions related to C*ommunication* were mentioned in another 18 narratives, increasing it to 11% (n = 75).

Most frequently the classifiers had proposed to prevent the recurrence of similar incidents by *informing others or discussing what had happened* (n = 481, 73%) and often thought that *no action was required* (n = 125, 19%). However, in the narratives, the rapporteurs had most commonly suggested *education* (n = 59, 9%) as a safeguard.

3.4. Reported active failures in wrong fluid selection incidents and safeguards to prevent them

Wrong fluid product selection incidents were reported to have occurred mainly during the dispensing/preparing phase (n = 607, 92%) of the medication process, followed by the administration (n = 35, 5%) and prescribing phase (n = 21, 3%) (Fig. 3).

In the narratives, the rapporteurs, had described e.g. a lack of concentration, or forgetfulness (n = 170, 26%) and physical feelings of tiredness or sickness (n = 18, 3%). To counteract these, the rapporteurs and classifiers had suggested safeguards known to them: *requiring accuracy,* i.e. reminding staff of diligence and to be more attentive to detail during the whole medication process (n = 471, 71%); *double-checking, use of check-lists and shift-changing checks* (n = 140, 21%); and *optimization of the fluid storage* in the ICUs (n = 100, 15%). In comparison, existing literature, other safeguards to prevent wrong fluid selection errors are recommended; most notably, involving manufacturers in improving the identification of fluid products, utilizing technology and strengthening pharmacy services in the fluid therapy process (Fig. 3).

4. Discussion

4.1. Results overview

In this national study covering all Finnish ICUs from 2007 to 2017, one wrong fluid product selection incident was, on average, reported every six days. While the reporting activity of these incidents seemed to have reached a plateau during the last five years of the study, only a fraction of medication incidents can be identified through voluntary reporting.[31] Most incidents were reported to have occurred during the dispensing/preparing phase. In Finland, nurses are mainly responsible for dispensing/preparing medicines, including fluids; a task for which hospital pharmacists or technicians could offer their expertise.[23] The most frequently reported wrong selection incidents occurred between Electrolyte solutions, between IV solution additives and between Nutritions; the latter two groups include high-alert medications, potassium concentrates and parenteral nutritions, that may cause significant harm to the patient, if used in error.[32] At least a quarter of the reported fluid selection errors led to consequences for patients. To prevent the recurrence of such incidents, the rapporteurs and classifiers had made some usable suggestions, e.g. optimizing fluid storages or employing double-checking of fluids, using checklists and shift changing checks, but most often the need for requiring accuracy, i.e. reminding staff of diligence and to be more attentive to detail during the whole medication process, was mentioned as a safeguard. Comparing these safeguards with those found in existing literature, showed a disparity; according to the literature safety within the fluid therapy processes should be improved by utilizing more extensively protective safeguards, which is also in line with the WHO Global Plan of Action on Patient Safety.[12]

4.2. Latent conditions and active failures in wrong fluid product selection incidents and safeguards to prevent them

In this study, the *LASA phenomenon* and *Working environment and resources* were both identified in nearly a third of the wrong fluid product selection incidents as latent conditions, followed by *Working methods* and *Education, induction and competence*, both in one-fifth of the incidents. These latent conditions, especially overburdened staff; as well as psychological aspects, like cognitive biases, may further contribute to the LASA phenomenon.[7] Confusion is compounded by similarities in the spelling of the names of medicines, especially, if sharing at least three identical letter strings or groups of letters at the beginning of the names[33]; as well as similarities in the infusion bags with a transparent bag, clear fluid and black labelling. Estock et al. (2018) have shown in high-fidelity clinical simulation, that selection errors may be reduced by using redesigned labels to identify and select the right intravenous bag.[34]

The findings of this study related to the fairly stably reported LASA phenomenon, the recommendations of the then NPSA on designing medicine packaging and labelling,[10] and the intentions of the ISMP to launch discussions with regulators and manufacturers on the LASA risks with premixed and base solutions,[11] show that the LASA phenomenon of fluid products is worldwide. Thus, developing safe product names and readable labels and barcodes should take place both at national and international levels, between medication safety organizations, manufacturers, regulators and end-users to find solutions to ensure safe identification of the products at all phases of the fluid therapy process.[11,20]

At the organizational level, the wrong fluid product selection errors should also be prevented. Hospital pharmacies should consider, in addition to prices, safety management in the medicine procurement process by avoiding LASA medicines and favouring barcodes on the primary drug packaging.[30] They could also offer re-packaging and attaching extra stickers on the packaging[20]; using different typographical strategies (e.g. TALLman Lettering),[20,21] and inform healthcare professionals about changes in the formulary.[30]

When developing safeguards, the working environment, working methods, by utilizing organized fluid storages,[7,11,21] double-checking-policies[3,7] or technology, e.g. using bar coding during dispensing[22] and administering[20,21] to verify right fluid product, as well as the individuals and their activities should also be taken into account. Cognitive biases, errors or distortions in decision-making, are increasingly recognized as contributors to patient safety incidents.[16] Person-, patient-, and system-related factors, such as excessive workload, work-related stress, lack of resources, and complexity of tasks, observed also in this study, may expose, or increase the probability of, cognitive biases. Thus, it is important for organizations to gain knowledge about cognitive biases and the factors

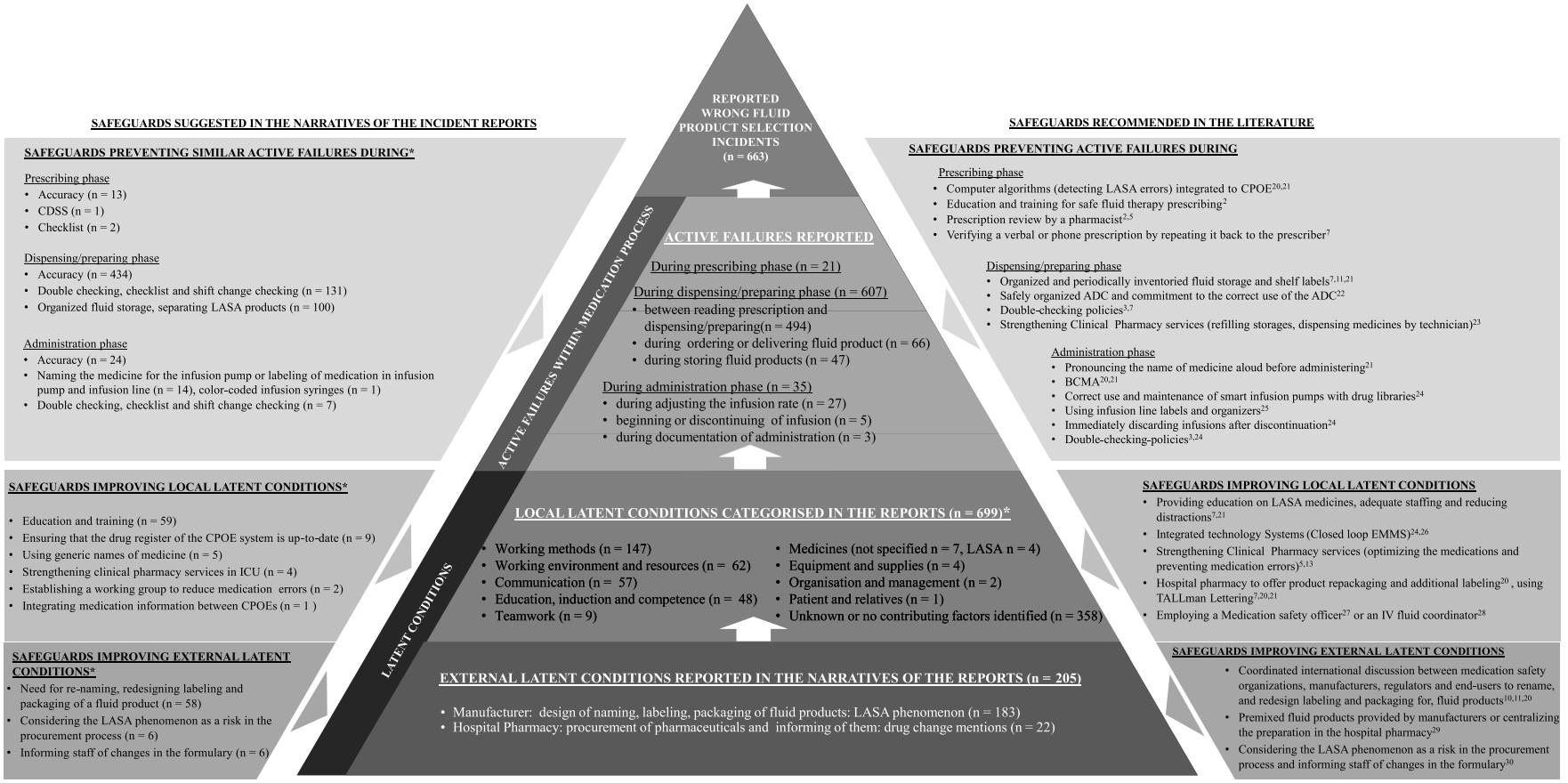

Fig. 3. Triangle of reported latent conditions and active failures in different parts of medication process related to wrong fluid product selection incidents, surrounded by safeguards identified in the narrative descriptions of incident reports (on the left of the triangle) and existing literature (on the right of the triangle). [2,3,5,7,10,11,13,20–30] * More than one latent condition or safeguard suggestion could have been reported for each fluid selection incident. Abbreviations: CPOE, Computerized Physician Order Entry; CDSS, Clinical Decision Support System; BMCA, Bar Code Medication Administration; ADC, Automated Dispensing Cabinet; Closed Loop EMMS, Closed Loop Electronic Medication Management Systems; and LASA, Look Alike and Sound Alike medications.

affecting them. Further, improving work system conditions, such as investing in the well-being of healthcare personnel and strategies to reduce work-related stress, optimizing the physical work environment, ensuring adequate staffing and expertise and regular training on medicines, are crucial strategies to reduce errors in general.

Hospital pharmacies in turn, can improve medication safety in ICUs by optimizing and maintaining fluid storage and offering drug stock refilling service provided by pharmacy technicians. Under the supervision of pharmacists, appropriately trained technicians could be involved in dispensing and preparing medicines to patients, which is already practice in several countries.[23] Such skill-mix allows pharmacists to devote time to clinical pharmacy services,[23] such as working in a team with prescribers and nurses, conducting medication and fluid product prescription reviewing,[5] and building and implementing strategies for safer medication processes,[13] as recommended by the European Association of Hospital Pharmacy.[35]

Some of the safety measures mentioned above may be complex interventions requiring changes in organizations and time for practical implementation. Therefore, risk management activities should be well-coordinated and adequately resourced with clear responsibilities with expert understanding of medication safety, as development work must be continuous. At the organizational level, such a task could be given to Medication Safety Officers (MSO)[27] or IV Fluid Coordinators[28] responsible for safe fluid therapy training, reviewing IV fluid related incident reports, and implementing evidence-based best practices in IV fluid therapy processes. They could also develop guidance for safe fluid therapy practices at the national or international levels (e.g. to tackle the LASA phenomenon as a medication safety risk with the contribution of the regulators and manufacturers). In Finland, the first MSO was employed in one of the Healthcare districts in 2017[6]; their number has since increased.

4.3. Strengths and limitations

This study included all fluid selection incident reports from all Finnish ICUs on the mainland during eleven years. Data aggregation was employed to uncover systematic failures of certain incidents that are not easily identifiable at the local level.[13] Another strength of this study was the analysis of both the structured categorized data and the free-text narratives of the incident reports. These together provided a comprehensive picture of some of the points of risk associated with wrong fluid product selection incidents, for which system based safeguards should be developed to prevent further errors. It should be noted that while the analysis of qualitative data (i.e. the narratives) is influenced by the backgrounds of the researchers,[19] steps were taken to ensure rigorous and credible analysis. To confirm objectivity, the categorizations used in the analysis were agreed upon with all authors and any ambiguities were discussed with the second researcher. While independent qualitative analysis of the narrative data by two researchers could have improved the reliability of the analysis, the researchers' experience and expertise in hospital pharmacy and in research may be seen as strengthening factors in objective analysis.

Voluntary incident reporting systems have limitations, such as underreporting[31] and variations in the quality of categorizing,[14] the latter of which was also observed in this study as narrative descriptions supplemented categorizations. The safety culture in the workplace, a professional's ability to identify the incident, feedback and development measures based on reported incidents[31] as well as ease of use of reporting systems,[36] all influence the reporting activity of healthcare professionals. Despite the limitations of incident reporting, it is considered an essential tool to learn from medication incidents and to develop prevention strategies to improve medication safety.

Reason's model has been one approach to optimize the safety outcomes of healthcare, involving retrospective examination after an error or near miss has occurred, to determine the root causes of the latent conditions or active failures, thus, leading to redesigning the system to eliminate similar future incidents. Although Reason's model highlights the diversity of situations, it still suggests a linear relationship between events. There are often many independent factors behind incidents and things may not be linear at all but complex. The other approach to improving safety is to study successes; how people foster safety through their work, as there are more successes than incidents.[37] Hollnagel (2018) suggests two models: Safety I follows Reason's model; and Safety II is focused on what has gone right in the system. Safety II recognizes that systems are complex and viewing human behaviour as a source of creativity as opposed to a dangerous source of variation, requiring elimination. Another voluntary reporting system, utilizing Safety II, has been used in some healthcare districts in Finland since 2020 (personal communication with Awanic Ltd. 6.4.2022). Indeed, Safety II could be applied in further research by observing the fluid treatment process and analyzing the factors that lead to success, i.e. what happens and what makes everything go right, taking into account the same internal and external latent conditions and active functions.

5. Conclusions

The study showed that wrong fluid product selection incidents were reported frequently, and both *latent conditions* and *active failures* were present in the incidents. To minimize the serious LASA phenomenon, multiprofessional collaboration, coordinated international discussion and agreements of solutions with manufacturers, regulators and end-users, are needed; however, work is also needed to reduce the other latent factors, such as Working environment and resources as well as cognitive biases in daily work that may contribute to the occurrence of LASA related errors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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