Development and Prioritisation of Policy Recommendations for Medication Safety Improvement for Intensive Care Units – A European Association of Hospital Pharmacists Special Interest Group Delphi Study

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Abstract

Objectives

Medication Errors (MEs) are a leading cause of morbidity and mortality in the healthcare system. Patients admitted to Intensive Care Units (ICUs) are potentially more susceptible to MEs due to severity of illness, the complexity of treatments they receive and the challenging nature of the ICU setting. The European Association of Hospital Pharmacists established a Special Interest Group (SIG) to undertake a programme of work to develop and prioritise recommendations to support medication safety improvement in ICUs across Europe.

Methods

Initial policy recommendations for medication safety within the ICU environment were developed following reviews of the literature and engagement with relevant stakeholders. A Delphi panel of 21 members of the SIG, comprised healthcare professionals (HCPs) with expertise in ICU and/or medication safety, was convened in 2022. We conducted two rounds using a modified Delphi technique whereby participants anonymously ranked on a nine-point Likert scale the policy recommendations according to their priority for implementation.

Results

In total, 32 policy recommendations were developed. In Delphi Round 1, 19 HCPs participated; consensus was achieved on most recommendations and partial consensus on six. At Delphi Round 2, 18 HCPs participated. After two Delphi rounds, consensus was achieved on all 32 recommendations. All recommendations were considered 'high priority' except one that was considered 'medium priority'.

Conclusions

Through this study it was possible to develop and prioritise evidence-based policy recommendations to enhance medication safety, which may contribute to reducing MEs in ICUs across Europe. All recommendations were considered 'high priority' for implementation except one, indicating the perceived value of these recommendations in improving medication safety through preventing MEs in ICUs.

Keywords

Consensus; Medication Errors; Prevention and Control; Patient Safety; Intensive Care Units; Delphi Technique;

Manuscript:
What is already known on this topic
- The intensive care unit is a challenging setting for safe medication use

- Critically ill patients, high-risk interventions and the complex intensive care unit environment combine to increase the risk of medication errors

- Medication errors can occur across multiple points in the medication use process

What this study adds
- This study, which used evidence from literature and stakeholders, adopted a systems-approach to develop 32 policy recommendations across eight categories

- Through the use of Delphi methodology, consensus and prioritisation of these recommendations was undertaken

How this study might affect research, practice or policy
- These recommendations can be used by intensive care units to develop strategies relevant to their context to improve medication safety practices

Introduction

Medication errors (MEs) are a leading cause of morbidity and mortality in the healthcare system. [1] Patients admitted to intensive care units (ICUs) are potentially more susceptible to MEs due to the complexity and intensity of treatments they receive. [2] Previous studies have identified risk factors contributing towards MEs and reported on strategies that could prevent them. [3, 4] To support individual hospitals and health organisations in ME risk mitigation, the European Association of Hospital Pharmacists (EAHP) established a Special Interest Group (SIG) that set out to develop a set of recommendations for reducing MEs in European ICUs. The body of work comprised four work packages; the first of these was two literature reviews to 1. determine the prevalence of MEs, identify potential sources, causes and contributing factors to MEs; and 2. identify prevention strategies for improving medication safety in the ICU setting. [5] Formal systematic reviews or comparison of the evidence-base supporting these strategies was beyond the scope of the available resources.

The second work package, an e-survey, was conducted with healthcare professionals (HCPs) working in ICUs to identify the medication safety practices most commonly used, or planned for implementation, in ICUs (submitted for publication). The third work package involved focus group discussions with ICU and medication safety HCPs to explore patient safety culture and advancement of medication safety, and the factors influencing implementation of ME prevention strategies in ICUs across Europe (submitted for publication).

This study describes the fourth work package, the aim of which was to utilise the findings from the three other work packages to develop and prioritise a list of policy recommendations to support medication safety improvement in ICUs across Europe.

Methods

Study design

A modified Delphi technique, a methodology that utilises a panel of experts to achieve consensus in a clearly defined and systematic manner, was employed by the EAHP SIG to develop and prioritise the list of policy recommendations. This technique has commonly been used to produce recommendations, including best practice and international patient safety recommendations, where available evidence is lacking or unavailable. [6]

The classical Delphi technique uses a series of questionnaires issued to an expert panel in an iterative manner. A summary of results from individual rounds is provided as anonymous feedback in subsequent rounds, with the aim of converging opinion and reaching consensus.[6] The term 'modified' Delphi has been applied where face-to-face or online meetings, in tandem with the iterative rounds of consensus, are used. Other modifications include a research team, rather than an expert panel, defining the issues requiring consensus during the initial phase of the process. [6] For this study,

the research team - a sub-group of the SIG - undertook development of the initial list of policy recommendations based on the earlier phases of this study as described above. This group was comprised of seven pharmacists from different European countries, of whom three were actively working in university hospital ICUs, one was a medication safety pharmacist, and three were academic pharmacists with expertise in medication safety. A further modification from the classical Delphi technique was that we conducted the first consensus round during an online meeting in place of distributing the questionnaire to the panel members separately.

For the subsequent stages of the study, all members of the EAHP SIG (n=21) were invited to participate as members of the expert Delphi panel. As part of their selection for the SIG, each member was working within ICUs and/or working as medication safety experts and therefore could be considered experts and eligible to participate in the panel. The SIG membership comprised a diverse group of HCPs from 13 European countries within Northern, Southern and Western European region. Sixteen members had a pharmacy background, four had a medical background and one a nursing background; 17 were women. This study is reported according to Junger et al.'s recommended 'Guidance on Conducting and REporting DElphi Studies (CREDES)'. [7]

Ethical Considerations

Ethical approval was obtained by The University of Helsinki Ethical Review Board in Humanities and Social and Behavioural Sciences (Statement: 18/2022). Participation by the panel of experts was voluntary and confidential and no incentives were offered. Each SIG member received an e-mail with a cover letter and a participant information sheet. Participants were also informed that submission of their responses via the online survey tool would be considered as proof of informed consent to participate. Although anonymity is commonly preserved in Delphi studies, this was not possible in this study as participants were known to each other through their SIG membership. However, the identities of individual participants who opted to participate was not known and responses were submitted anonymously into a General Data Protection Regulation compliant online survey tool (easy-feedback.com).

Development of Recommendations and Delphi Consensus Processes

Stage 1: Identification of Recommendations

The following sources of information, as provided by earlier phases of the SIG work packages, were used to develop the initial list of the policy recommendations to be presented to the Delphi panel:

- ME prevention strategies used to improve medication safety in the ICU environment as identified through the literature review; insert (5 (EAHP report) AND [9-29] HERE

- ME prevention strategies both currently in use and being planned in ICUs across Europe as identified through the conducted survey; and

- Perceptions of patient safety, medication safety, and experiences of ME prevention strategies as identified from the focus group discussions.

The initial list of policy recommendations was categorised and agreed on by the SIG sub-group prior to commencement of Stage 2.

Stage 2: Iterative Consensus Rounds

A series of iterative consensus rounds were commenced in October 2022, with prior agreement that a maximum of three rounds would be held. The online survey tool (easy-feedback.com) was used for recording the responses. The level of priority of each recommendation was scored using a 9-point Likert scale where a score of 1 indicated 'definitely not a priority' and a score of 9 indicated 'a key priority'. Additional guidance or specific criteria for prioritisation were not provided.

In addition to the Likert scale score for each recommendation, participants were also invited to record any comments on individual recommendations within a dedicated section on the online survey. These comments provided a better understanding of the rationale behind the responses provided at each round and they could be used to modify the recommendations for future rounds as appropriate.

Anonymous responses were downloaded for further analysis using Microsoft Excel® (Version 2016 or newer). The median and inter-quartile range (IQR) for each recommendation was calculated and the results analysed for the degree of consensus. The following pre-determined consensus definitions were applied. [8]

- 'Consensus' was considered to exist if the interquartile range of the participants' responses fell within any three-point range

- 'Disagreement' was considered to exist if the interquartile range span both the 1–3 range and the 7–9 range

- If neither consensus nor disagreement existed, 'Partial Agreement' was considered to have occurred

Where consensus existed, it was considered that the recommendation was a 'high priority' if the median score was within the 7–9 range, a 'low priority' if it was within the 1–3 range, and a 'medium priority' if it was within the 4–6 range.

After each round, feedback was provided to all panel members which included the distribution of the panel's response and the list of comments.

Delphi Panel Round 1

All 21 members of the SIG received an invitation to participate in Delphi Round 1. A virtual presentation describing the process for achieving consensus in an iterative manner was delivered to the participants. They were then presented with a brief description of each recommendation as determined in Stage 1. To allow panel members to familiarise themselves with the recommendations, the complete list was sent to all members of the SIG in advance of the meeting.

A link to the online survey was provided in an e-mail during the meeting and the participants were instructed that they could submit their responses either during or after the meeting. It was also re-iterated that participants did not need to conform to the group view. In addition, each individual panel member was asked to download and save their own responses. In subsequent rounds, this allowed panel members to see both their own response and that of the rest of the panel without knowing the identity of the other individuals providing scores or comments.

On completion of this, and subsequent rounds, a single reminder email with a link to the Delphi survey was sent to the panel prior to the stated deadline.

Subsequent Delphi Panel Rounds

Those recommendations for which consensus was not reached during previous rounds were progressed to subsequent rounds in an iterative manner. Recommendations were modified, where appropriate, based on the comments received during the previous round. An updated version of the online survey was devised specifically for each round. The original wording of any amended recommendations was included in the survey along with: the reworded recommendation, the median and inter-quartile range (IQR) of the panel's scores, and any comments provided by individual panel members in the previous round.

In contrast to Delphi Round 1, subsequent rounds were conducted by e-mail in consideration of geographical diversity and time constraints of individual Delphi panel members. Each participant received an e-mail with a link to the survey and were asked to submit their scores using the online

survey tool within seven days of receipt of the e-mail. The participants had the option to amend or retain their own Delphi Round 1 score after having considered the group results of Delphi Round 1.

Results

Thirty-two initial policy recommendations (grouped into eight categories) to improve medication safety in ICUs across Europe were developed. Due to the anonymous participation, the backgrounds of the respondents cannot be described but details on the full EAHP SIG membership (n=21) are described above.

Delphi Panel Round 1

The presentation for Round 1 of the Delphi panel took place on 13th October 2022. A total of 19 HCPs participated and all but one of the participants scored each of the 32 policy recommendations; one participant did not to respond to Recommendation #28. Consensus was achieved on 26 of the recommendations (Table 1), with partial consensus on six recommendations (Recommendations 5, 6, 8, 13, 27 and 30). Disagreement was not found on any recommendation. Recommendations 4, 8 and 30 were considered as medium priority, with the remaining 29 considered to be of high priority.

Table 1: The consensus received for, and the priority given to, the policy recommendations in Delphi Round 1 by the Delphi panel of experts (n=19)*

Category	No.	Recommendation	Median (Q1-Q3; IQR)	Consensus (Priority)
Organisational Safety Culture & Working Environment	**1**	Create and maintain an open, transparent and non-hierarchical 'no blame' culture supported by the ICU management to support staff in identifying, sharing, reporting and learning from incidents and near misses.	9 (9-9;0)	Consensus **(High)**
	2	Implement an effective system to support the reporting of (medication-related) incidents and near misses, including mechanisms to provide feedback on reports to ICU staff.	8 (8-9;1)	Consensus **(High)**
	3	Undertake routine, systematic and multi-disciplinary review of all ICU related incident reports to identify medication safety areas of risk, opportunities for improvement and provide feedback to ICU staff, e.g., use of risk huddles.	8 (8-9;1)	Consensus **(High)**
	4	Nominate a Medication Safety Lead within the ICU setting to work closely with the organisational Medication Safety Officer (or equivalent) where such a role exists on the implementation and promotion of medication error prevention strategies.	6 (6-8;2)	Consensus **(Medium)**
	5	Undertake regular audits and self-assessment questionnaires, including measurement of patient safety climate in the ICU to monitor medication safety within the ICU.	7 (5-8;3)	**Partial Consensus (High)**
	6	Ensure adequate budget allocation to support sustained improvements in medication safety, including investment in human resources and appropriate technology in the ICU setting.	8 (6-9;3)	**Partial Consensus (High)**
	7	Ensure a safe working environment is provided for ICU staff to practise in a safe and efficient manner, e.g., adequate lighting, avoidance of interruptions.	8 (7-9;2)	Consensus **(High)**
Technology	**8**	Implement Automated Dispensing Cabinets for the storage of medications in the ICU.	6 (4-7;3)	**Partial Consensus (Medium)**
	9	Replace paper-based prescriptions with electronic prescribing systems, e.g., computerised physician order entry, with associated clinical decision support appropriate to the ICU setting.	9 (7.75-9;1.25)	Consensus **(High)**
	10	Implement the use of Barcoded Medication Administration to reduce medication administration errors and support complete documentation.	7 (6-8;2)	Consensus **(High)**
	11	Administer all medication infusions via programmable infusion pumps utilising 'Dose Error Reduction Software' or 'Smart-pumps', which contain a complete and regularly reviewed and updated drug library.	8 (6-8;2)	Consensus **(High)**
	12	Ensure policies are in place to reduce workarounds and over-rides in the use of implemented technology, e.g., bypassing smart-pump drug libraries, barcode medication administration workarounds and automated dispensing cabinet over-rides.	7 (6-8;2)	Consensus **(High)**
	13	Identify and optimise all opportunities to integrate existing and future systems with the aim of providing 'closed loop' medication management, supporting the '5 rights' of medication administration.	7 (5-8;3)	**Partial Consensus (High)**
	14	Provide dedicated resources to facilitate the implementation, optimisation, maintenance and regular updates to all systems involved in medication management within the ICU.	8 (7-9;2)	Consensus **(High)**
Clinical Pharmacy	**15**	Provide a dedicated and specialised clinical pharmacy service to the ICU at a staffing level sufficient to ensure regular review and verification of all medications, attendance at multi-disciplinary rounds and input into the development of policies, procedures and guidelines.	9 (8-9;1)	Consensus **(High)**
	16	Adopt formal antimicrobial stewardship with multidisciplinary input to ensure appropriate use of antimicrobials and reduce antimicrobial resistance.	9 (8-9;1)	Consensus **(High)**
Education & Training	**17**	Provide staff with protected time during working hours and access to a range of education and training opportunities in safe medication use to include new staff from all disciplines, new equipment/medications, refresher training and competency assessment.	8 (7-9;2)	Consensus **(High)**
	18	Standardise and reduce the range of available/recommended medication infusion concentrations.	9 (8-9;1)	Consensus **(High)**

Category	No.	Recommendation	Median (Q1-Q3; IQR)	Consensus (Priority)
Intravenous Medication Management	19	Provide supporting protocols and guidelines on preparation of intravenous medications as appropriate to the setting and availability of 'ready-to-administer' infusion solutions.	9 (8-9;1)	Consensus **(High)**
	20	Minimise 'bedside' preparation of intravenous medications and replace with procured and centrally prepared 'ready-to- administer' or 'ready-to-use' medications wherever possible.	8 (7-9;2)	Consensus **(High)**
	21	Ensure ease of access to information on intravenous compatibilities.	8 (7-9;2)	Consensus **(High)**
	22	Ensure processes are in place to support safe intravenous medication administration to include: appropriate labelling of medications and administration lines utilising targeted risk reduction strategies, e.g., use of colours, TALLman lettering; administration line checks; infusion pump checks.	8 (7-9;2)	Consensus **(High)**
High-Risk Medication Management	23	Maintain a high-risk medication list that is reviewed regularly and is context-specific, e.g., paediatrics, with a robust set of associated risk mitigation processes for all stages of the medication use process.	7 (6-8;2)	Consensus **(High)**
	24	Ensure targeted and risk assessed organisational policies and procedures are in place to support checking procedures for the preparation and administration of high-risk medications, e.g., items requiring independent double-checking, specific labelling requirements.	8 (7-9;2)	Consensus **(High)**
Medication History & Reconciliation	25	Employ standardised procedures, including patient, family and carer involvement as appropriate, to obtain and document an accurate and complete list (best possible medication history) of each patient's current medication on admission to the ICU.	8 (7-9;2)	Consensus **(High)**
	26	Implement a formal and thorough medication reconciliation process on both admission to, and discharge from, the ICU to ensure accurate and comprehensive medication information is communicated consistently.	8 (7-9;2)	Consensus **(High)**
	27	Promote interdisciplinary communication across entire medication use process, utilising a range of mechanisms and structures, e.g., handover procedures and documentation, multidisciplinary rounds/meetings, use of notice boards, memos.	8 (6-9;3)	**Partial Consensus (High)**
	28 *	Minimise the use of verbal orders with provision of defined supporting processes, e.g., pre-printed templates, order sets.	8 (7-9;2)	Consensus **(High)**
Access to Medications & Resources	29	Provide a pharmacy-led service to ensure consistent, appropriate and safe access to a full range of medications appropriate to individual ICUs, e.g., stock lists, regular top-up service, drug shortage management, defined storage locations, segregation of high-risk and sound-alike/look-alike medications.	9 (8-9;1)	Consensus **(High)**
	30	Source and supply medications in 'unit-dose' form with individual barcode where possible to support barcode medicines administration and closed-loop medication management.	6 (4-7;3)	**Partial Consensus (Medium)**
	31	Ensure all appropriate antidotes, reversal agents, rescue agents and relevant protocols are readily available.	9 (7-9;2)	Consensus **(High)**
	32	Maintain a comprehensive and easily accessible suite of up-to-date guidelines and reference sources, which are: approved at an organisational level; made available in digital format where possible; and with robust governance and version control measures in place.	8 (7-9;2)	Consensus **(High)**

* Only 17 participants responded to Recommendation 28.

The feedback received during Delphi Round 1 was used to modify, as appropriate, the wording of the six recommendations (Recommendations 5, 6, 8, 13, 27, 30) that had received partial consensus for Delphi Round 2. All but two (Recommendations 6 and 30) were reworded.

Delphi Panel Round 2

Eighteen HCPs provided their responses for Recommendations 8, 13 and 27, and 17 HCPs to Recommendation 30 (Table 2) in the Delphi Round 2 survey sent by e-mail to the panel on 15th

November 2022. After this round was completed, a discrepancy in the calculation of the interquartile range of two recommendations in Delphi Round 1 data was identified. This was corrected and a supplementary Delphi Round 2b was arranged for prioritising Recommendations 5 and 6 (Table 2); the original Round 2 was subsequently referred to as Delphi Round 2a. Seventeen HCPs responded to the Round 2b survey which was circulated by e-mail on 6th December 2022. The participants classified all recommendations as 'high priority' with 'consensus' in the combined results for each portion of Delphi Round 2 (Table 2).

Table 2: The consensus received for, and the priority given to, the policy recommendations in Delphi Round 2a and 2b by the Delphi panel of experts (n=18)*

No. (Delphi Round)	Original recommendation Delphi Round 1	New recommendation Delphi Round 2	Median (Q1-Q3; IQR)	Consensus (Priority)
5 (2b)*	Undertake regular audits and self-assessment questionnaires, including measurement of patient safety climate in the ICU to ***monitor*** medication safety within the ICU.	Undertake regular audits and self-assessment questionnaires, including measurement of patient safety climate in the ICU, to **inform improvement of** medication safety within the ICU.	7.5 (6-8; 2)	Consensus **(High)**
6 (2b)*	Ensure adequate budget allocation to support sustained improvements in medication safety, including investment in human resources and appropriate technology in the ICU setting.	Unchanged	8 (7.5-9; 1.5)	Consensus **(High)**
8 (2a)	Implement Automated Dispensing Cabinets for the storage of medications in the ICU.	Implement Automated Dispensing Cabinets for the storage of medications in the ICU, **ensuring adequate resources for training, monitoring of usage and optimisation.**	7 (5-7.25; 2.25)	Consensus **(High)**
13 (2a)	Identify and optimise all opportunities to integrate existing and future systems with the aim of providing 'closed loop' medication management, ***supporting the '5 rights' of medication administration.***	Identify and optimise all opportunities to integrate existing and future systems with the aim of providing 'closed loop' medication management, **minimising opportunities for error at each stage of the medication use process.**	7 (6.75-8.25; 1.5)	Consensus **(High)**
27 (2a)	***Promote*** interdisciplinary communication across entire medication use process, ***utilising a range of mechanisms and structures,*** e.g., handover procedures and documentation, multidisciplinary rounds/meetings, use of notice boards, memos.	**Ensure clear policies and processes are in place to support** interdisciplinary communication across entire medication use process, e.g., handover procedures and documentation, multidisciplinary rounds/meetings, use of notice boards, memos.	8 (6.75-9; 2.25)	Consensus **(High)**
30 (2a)*	Source and supply medications in 'unit-dose' form with individual barcode where possible to support barcode medicines administration and closed-loop medication management.	Unchanged	7 (4.5-7; 2.5)	Consensus **(High)**

* Only 17 participants responded to Recommendations 5, 6 and 30.

Final Policy Recommendations on Medication Safety Improvement in Intensive Care

After two Delphi panel rounds, consensus was achieved on all 32 policy recommendations. All but one (Recommendation 4; medium priority) were considered as 'high priority'. Further Delphi panel

rounds were not required. The final recommendations are presented in Table 3 along with a selection of supporting evidence from research studies, published policies or standards, and a summary of the relevant facilitators as identified from the focus group discussions conducted in one of the other SIG work packages.

Table 3: Policy Recommendations on Medication Safety Improvements in the ICU Setting

Category	Recommendation (Ranked within Categories by Delphi Priority Scores)	Supporting Evidence	
		Facilitators for Improving Medication Safety from EAHP SIG Focus Group	Refs
Organisational Safety Culture & Working Environment	Create and maintain an open, transparent and non-hierarchical 'no blame' culture supported by the ICU management to support staff in identifying, sharing, reporting and learning from incidents and near misses.	Open culture/interprofessional teamwork	[1, 9, 10]
	Implement an effective system to support the reporting of (medication-related) incidents and near misses, including mechanisms to provide feedback on reports to ICU staff.	Use of IT e.g. incident reporting systems/ engaging, giving feedback to, & communicating with, staff about incidents/ safety	[11] [2]
	Undertake routine, systematic and multi-disciplinary review of all ICU related incident reports to identify medication safety areas of risk, opportunities for improvement and provide feedback to ICU staff, e.g., use of risk huddles.	Working interprofessionally/engaging, giving feedback to staff/incident reporting/ auditing/researching medication safety	[1] [2]
	Ensure adequate budget allocation to support sustained improvements in medication safety, including investment in human resources and appropriate technology in the ICU setting.	Funding/human resources/technology	[1]
	Ensure a safe working environment is provided for ICU staff to practise in a safe and efficient manner, e.g., adequate lighting, avoidance of interruptions.	Management/resources	[1] [3]
	Undertake regular audits and self-assessment questionnaires, including measurement of patient safety climate in the ICU, to inform improvement of medication safety within the ICU.	Auditing/researching medication safety	[13]
	Nominate a Medication Safety Lead within the ICU setting to work closely with the organisational Medication Safety Officer (or equivalent) where such a role exists on the implementation and promotion of medication error prevention strategies.	Medication safety pharmacist/team	[12]
Technology	Replace paper-based prescriptions with electronic prescribing systems, e.g., computerised physician order entry, with associated clinical decision support appropriate to the ICU setting.	Use of IT systems	[14, 16]
	Provide dedicated resources to facilitate the implementation, optimisation, maintenance and regular updates to all systems involved in medication management within the ICU.	Management/resources e.g. funding/human resources/use of IT systems	[11]
	Administer all medication infusions via programmable infusion pumps utilising 'Dose Error Reduction Software' or 'Smart-pumps', which contain a complete and regularly reviewed and updated drug library.	Use of IT systems	[14, 17]
	Identify and optimise all opportunities to integrate existing and future systems with the aim of providing 'closed loop' medication management, minimising opportunities for error at each stage of the medication use process.	Management/use of IT systems/training/learning about medication safety	[4, 9]
	Implement the use of Barcoded Medication Administration to reduce medication administration errors and support complete documentation.	Use of IT systems	[4, 14]
	Ensure policies are in place to reduce workarounds and over-rides in the use of implemented technology, e.g., bypassing smart-pump drug libraries, barcode medication administration workarounds and automated dispensing cabinet over-rides.	Management/use of IT systems/training/learning about medication safety	[14, 18]
	Implement Automated Dispensing Cabinets for the storage of medications in the ICU, ensuring adequate resources for training, monitoring of usage and optimisation.	Resources e.g. use of IT-systems /training/learning about medication safety	[14, 15]
Clinical Phar	Provide a dedicated and specialised clinical pharmacy service to the ICU at a staffing level sufficient to ensure regular review and verification of all medications, attendance at multi-disciplinary rounds and input into the development of policies, procedures and guidelines.	Working interprofessionally/human resources/pharmacists	[11, 19]

Category	Recommendation	Stakeholders	Ref
	Adopt formal antimicrobial stewardship with multidisciplinary input to ensure appropriate use of antimicrobials and reduce antimicrobial resistance.	Working interprofessionally/national programmes/management/medication safety pharmacist/team	[20]
Education & Training	Provide staff with protected time during working hours and access to a range of education and training opportunities in safe medication use to include new staff from all disciplines, new equipment/medications, refresher training and competency assessment.	Working interprofessionally/dedicated time/energy for training/learning/medication safety pharmacist/team	[21]
Intravenous Medication Management	Standardise and reduce the range of available/recommended medication infusion concentrations.	National programmes/management/medication safety pharmacist/team	[22, 23]
	Provide supporting protocols and guidelines on preparation of intravenous medications as appropriate to the setting and availability of 'ready-to-administer' infusion solutions.	National programmes/management/medication safety pharmacist/team	[24]
	Minimise 'bedside' preparation of intravenous medications and replace with procured and centrally prepared 'ready-to- administer' or 'ready-to-use' medications wherever possible.	National programmes/management/pharmacists	[22, 23]
	Ensure ease of access to information on intravenous compatibilities.	National programmes/management/medication safety pharmacist/team	
	Ensure processes are in place to support safe intravenous medication administration to include: appropriate labelling of medications and administration lines utilising targeted risk reduction strategies, e.g., use of colours, TALLman lettering; administration line checks; infusion pump checks.	National programmes/management/medication safety pharmacist/team	[14, 18]
High-Risk Medication Manageme	Ensure targeted and risk assessed organisational policies and procedures are in place to support checking procedures for the preparation and administration of high-risk medications, e.g., items requiring independent double-checking, specific labelling requirements.	National programmes/management/medication safety pharmacist/team	[14, 25]
	Maintain a high-risk medication list that is reviewed regularly and is context-specific, e.g., paediatrics, with a robust set of associated risk mitigation processes for all stages of the medication use process.	National programmes/management/medication safety pharmacist/team	[14]
Medication History & Reconciliation	Employ standardised procedures, including patient, family and carer involvement as appropriate, to obtain and document an accurate and complete list (best possible medication history) of each patient's current medication on admission to the ICU.	National programmes/management/medication safety pharmacist/team/HCPs/patients	[11, 26]
	Implement a formal and thorough medication reconciliation process on both admission to, and discharge from, the ICU to ensure accurate and comprehensive medication information is communicated consistently.	National programmes/management/medication safety pharmacist/team/HCPs/patients	[4, 11, 27]
	Minimise the use of verbal orders with provision of defined supporting processes, e.g., pre-printed templates, order sets.	Working interprofessionally/national programmes/management/medication safety pharmacist/team	[14]
	Ensure clear policies and processes are in place to support interdisciplinary communication across entire medication use process, e.g., handover procedures and documentation, multidisciplinary rounds/meetings, use of notice boards, memos.	Working interprofessionally/communicating with colleagues, national programmes/management/medication safety pharmacist/team/HCPs/patients	[27]
Access to Medication & Resources	Provide a pharmacy-led service to ensure consistent, appropriate and safe access to a full range of medications appropriate to individual ICUs, e.g., stock lists, regular top-up service, drug shortage management, defined storage locations, segregation of high-risk and sound-alike/look-alike medications.	National programmes/management/human resources e.g. pharmacists	[11]
	Ensure all appropriate antidotes, reversal agents, rescue agents and relevant protocols are readily available.	Management/resources/medication safety pharmacist/team	[14]
	Maintain a comprehensive and easily accessible suite of up-to-date guidelines and reference sources, which are: approved at an organisational level; made available in digital format where possible; and with robust governance and version control measures in place.	Management/resources/medication safety pharmacist/team/use of IT systems	[21]
	Source and supply medications in 'unit-dose' form with individual barcode where possible to support barcode medicines administration and closed-loop medication management.	Management/use of IT systems	[28, 29]

Discussion

A panel of HCPs from up to 13 different European countries have produced a consensus-based list of 32 policy recommendations for medication safety improvement in the intensive care setting. The high consensus levels and prioritisation of almost all of these recommendations are indicative of the need for safety initiatives to mitigate the risks, both perceived and evident from previously published research, associated with medication management in ICUs. The medication management process in the ICU is complex; a study in the paediatric ICU setting identified 30 sub-tasks as part of the prescribing process alone and how each of these needed to be completed correctly in order for the correct prescription to be written. [30] This complexity in the medication use process in tandem with the acuity of illness of the ICU patient cohort requires multi-faceted risk mitigation strategies and interventions. [3] We adopted a systems approach when developing these recommendations as we recognised that reducing the occurrence of MEs and promoting patient safety requires changes to the underlying system of care. This is apparent in the breadth of policy recommendations over eight discrete categories ranging from the entire health system, to individual organisations, down to local ICU level interventions and resources.

We have supplied examples of supporting literature for many of the policy recommendations as outlined in Table 3, however, it has not been possible to provide an exhaustive list. An evidence-base exists for many ME reduction strategies, e.g., benefits of an ICU clinical pharmacy service [19] and electronic prescribing [16], but there is a gap in peer-reviewed evidence for others. In these cases, despite recommendations from individual professional bodies and patient safety organisations, robust evidence is still lacking. Reasons for this include the complexity of some of the proposed interventions, particularly those which are technology-based. Not only is successful implementation of these a significant undertaking requiring significant resources, but achieving and demonstrating intended benefits is also complex and difficult. [31] The potential for unintended consequences and implications of changes in workflow also require consideration. [32] Where research is conducted on these systems, comparing results from studies using different methodologies, disparate systems and levels of integration impedes generalisability of reported results. Despite this, use of technology in medication processes in European ICUs is increasing, as evidenced from the use of electronic prescribing, automated dispensing cabinets and 'smart-pumps', as reported in the survey conducted by the SIG in an earlier phase of this research. [5] The consensus reached by the expert panel in this study provides further weight to support the need for investment in these solutions.

Many of the policy recommendations deemed to be high priority require few resources and should be more achievable in most ICUs. Although lower down on the Institute of Safe Medication Practices (ISMP) Rank Order of Error Reduction Strategies, the use of good policy, procedures and provision of

education and information to support staff in key areas such as management of high-risk and intravenous medications were considered high priority by the panel. [33] Standardisation, widely recognised by safety agencies as key to medication safety, was also identified as a priority. Although some of these strategies are more onerous to implement, e.g., standard concentration infusions, with others reliant on conditions being met outside of individual organisations, e.g., access to unit-dose medications, many are achievable within individual ICUs without substantial investment in terms of time or financial resources.

Strengths and limitations

A key strength of this study was the representation from 13 European countries covering the Northern, Southern and Western regions of Europe. Utilisation of online meetings in addition to e-mail - a modified version of the Delphi technique - facilitated this broad participation, while also allowing verbal clarification of understanding where necessary for non-native English speakers. Furthermore, use of purposive sampling in assembly of the EAHP SIG and the subsequent willingness to participate, ensured the panel composition included HCPs from various backgrounds in ICU settings and/or medication safety with relevant expertise. The range of resources used to develop the initial list of recommendations, including both previous literature and new information as gathered from the survey and focus groups, provides confidence that both previously identified ME prevention strategies and perceptions of HCPs working in ICUs and within medication safety across Europe were incorporated. Limitations include identification of the recommendations from literature review and expert opinion, without measures of effectiveness based on quality of evidence, and the inability to stratify the recommendations on ease of implementation or requisite resources. Further limitations include lack of participation of HCPs from Eastern European and over-representation by pharmacists. As with any Delphi panel study, there may be some response bias such as individuals with greater interest or expertise in medication safety being more likely to participate.

Conclusion

The Delphi technique was successfully used to develop and prioritise policy recommendations to enhance medication safety in ICUs in Europe. All recommendations, except one, were considered 'high priority' for implementation, indicative of the perceived value of these recommendations in improving medication safety by preventing MEs from occurring in ICUs. The results of this study can help inform individual ICUs in reviewing their local context and identifying priorities to improve medication safety.

Footnotes

Authorship statement:

Moninne Howlett and Suzanne McCarthy contributed equally to this paper and are to be regarded as first authors; they designed the study methodology, data collection tool, analysed the data, finalised the recommendations, drafted and revised the paper. Raisa Laaksonen and Virginia Silvari conceptualised the study, contributed to the design of the study, monitored data collection and analysis, and revised the paper. Bryony Dean Franklin contributed to the design of the study and revised the paper.

Contributorship statement:

All members of the EAHP Special Interest Group for the Investigation of Medication Errors in Intensive Care Units contributed to the design of the study. The members of this group were: Angela Amigoni (Italy), Irene Aquerreta (Spain), Božena Bürmen (Slovenia), Andrea Burch (Switzerland), Claire Chapuis (France), Suzanne Cooper (United Kingdom), John Dade (United Kingdom), Bryony Dean Franklin (United Kingdom), Dylan W. De Lange (the Netherlands), Moninne Howlett (Republic of Ireland), Minna Kurttila (Finland), Raisa Laaksonen (Co-Chair of the SIG, Finland), Chiara Lamesta (Italy), Jana Lass (Estonia), Maria Cruz Martin (Spain), Suzanne McCarthy (Republic of Ireland), Virginia Silvari (Co-Chair of the SIG, Republic of Ireland), Inese Sviestina (Latvia).

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Competing Interests

Raisa Laaksonen and Virginia Silvari are associate editors of the European Journal of Hospital Pharmacy. All other authors have no competing interests.

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