THE UNIVERSITY OF SYDNEY

eHealth High Risk Medicine Safety

Rapid literature review and environmental scan

Report prepared by

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Executive summary

Context and aims

Prescribing errors are common in hospitals, occurring in approximately 7% of medication orders and 50% of hospital admissions.[1] However, errors associated with high-risk medicines (HRMs) have a greater propensity to cause harm, and can lead to increased mortality and higher costs when compared to non-high-risk medicines.[2] In hospitals, electronic medical records (EMRs) and electronic medication management systems (EMMs) support the medication process, including prescribing, dispensing and medication administration. These systems can have varying levels and types of decision support aimed to improve medication safety, including the safe use of HRMs.[3-5]

The work described here, conducted for the eHealth High Risk Medicine Safety (e-HRM) Advisory Group, comprises an environmental scan and literature review to examine and understand how EMR and EMM systems present and manage issues/risks relating to HRMs in Australian health service organisations.

Key questions

1. What strategies (e.g. EMR configuration, functionalities, clinical decision support systems or alerts) have been implemented through EMR/EMM systems to monitor the safety of high-risk medicines?
2. What strategies have been implemented through EMR/EMM systems to manage high-risk medicines?
3. What strategies have been implemented through EMR/EMM systems to present high-risk medicines?
4. To what extent are these strategies perceived as acceptable and satisfactory by clinicians?
5. What is the impact of these strategies in increasing high-risk medicine safety and decreasing the number of patient safety adverse events?
6. Have implemented strategies produced any unintended consequences – positive or negative?

Methods

The research team used a multi-method approach including a targeted literature review, structured interviews, and document reviews to address the research questions.

For this report, high-risk medicines (HRMs) were defined based on the Australian Commission on Safety and Quality in Health Care's "APINCH" list[6]:

- Antimicrobials
- Potassium and other electrolytes

- Insulin
- Narcotics (opioids) and other sedatives
- Chemotherapeutic agents
- Heparin and other anticoagulants

Targeted literature review

Objectives

To identify the strategies that have been implemented through EMR/EMM to present, manage, and monitor the safety of HRMs, and for each strategy collate data on:

a. Clinician perspectives and acceptance of the strategy
b. The impact of the strategy on high-risk medicine safety and patient safety adverse events
c. Any unintended consequences (positive or negative) produced by the strategy

To achieve these objectives, three searches were conducted:

1. A review of systematic reviews, both national and international
2. A review of primary studies undertaken in Australia
3. A review of Australian grey literature

Search and screening of academic papers

For searches 1 (systematic review) and 2 (primary Australian studies), the databases Cochrane Systematic Reviews, Medline and Embase were searched. The search strategy was developed with the assistance of an expert librarian. The search was conducted on the 11th of October 2023. All potentially relevant papers were imported into a systematic review management software (Covidence) for screening. The reference lists of included papers were also searched for relevant studies.

To identify relevant reviews and primary studies, 10% of titles and abstracts were screened based on the eligibility criteria by two researchers to ensure consistency. The remaining titles and abstracts were divided and screened by one researcher. Full texts for papers that met the inclusion criteria based on title and abstract were then screened by one researcher. Any papers where it was unclear if inclusion criteria were met, were discussed as a group until consensus on inclusion was reached.

Search and screening of grey literature

The environmental scan was conducted using OpenGrey and relevant government websites across Australian states and territories. These were reviewed to identify grey literature, reports, policies, and guidelines pertaining to strategies implemented through EMR/EMM related to HRMs. Documents were screened by one reviewer and any documents where it was unclear if inclusion criteria were met were discussed as a group until a consensus on inclusion was reached.

Data extraction

The following data was extracted from all eligible academic papers and relevant grey literature:

- Paper characteristics
- Strategies implemented to monitor, manage or present high-risk medicines (e.g., EMR configuration, functionalities, clinical decisions support systems or alerts)
- Clinician perceptions and acceptability of strategies
- Effectiveness of strategies
- Unintended consequences of strategies

Structured interviews

Objectives

To identify the strategies that Australian states and territories have implemented through EMR/EMM to present, manage, and monitor the safety of high-risk medicines. We also aimed to explore if the strategies had been evaluated, specifically relating to:

a. clinician perspectives and acceptance
b. impact on high-risk medicine safety and patient safety adverse events
c. unintended consequences

Stakeholder engagement

Stakeholders with knowledge of high-risk medicine strategies in hospitals (e.g. clinical informatics staff, EMM pharmacists, Directors of Pharmacy Departments) were eligible to participate. An invitation letter and/or advertisement (Appendix 2) was distributed to potential participants, including known contacts and relevant society members. Snowball sampling was also used, where participants were asked to recommend other colleagues who may wish to take part. Participants were offered a $50 voucher for their time.

Data collection and analysis

A structured interview guide was developed for interview discussions (Appendix 3). In the interviews, participants were asked to describe strategies used for the APINCH list, but also asked if there were any site-specific HRMs that were presented, managed or monitored in their EMM/EMR. Interviews were conducted via telephone or video conference with each participant and audio recorded. Responses were collated into a spreadsheet.

Results

Five systematic reviews met our criteria for inclusion. Two reviews focused on antimicrobials, two on insulin and one on chemotherapy. In total, 10 Australian papers met our inclusion criteria. Half the studies (n=5) described strategies for the management and monitoring of antimicrobials, two papers focused on anticoagulants, two papers on opioids, and one paper described strategies for multiple HRMs. Of the 33 government or organisational websites/reports searched, only 10 included recommendations for presenting, managing or monitoring HRMs in EMM/EMRs. In total, 33 structured interviews were conducted with participants across Australia and 645 strategies were described during interviews.

Antimicrobials

The main EMM/EMR presentation strategy we identified for antimicrobials was use of tallman lettering.

Key EMM/EMR management strategies included alerts, order sentences, and forcing functions, particularly mandatory documentation of indications and/or antimicrobial approval numbers. These strategies align with the one recommendation specific to antimicrobials we uncovered in our grey literature review, that of the EMM system supporting the approvals workflow.

We found some evaluation of these management strategies in both the international and Australian literature. In some cases, these clinical decision support features were reported to reduce antimicrobial prescribing, improve antimicrobial appropriateness, and were associated with improvements in some clinical outcomes (like reduced length of stay). However, we also found evidence of strategies being worked around or abandoned, reflecting poor alignment with end-user workflow.

Common monitoring strategies for antimicrobials included dashboards, reports and medication lists. Interview participants reported that these were well liked, especially by AMS teams, but we identified no formal evaluations of these.

Potassium and other electrolytes

Uppercase text was a frequently used strategy to present potassium and other electrolytes on screen, as was the display of special instructions (e.g. hypertonic). The main EMM/EMR strategies we identified to support management of potassium and other electrolytes included limiting EMM features to particular users (e.g. senior prescribers, ICU clinicians), order sentences, and alerts. No formal evaluations of strategies were uncovered during interviews or in our literature review.

The only strategy we identified for monitoring potassium and other electrolytes in EMM/EMR was the use of reports.

Our grey literature review identified only recommendations related to EMM supporting cardiac monitoring, but we did not identify any strategies on this via our structured interviews.

Insulin

Additional text on screen (brand, formulation, concentrations, etc) was a common approach taken to present insulin in EMM/EMR. The main EMM/EMR strategies we identified to support management of insulin included forcing functions, order sets, alerts and dashboards. The main forcing function used was restricting prescribing to brand names only, but forced entry of information like form, dose and blood results was also common. This latter finding aligns with the recommendation uncovered in our grey literature review, of prompting the review and documentation of blood glucose levels before administration in EMM/EMR. Our interviews revealed that this was sometimes a forcing function (e.g. mandatory review or entry of blood results), and sometimes a prompt to nurses in the form of an alert.

We found no Australian evaluations of these strategies in the literature, and interview participants reported only anecdotal improvements in safety following implementation. We identified a small number of international evaluations of order sets and alerts which indicated that these were effective in improving glycaemic control.

Dashboards were the most frequent strategy used to monitor insulin in EMM/EMR.

Narcotics, opioids and other sedatives

Presenting both generic and brand names on screen was a frequently used strategy for presentation of narcotics, opioids and other sedatives in EMR/EMM.

The main EMM/EMR strategies we identified to support management of narcotics, opioids and other sedatives, included alerts and order sets. A large number of alert types were identified, such as cumulative dose warnings, duplication warnings, patch removal alerts, and paper-chart reminders. Many of these features targeted duplication and overdosing, and so align with our grey literature review, which identified several recommendations relating to minimising duplication and ensuring appropriate dosing (e.g. calculators) of narcotics, opioids and other sedatives in EMM/EMR.

Chemotherapy agents

Fewer strategies relating to chemotherapy were reported by interview participants. Presentation strategies related primarily to including text on screen to indicate medicines were cytotoxic and precautions should be used for handling. Order sentences and order sets were also used, as were alerts for handling instructions, height and weight changes, and displaying local information.

Our grey literature review identified a large number of recommendations related to chemotherapy presentation and management in EMM/EMR including alerts, set up of protocols, and system authorisation for users (who can prescribe, verify and administer chemotherapy in EMM/EMR). These are generally consistent with our fundings from structured interviews.

Heparin and other anticoagulants

The most common presentation strategy for heparin and other anticoagulants was the display of both brand and generic names on screen.

The main EMM/EMR strategies we identified to support management of heparin and other anticoagulants included alerts, order sets and order sentences. A large range of alerts were used, including reminders to complete a VTE risk assessment, brand confirmation, duplication warnings, target INR and indication reminders, and dose check alerts. Forcing functions, including mandatory entry of order elements like duration of therapy and target INR levels, were also a frequently used strategy. Like other HRMs, no formal evaluations of these strategies were reported. We identified one Australian evaluation of patient-specific alerts to guide appropriate prescribing on discharge, and this showed that alerts improved appropriateness of warfarin prescribing.

Our grey literature review identified a large number of recommendations related to presentation, management and monitoring of heparin and other anticoagulants in EMM/EMR, including ensuring the visibility of order details (like order status), alerts, and use of a VTE risk assessment tool.

Common strategies across all high-risk medicines

Although specific details and content differed across HRMs, high-level strategies were highly consistent across all HRM classes. With respect to presentation, tallman lettering and highlighting were frequently used across all HRM types, with symbols and colour often used to indicate that a medicine was high risk. Text was also a frequent addition to communicate key information.

With respect to management strategies, alerts, order sentences and order sets were common to all HRM classes, and also emerged as recommended strategies in our grey literature review. Similarly, audits/reports and dashboards were common monitoring strategies across all HRMs, and these were also recommended in sources we identified in the grey literature.

Conclusion

Overall, our literature and environmental scan identified a large number of strategies that have been implemented to present, manage and monitor HRMs in EMM/EMR. Although specific details and content differed across HRMs, high-level strategies were consistent, with highlighting (e.g. colour), alerts, order sentences, order sets and dashboards frequently used to support use of all HRMs.

We identified very few evaluations of strategies, both in the literature and through structured interviews, making it difficult to draw firm conclusions about which strategies are more effective than others and accepted by clinicians. Systematic reviews and Australian papers revealed that some strategies can be effective in supporting safe use of HRMs, but the Australian papers also highlighted that strategies were not always accepted or used as intended, and were sometimes worked around or bypassed. This is consistent with what we uncovered via our interviews, with participants highlighting some challenges associated with strategy implementation. Participants reported that some strategies were not liked and used, and also described instances of users working around or ‘gaming’ EMM/EMR strategies when they were perceived to slow down or block workflow. In some cases, users were unaware of strategies (e.g. dashboards or order sets), resulting in low uptake of these features.

These findings suggest that for the full benefits of EMM/EMR strategies to be realised, features should be well-designed and align with user workflow, to increase acceptance and use of strategies**. We recommend adopting a user-centred approach**. Additionally, findings suggest that lack of awareness of features may hinder uptake, so **we recommend clear and effective communication and dissemination strategies** be adopted by sites when implementing a new strategy.

A small number of unintended consequences of strategy implementation, both positive and negative, were also uncovered. The main positive unintended consequence was that strategies (e.g. dashboards) were helpful for the management of drug recalls or drug shortages. The

main negative unintended consequence was the additional workload required to set up and maintain the strategies described (e.g. building order sentences).

In the absence of robust evidence regarding the effectiveness of strategies to reduce adverse events, particularly comparative studies, **we recommend sites take a cautionary approach when implementing new strategies.** Initial piloting should be conducted before strategies are scaled, and **mechanisms (e.g. feedback loops) should be in place for ongoing monitoring and evaluation** of strategies.

Background

Prescribing errors are common in hospitals, occurring in approximately 7% of medication orders and 50% of hospital admissions.[1] However, errors associated with high-risk medicines (HRMs) have a greater propensity to cause harm, and can lead to increased mortality and higher costs when compared to non high-risk medicines.[2] In hospitals, electronic medical records (EMRs) and electronic medication management systems (EMMs) support the medication process, including prescribing, dispensing and medication administration. These systems can have varying levels and types of decision support aimed to improve medication safety, including the safe use of HRMs.[3-5]

In Australia, there is no standardised list of HRMs, and such lists are often developed based on incident reporting systems across different health services, jurisdictions, and countries.[7] The classification of high-risk medicines can vary across hospitals and healthcare settings, with the "APINCH" acronym widely utilised in Australian hospitals to help clinicians focus on a specific group of medicines associated with a high potential for medication-related harm.[7] For this report, high-risk medicines (HRMs) were defined based on the Australian Commission on Safety and Quality in Health Care's "APINCH" list[6]:

- Antimicrobials
- Potassium and other electrolytes
- Insulin
- Narcotics (opioids) and other sedatives
- Chemotherapeutic agents
- Heparin and other anticoagulants

The work described here, conducted for the eHealth High Risk Medicine safety (e-HRM) Advisory Group, comprises an environmental scan and literature review to examine and understand how EMR and EMM systems present and manage issues/risks relating to HRMs in Australian health service organisations.

Key questions

1. What strategies (e.g. EMR configuration, functionalities, clinical decisions support systems or alerts) have been implemented through EMR/EMM systems to monitor the safety of high-risk medicines?
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3. What strategies have been implemented through EMR/EMM systems to present high-risk medicines?
4. To what extent are these strategies perceived as acceptable and satisfactory by clinicians?
5. What is the impact of these strategies in increasing high-risk medicine safety and decreasing the number of patient safety adverse events?
6. Have implemented strategies produced any unintended consequences – positive or negative?

Methods

The research team used a multi-method approach comprising a targeted literature review, structured interviews, and document reviews to address the research questions.

Targeted literature review

Objectives

To identify the strategies that have been implemented through EMR/EMM to present, manage, and monitor the safety of HRMs, and for each strategy collate data on:

a. Clinician perspectives and acceptance of the strategy
b. The impact of the strategy on high-risk medicine safety and patient safety adverse events
c. Any unintended consequences (positive or negative) produced by the strategy

To achieve these objectives, three searches were conducted:

1. A review of systematic reviews, both national and international
2. A review of primary studies undertaken in Australia
3. A review of Australian grey literature

Search strategy

Search for academic papers

For searches 1 (systematic review) and 2 (primary Australian studies), the databases Cochrane Systematic Reviews, Medline and Embase were searched. The search strategy was developed with the assistance of an expert librarian. Keywords for our main search are listed in Table 1. The complete search strategy is in Appendix 1**.** The search was conducted on the 11th of October 2023.

The results of the search were restricted to 1) systematic reviews and 2) Australian primary studies using the search terms in Table 2. All potentially relevant papers were imported into a systematic review management software (Covidence) for screening. The reference lists of included papers were also searched for relevant studies.

Table 1. Search terms (keywords)

	Category	Keywords
1	High risk medication terms	High-risk* high-alert* high risk* high alert* high-hazard* high-chance* high-danger* high-peril* medication* medicine* drug* pharmaceutical* Antimicrobial* Antibiotic* anti-infective agent* anti infective agent* Anti-Bacterial* or antibacterial* Antifungal* Antiviral* Antiparasitic* Potassium* magnesium* phosphorus* Phosphate* calcium* Hypertonic sodium chloride* insulin narcotic* opioid* sedative* or sedating Anaesthetic* or anesthetic* Benzodiazepine* chemotherapy drug* Cytotoxic drug* heparin* anticoagulant* Factor Xa inhibitors Direct thrombin inhibitors Thrombolytics
2	EMR/EMM terms	Decision support system* Computer-Assisted Decision*.mp. Clinical decision support*.mp. electronic health record*.mp. electronic medical record*.mp. Medical Order Entry Systems e-prescribing system.mp. electronic prescribing* computeri?ed physician order entr* computeri?ed provider order entr* electronic medication management*

		(CPOE or EMM or EMR or EMMS or EHR or EPS or CDSS or CDS)
3	Hospital setting terms	Hospital* Inpatient*

Table 2. Search terms to restrict our review to systematic reviews and Australian primary studies

	Category	Keywords
4a	Review restriction	Systematic review.tw,pt. exp Systematic review/ Systematic review*.tw,pt.
4b	Australian studies restriction	Australia/ or australia* OR oceani* OR "New South Wales" OR sydney OR queensland OR brisbane OR victoria OR melbourne OR "Australian Capital Territory" OR canberra OR "Northern Territory" OR darwin OR "South Australia" OR adelaide OR tasmania OR hobart OR "Western Australia" OR perth

Search for grey literature

The environmental scan was conducted using OpenGrey and relevant government websites (Table 3) across Australian states and territories. These were reviewed to identify grey literature, reports, policies, and guidelines pertaining to strategies implemented through EMR/EMM related to HRMs.

Table 3. Websites, documents, policies and/or guidelines where information on high risk medicines in electronic medication management systems was found

Source	Link
Canberra Health Services, High risk medicines policy	https://www.canberrahealthservices.act.gov.au/__data/assets/word_doc/0008/1981349/High-Risk-Medicines-Policy.docx#:~:text=The%20High%2DRisk%20Medicines%20Policy,associated%20with%20high%2Drisk%20medicines
NSW health, Clinical Excellence Commission, High risk medicines management	https://www1.health.nsw.gov.au/pds/ActivePDSDocuments/PD2020_045.pdf
eHealthNSW, Minimising Inappropriate Dual Anticoagulation in NSW	https://nswhealth.sharepoint.com/sites/EHNSW-ClinicalApplicationsHub-Solutions/Collateral/Memo%20from%20CEC%20and%20eHealth.pdf
Clinical oncology society of Australia (COSA) guidelines for the safe prescribing, dispensing and administration of systemic cancer therapy	https://wiki.cancer.org.au/australia/Clinical_question:What_factors_should_be_taken_into_account_when_using_electronic_systems_to_support_the_delivery_of_cancer_therapy%3F
Australian Commission on Safety and Quality in Health Care, National Guidelines for On-Screen Display of Medicines Information	https://www.safetyandquality.gov.au/publications-and-resources/resource-library/national-guidelines-screen-display-medicines-information
Australian Commission on Safety and Quality in Health Care: Electronic Medication	https://www.safetyandquality.gov.au/publications-and-resources/resource-library/electronic-

Management Systems – A guide to safe implementation (third edition)	medication-management-systems-guide-safe-implementation-third-edition
Australian Commission on Safety and Quality in Health Care: Electronic Medication Management Systems Business Requirements – An addendum to Electronic Medication Management: A guide to safe implementation (3rd edition)	https://www.safetyandquality.gov.au/publications-and-resources/resource-library/electronic-medication-management-systems-business-requirements-addendum-electronic-medication-management-guide-safe-implementation-3rd-edition
Australian Commission on Safety and Quality in Health Care: Electronic Medication Management Self-Assessment Domain and Indicators Summary	https://www.safetyandquality.gov.au/publications-and-resources/resource-library/electronic-medication-management-self-assessment-domain-and-indicators-summary
Australian Commission on Safety and Quality in Health Care: National Anticoagulant Incident Analysis report	https://www.safetyandquality.gov.au/publications-and-resources/resource-library/national-anticoagulant-incident-analysis-report
Victorian State Government: The Department of Health and Human Services. Policy for minimising harm caused by medicines	https://www.health.vic.gov.au/publications/policy-for-minimising-harm-caused-by-medicines

Screening and data extraction

Academic papers

To identify relevant reviews and primary studies, 10% of titles and abstracts were screened based on the eligibility criteria (Table 4) by two researchers to ensure consistency. The remaining titles and abstracts were divided and screened by one researcher. Full texts for papers that met the inclusion criteria based on title and abstract were then screened by one researcher. Any papers where it was unclear if inclusion criteria were met were discussed as a group until consensus on inclusion was reached. The screening process is depicted in Figure 1.

Table 4. Eligibility criteria

Inclusion	• Reviews, papers and documents focused on strategies implemented through EMR/EMM
	• Strategies focused on HRMs including:
	  ○ Antimicrobials
	  ○ Potassium and other electrolytes
	  ○ Insulin
	  ○ Narcotics, opioids, and sedatives
	  ○ Chemotherapeutic agents
	  ○ Heparin and other anticoagulants
	• Strategies implemented through EMR/EMM
	• Hospital setting
	• Published in the last 10 years

Exclusion	• Not in English • Not peer-reviewed (reviews and papers) or not from a legitimate government website • Commentaries or reviews that do not use systematic search methodology (e.g. narrative reviews)

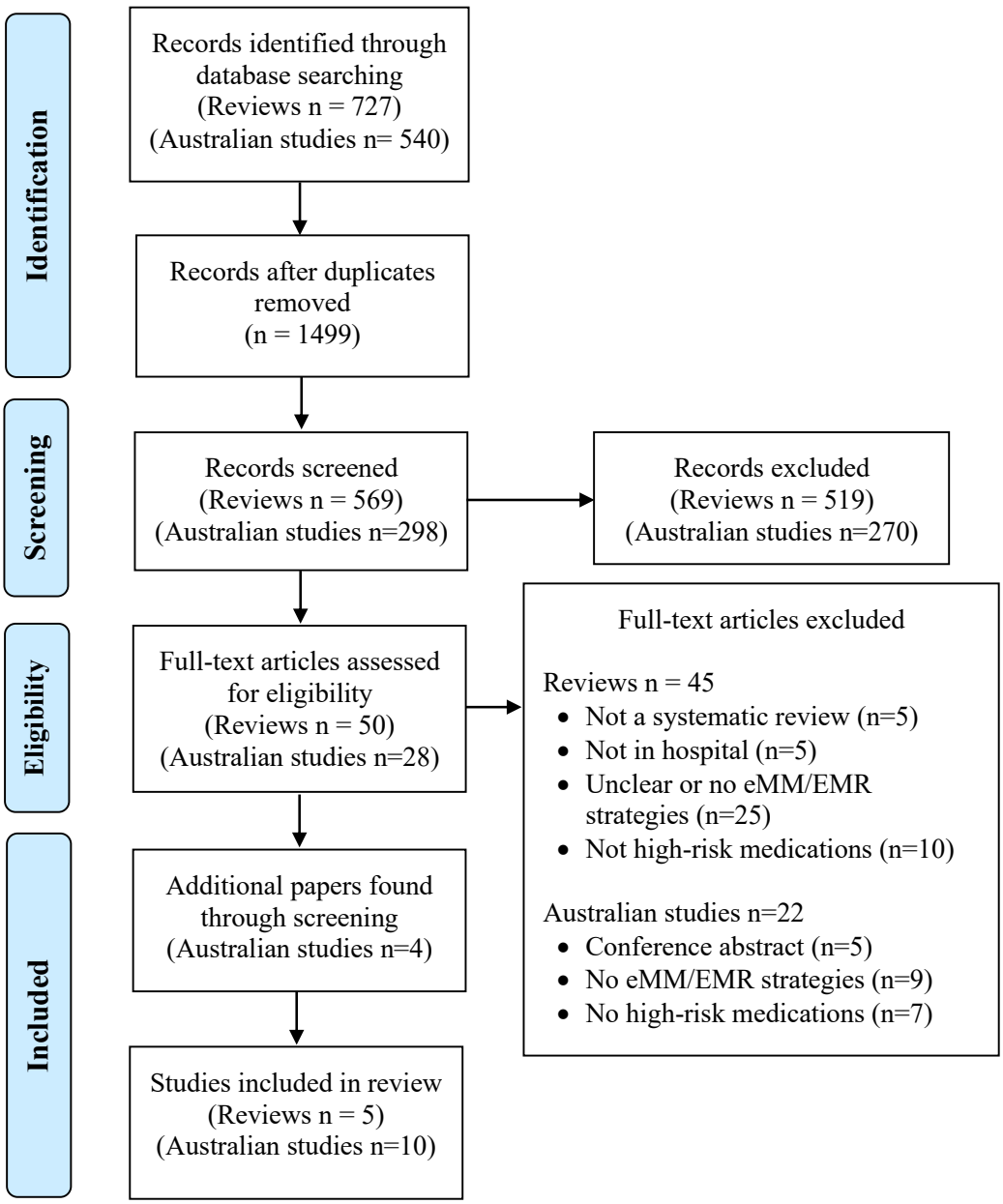

Figure 1. Screening and selection methodology for academic papers

Grey literature

Documents were screened by one reviewer and any documents where it was unclear if inclusion criteria were met were discussed as a group until a consensus on inclusion was reached.

Data extraction

The following data was extracted from all eligible academic papers and relevant grey literature:

- Paper characteristics

- Strategies implemented to monitor, manage or present high risk medicines (e.g. EMR configuration, functionalities, clinical decisions support systems or alerts)
- Clinician perceptions and acceptability of strategies
- Effectiveness of strategies
- Unintended consequences of strategies

Structured interviews

Objectives

To identify the strategies that Australian state and territories have implemented through EMR/EMM to present, manage, and monitor the safety of high-risk medicine. We also aimed to explore if the strategies had been evaluated, and if yes, specifically related to:

a. clinician perspectives and acceptance
b. impact on high-risk medicine safety and patient safety adverse events
c. unintended consequences

Stakeholder engagement

Stakeholders with knowledge of high-risk medicine strategies in hospitals (e.g. clinical informatics staff, EMM pharmacists, Directors of Pharmacy Departments) were eligible to participate. An invitation letter and/or advertisement (Appendix 2) was distributed to potential participants using the strategies in Table 5. Participants were offered a $50 voucher for their time.

Table 5. Recruitment strategies

Recruitment Strategy	Description
Known contacts	Stakeholders known to the research team and the e-HRM Advisory Group were contacted and invited to participate
Relevant society	We approached the Society of Hospital Pharmacists' EMM leadership committee members and invited them to take part
Snowball sampling	Participants were asked to recommend other colleagues who may wish to take part

Data collection and analysis

A structured interview guide was developed for interview discussions (Appendix 3). In the interviews, participants were asked to describe strategies used for the APINCH list, but also asked if there were any site-specific HRMs that were presented, managed or monitored in their EMM/EMR. Interviews were conducted via telephone or video conference with each participant and audio recorded. Responses were collated into a spreadsheet.

Document review

All participants were also invited to share any relevant documents relating to the EMR/EMM strategies, including any evaluation reports, but very limited additional information was provided.

Results

Results from academic papers

Systematic reviews

Five systematic reviews met our criteria for inclusion. Key demographic information including the year published, the number of studies included, and the aim, appear in Appendix 4 (Table A1) . Only one of the reviews[8] performed a meta-analysis, and it included all strategies without specific emphasis on strategies embedded in EMR/EMM. Two reviews focused on antimicrobials, two on insulin and one on chemotherapy. The reviews were published between 2016 and 2022. Most strategies for antimicrobials and insulin related to the management of these medications. For chemotherapeutic drugs, the strategies related to management and presentation. Strategies are presented below with complete data extraction tables available in Appendix 4 (Table A3).

Australian primary studies

In total, 10 papers met our inclusion criteria and described the implementation or evaluation of strategies focused on HRMs management in EMR/EMM in an Australian setting. Papers were published between 2015 and 2023, and most were single site studies (n=7). Of the 10 Australian papers, 2 papers[9 10] were also included in one of the systematic reviews[11]. Key demographic information from papers, including setting, aim and method, appear in Appendix 4 (Table A2).

Half the studies (n=5) described strategies for the management and monitoring of antimicrobials,[10 12-15] two papers focused on anticoagulants,[16 17] two papers on opioids,[18 19] and one paper described strategies for multiple HRMs.[20]

In total, 34 strategies were described in papers. Only one strategy related to the presentation of HRMs, 27 strategies related to management of HRMs and 6 strategies related to monitoring.

Strategies are presented for specific APINCH medications below with data extraction tables available in Appendix 4 (Table A4). No strategies were identified for high-risk medications generally and for potassium and other electrolytes.

Antimicrobials

Results from systematic reviews

Two systematic reviews included strategies for antimicrobial prescribing and stewardship in hospitals.[8 11]

Baysari et al[8] reviewed evidence on the effectiveness of information technology interventions to improve antimicrobial prescribing. Results related to clinical decision support (CDS) and surveillance systems are outlined below.

Studies that assessed clinical decision support (CDS) embedded within the EMR/EMM were evaluated (n=21). A reduction in antimicrobial prescribing was found in all studies that measured antimicrobial use pre and post implementation (n=4). Nine papers reviewed antimicrobial appropriateness, and CDS was also associated with more appropriate prescribing in most studies (n=8). Four studies measured the impact of CDS on patient length of stay, and in two studies a reduction in length of stay was found.[8]

Variability was observed in the type of the decision support that was applied to practice and subsequently assessed. The support measures encompassed a spectrum, including guidance in selecting indications, order sets, alerts and surveillance systems. Details are outlined in Table 6.[8]

Surveillance systems were described in five studies and included strategies to monitor results, antimicrobial orders, and identify patients on inappropriate antimicrobials. In the two studies that evaluated the systems, less than a third of problems identified by the surveillance systems led to pharmacist interventions. Outcome measures varied, but statistically significant reductions were reported in cost of antimicrobials, patients prescribed excessive antimicrobial dosages, adverse drug events, mortality and patient length of stay in at least one study after implementation of a surveillance system.[8]

The aim of Jenkins et al's review[11] was to identify interventions implemented in EMM systems and the outcome measures used to monitor their impact. Interventions included alerts, order sets, restriction of access, mandated documentation, embedded guidelines and automatic prescription stop (Table 6). Outcomes were categorised as quality outcomes (e.g. adherence to guidelines, mortality, readmission rates, rates of Clostridioides difficile infections, appropriate and accurate documentation, time to administration, appropriateness of IV-to-oral switch), and quantity outcomes (e.g. length of stay, duration of therapy, consumption). In papers assessing quality outcomes, 41% showed a positive change and 54% showed no change (n=28 studies). In papers on quantity outcomes, the majority (72%) showed no change, and 20% showed a positive change.[11]

Table 6. Strategies reported in reviews on management and monitoring of antimicrobials

Strategy	Additional details
Management	
Forcing functions	Requirement to select an indication from a list of appropriate indications Indication or justification to gain approval
Order sets	Pre-written/ default orders, order sets or components Simple order set: includes all essential elements for an antimicrobial prescription Complex order set: includes a range of requests e.g. clinical severity scoring, dose adjustments for special population, laboratory test requests and monitoring
Alerts	Alerts notifying physicians of serious blood stream infections Alerts staff of potentially inappropriate antimicrobials
Guidelines	Embedding guidelines into the EMR
Calculator	Initial dosing and monitoring of amikacin and tobramycin
Automation	Automatic prescription stop when specific criteria was fulfilled
Monitoring	
Surveillance systems	Generates report of potentially inappropriate antimicrobials

Results from Australian primary studies

Table 7. Strategies reported in Australian papers (n=5) on management and monitoring of antimicrobials

Strategy	Additional details
Management	
Alerts	Alert informing of restrictions and policy Alert recommending therapeutic drug monitoring
Order sentences	Customised order sentences Order sentences including an indication
Forcing functions	Indications at point of prescribing
Order sets	-
Automation	Automatic stop dates
e-referrals	For AMS pharmacist review
Link to guidelines	Link to local policy
Monitoring	
Dashboard	Local antimicrobial dashboard
Medicine list/report	Data extraction capabilities Antimicrobial specific report
Audit & feedback template	To provide feedback to prescribing teams

Five studies focused on strategies for management and monitoring of antimicrobials. One 2017 study used a controlled pre-post design to examine the impact of replacing antimicrobial alerts with order sentences and found no change in accuracy of indication documentation, appropriateness of prescribing or compliance to the hospital policy.[12] Interviews with prescribers at the hospital revealed that they were positive about order sentences but said that long lists could lead to mis-selection. This study also uncovered user workarounds, as prescribers reported 'gaming' the system because the approval process did not align with their workflows.[12]

In another study (2015) that interviewed prescribers about therapeutic drug monitoring (TDM) for gentamicin, it was revealed that most users were unaware of the TDM service, and most had not noticed the EMM alert that informed them of the available service.[14]

In a 2017 pre-post study that evaluated the transition from an alert prompting prescribers to seek approval for restricted antimicrobials (and enter approval number) to mandatory documentation of indications (and approval numbers) at point of prescribing, it was found that compliance to the hospital policy improved from 55% to 76%, and failure to seek approval reduced from 70% to 0%. As above, the chart review also uncovered system workarounds. Prescribers circumvented the system by documenting non-compliant entries into the approval number field.[10]

A prospective observational chart review study (2021) evaluated the implementation of a progress note template for AMS teams to provide audit and feedback to prescribers.[15] The template resulted in an increase in antibiotic appropriateness from 55% to 71%, and feedback recommendations were accepted by prescribers 47%, 71% and 96% at 1 day, 2 days and 7 days post AMS round respectively.[15]

Insulin

Results from systematic reviews

Two systematic reviews included strategies relating to insulin management.

Sly et. Al.'s[21] review focused on strategies to improve safety and quality of diabetes management in non-critical care inpatient settings. The population group included all inpatients with diabetes. The review included some CDS strategies that were embedded in EMR/EMM including insulin order sets (n=8), prescribing alerts (n=3), and hypoglycaemia management (n=1). The review reported that the insulin order sets resulted in a clear improvement in glucometric measures, which included reduced mean glucose, and an increased proportion of blood glucose levels within target range. With alerts, the review found hard stop alerts were most effective in reducing inappropriate prescribing. The study developed a CDS system that provided patient-specific hypoglycaemia management guidance for nursing staff and found that the guidance led to increased protocol adherence compared with a paper-based protocol.

Jones et. Al.[22] reviewed the impact of strategies used in non-critical care inpatient/hospital settings on glycaemic control parameters. The focus was on medical applications used for subcutaneous insulin dose calculation. Strategies were from six papers and included guidelines and order sets. Most studies resulted in better glycaemic control, however the review reported the risk of hypoglycaemia in the studies was low.

Table 8. Strategies reported in reviews on management of insulin

Strategy	Additional details
Management	
Guideline	Glycaemic management protocols and insulin protocols in the EMR
Order sets	Insulin order sets: standardized insulin order sets which promoted basal bolus insulin ordering and provided weight and diet-based dosing recommendations in addition to a hypoglycaemia management protocol.
Surveillance system/ alerts	Daily lists or glycaemic alert systems triggering automatic review for patient who met pre-defined glycaemic criteria
Patient tailored decision support	Individualised patient-specific hypoglycaemia management guidance in EMR for nursing staff

Results from Australian primary studies

Table 9. Strategies reported in an Australian paper (n=1) on management and monitoring of insulin

Strategy	Additional details
Management	
Order sets	-
Alerts	-
Forcing function	Forced review of blood glucose results at point of prescribing

Monitoring	
Dashboard	Diabetic dashboard

A 2021 paper, comprising interviews with clinicians and EMM experts across a local health district in NSW, identified a number of EMM management and monitoring strategies for insulin (Table 9) but no evaluations of these insulin strategies were reported.[20]

Narcotics, opioids, and sedatives

Results from systematic reviews

No systematic reviews were identified focusing on strategies for narcotics, opioids and sedatives.

Results from Australian primary studies

Table 10. Strategies reported in Australian papers (n=2) on presentation, management and monitoring of opioids

Strategy	Additional details
Presentation	
Tall man; highlighting	Tallman and red text
Management	
Limited options	Forced selection of brand name
Order sentence	Combination laxative order sentence visible on screen when ordering opioid
Alert	Alert prompting completion of opioid management plan
Electronic form	Opioid management plan
Monitoring	
Dashboard	Displaying opioid management plans

In a pre-post study (2020), a combination laxative order sentence was made visible on screen when ordering opioids and this resulted in a small, non-significant increase in the combination laxative being prescribed (from 13% to 15% of patients).[18] However, a significant increase in co-prescription of docusate with sennosides among aged care patients (OR = 1.8, 95% CI 1.0–3.0, p = 0.03) was observed after this change.

In a recent quality improvement study (2023), introduction of an alert prompting prescribers to complete/update an opioid management plan (OMP) in the EMR resulted in 95% of ED patients and 96% of orthopaedic patients on an opioid prescription with an OMP completed.[19] Although this form was designed to be automatically incorporated into the discharge summary, 44% of ED patients and 94% of orthopaedic patients had an OMP in the discharge summary, reflecting a workflow issue in the ED.[19]

Chemotherapeutic agents

Results from systematic reviews

One review[23] identified strategies for chemotherapeutic medicines. Strategies related to presentation and management are listed in Table 11. Evaluation outcomes of strategies were not reported in this review.

Table 11. Strategies reported in review on presentation and management of chemotherapy

Strategy	Additional details
Presentation	
Clear distinction of medications	Distinction between chemotherapy agents and other medications
Definitions	Definition of chemotherapy protocols in the system
Display at point of prescribing	Displaying chemotherapy protocols at the time of prescription
Display of information when needed	Displaying the information needed at the time of prescribing (summary of diagnostic information, laboratory values, the patient's vital signs, chemotherapy medications, and supportive treatments for the patient)
Graphical display	Display of graphical reports for quantitative variables
Graphical display	Display of the patient treatment plan and protocol graphically
Management	
Alert	Alert for prescription error Alert for unusual parameters required for dose calculations (e.g. height or weight)
Automation	Automated dose calculations and adjustments
Definitions	Definition of solvents appropriate for any chemotherapy medication in the system Definition of access levels and user interface for different users (physician, nurse, and pharmacist)
Guidelines	Links to medical guidelines Embedding chemotherapy protocols in the EMR
Limited or default options	Creation of particular specifications for medications (such as route and unit), date and time, and default dosages for medications based on an automatically determined treatment protocol for the patient
Modifiable	Possibility to modify, reschedule, and disable the protocol for a certain patient, including procedures such as change of the patient's parameters, the dosage of medications, or the default units by the physician
Nudging data entry	Guiding or asking the user to complete the important prescription parameters
System interoperability	Interoperability with other hospital systems (pathology, pharmacy) Communication with centres outside the hospital
Tailoring alerts to users	Embedding capabilities for more flexibility in the system in relation to alerts (possibility of denying alerts by physicians and possibility of setting alerts)
Web-based prescribing	Prescribing via a web-based system
Workflow support	System's support of the hospital workflow
Permanent documentation	Permanent documentation of the patient's therapeutic information
Easy transfer of information	Possibility of receiving chemotherapy electronic prescriptions information from a pharmacist or nurse

Results from Australian primary studies

One 2021 paper, comprising interviews with clinicians and EMM experts across a local health district in NSW, described the use of order sets for chemotherapy, but no evaluation of this strategy was performed.[20]

Heparin and other anticoagulants

Results from systematic reviews

No systematic reviews were identified focusing on strategies for heparins and other anticoagulants.

Results from Australian primary studies

Table 12. Strategies reported in Australian papers (n=2) on management of anticoagulants

Strategy	Additional details
Management	
Alerts	Alerts to guide prescribing at discharge Warfarin dose check reminder for nurses
Forcing functions	Manual data entry of administration time if after the default time Mandatory duration for orders
Order sets	-

Two Australian studies described management strategies for anticoagulants in EMM/EMRs. One pre-post study (2021) evaluated the transition from basic warfarin and enoxaparin alerts to patient-specific alerts to guide appropriate prescribing on discharge. Both prescribing practices and prescriber satisfaction were assessed. Appropriateness of prescribing increased from 48% to 91%, there was a large reduction in high doses (39% vs 2%), and an improvement in key safety indicators, like hospital acquired complications (reduced by 26%), and length of stay (reduced by 11%).[16] 95% of prescribers were satisfied with the new CDS, compared to only 48% indicating they were satisfied with the basic alerts.

A 2020 chart review study of patients prescribed warfarin with several EMM strategies in place (mandatory documentation of durations and administration times, and a warfarin dose check reminder to nurses) found 28% of patients had warfarin errors, and 8% of patients had an INR>5.[17]

Results from Grey Literature

Of the 33 government or organisational websites/reports searched, only 10 included recommendations for presenting, managing or monitoring HRMs in EMM/EMRs. Overall, a total of 91 recommendations on presentation, management and monitoring of HRMs were identified, describing 36 unique strategies.

Presentation
In total, 18 recommendations that described 10 strategies related to the presentation of HRMs in EMM. The most frequently reported strategy was the content of text displayed on screen, reported in 7 recommendations. The position of different functionalities on screen was described in 2 recommendations, while other strategies appeared once each in the other recommendations (e.g. abbreviations, symbols, unit of measurement).

Management
In total, 71 recommendations that described 24 strategies related to the management of HRMs in EMM. The most frequently reported strategy was the use of alerts, described in 16 recommendations. Concomitant Prescribing/Monitoring support was a strategy identified in 9 recommendations, automation appeared in 8 recommendations, while calculators, system authorisation and review of relevant results appeared in 4 recommendations each. Other strategies involve the use of dashboards, EMM, fields, forcing functions, indicators, internal approval, limited options, mandatory data entry, medication reports, order sets, override function, risk assessment tool, system policy, system security, text, user testing and work system analysis.

Monitoring
There were 6 recommendations that described 2 strategies relating to monitoring HRMs in EMM. The most frequently reported strategy was the use of audits, as described in 5 recommendations. The use of dashboards was the other strategy included in one recommendation.

The strategies and recommendations for monitoring HRMs in EMM/EMRs are shown below for HRMs generally, and then the APINCH categories (Tables 13-19). When strategies and recommendations were pertaining to specific medications, these medications have been noted in the Tables.

High-risk medicines

Table 13. Strategies and recommendations for managing and monitoring all HRMs in EMM/EMR

Strategy	Recommendation
Management	
Alert	Use of shelf reminders, checklists and alerts and, where possible, these should be built into information technology systems [24]
	The use of the EMM system to support key tasks of the NSQHS safety and quality standards is continually monitored and evaluated. E.g. Alerting prescribers when prescribing look-alike, sound-alike and HRMs [25]

	EMM systems can support other safety and quality standards by alerting prescribers when prescribing look-alike, sound-alike and HRMs such as sedatives, antidepressants, antipsychotics and centrally acting pain relief to patients identified as at risk of a fall [26]
	Encounter-specific information designed to prompt practitioners to perform desired actions, which can be computer-based (e.g. SafeScript notifications). [27]
Automation	The EMM system should support conditional dosing – for example, warfarin based on an INR result, supplemental insulin based on abnormal BGLs and not adequately controlled by basal insulin, and medicine doses requiring renal or hepatic function test results [28]
	The EMM system should support variable-dosing regimen including loading doses – for example, heparin infusions [28]
	The EMM system should support providing support tools (for example, dose calculators) and templates that assist with variable-dose decision-making, integrated within medication prescribing, review and administration functions [28]
	The EMM system should automatically calculate the dates that dose changes will apply [28]
Concomitant Prescribing/ Monitoring support	Support the safe use of HRMs within the EMM system by: Reviewing duplication of scheduled administration and PRN doses [25]
	Support the safe use of HRMs within the EMM system by: Considering therapeutic duplication [25]
Continuous system improvement	Health service organisations should develop annual plans for the systematic improvement in medication safety and efficient clinical workflow enabled by their EMM systems, particularly considering the management of HRMs [26]
EMM/EMR optimisation	Continue to implement and optimise electronic medication management systems to facilitate the identification and prevention of missed doses, incorrect doses and duplicate therapy orders [29]
Fields	EMMs should record parental or guardian consent for adolescents on certain HRMs or clinical trial medicines [28]
Limited options	Support the safe use of HRMs within the EMM system by: Restricting dosing schedules for some medicines [25]
	Support the safe use of HRMs within the EMM system by: Configuring some medicines to be prescribed for inpatient use only [25]
Forcing functions	Prescriber should complete the 'Indication' for use box on EMM [24]
	Systems should use forcing functions and fail safes (such as limiting access or use, constraints, barriers or standardisation) as a risk reduction strategy [24]
	Parental or guardian consent for paediatric patients on HRMs or clinical trial medicines is documented in the EMM system [25]
Order sets	The EMM system should support prescribing as a single process without having to enter multiple separate orders [28]
Override function	Decision support should allow prescriber overrides to be visible at the time of medication administration; high-risk medication overrides should be given specific prominence [28]
Review of relevant result	The EMM system should have easy access to pathology results that support the accurate prescribing and administration of medicines such as warfarin and insulin. When results are missing or not available, the EMM system should provide a prompt to get them before prescribing or administering the next dose. [28]
System security	Support the safe use of HRMs within the EMM system by: Configuring administration lock-outs [25]

Text	A patient discharge medication list from the EMM system should include any appropriate cautions for HRMs administered in the past 12-24 hours [25]
	When high-dose medicines and increasing dose strengths are ordered, the EMMs should ensure the display of appropriate warnings, based on locally configured rules. [28]
User testing	The health service organisation should develop scripted product scenarios that reflect the intended use of the EMM system as part of the product evaluation. The test scenarios should include: Processes that consider the management of complex and HRMs, such as warfarin [26]
Work system analysis	Completing current-state process mapping early in the EMM project will provide a useful checklist to inform the EMM system tender requirements. The process map should include: Requirements of complex, high-risk and variable dose medicines (such as warfarin), and of specialised medicines (such as for patients who are in palliative care, undergoing chemotherapy or experiencing acute pain) [26]
Monitoring	
Audit	The EMM system annual work plan includes an audit schedule: The audit schedule could include a review of high-risk medicine usage [25]
	The use of the EMM system to support key tasks of the NSQHS safety and quality standards is continually monitored and evaluated. E.g. Alerting prescribers when prescribing look-alike, sound-alike and HRMs [25]
	The introduction of real-time prescription drug monitoring programs has enabled better and more targeted reviews, by allowing the department to access more comprehensive information in a more timely manner. Some elements of a review will continue to require in-depth analysis, for example monitoring high-risk activities that may result in harm to patients. [27]

Antimicrobials

Table 14. Strategies and recommendations for managing antimicrobials in EMM

Strategy	Recommendation
Internal approval	The EMM system should also support an approvals workflow for the prescribing of high-risk antimicrobials requiring internal approval. Approval workflow should include: medication orders awaiting internal approval, such as non-formulary and high-risk antimicrobials [28]

Potassium and other electrolytes

Table 15. Strategies and recommendations for managing potassium in EMM

Strategy	Recommendation
Concomitant Prescribing/ Monitoring support	Support the safe use of HRMs within the EMM system by: Undertaking cardiac monitoring when prescribing and administering potassium [25]
	EMMs should support cardiac electrolyte monitoring [26]

Insulin

Table 16. Strategies and recommendations for presenting and managing insulin in EMM

Strategy	Recommendation
Presentation	
Numbers	Leave a single blank, non-breaking space between a number and its unit of measure [30]
Text	To increase clarity, display both active ingredient and brand names for medicines posing a higher risk than normal, including insulin [30]
Management	
Alert	For insulin, clinicians should have access to enough recent BGLs to allow any trends to be apparent. [28]
	The EMM system should prompt for BGLs before administration of basal insulin doses. If supplemental doses have been administered, the EMM system should alert the prescriber to review the patient's basal insulin needs. [28]
Concomitant Prescribing/ Monitoring support	Support the safe use of HRMs within the EMM system by: Recording or reviewing blood glucose levels when prescribing and administering insulin [25]
	EMMs should support recording or reviewing of blood glucose levels [26]

Narcotics, opioids and other sedatives

Table 17. Strategies and recommendations for presenting and managing opioids in EMM

Strategy	Recommendation	Medication
Presentation		
Text	A warning statement that initiation of hydromorphone in opioid naïve patients is hazardous and rarely warranted and that specialist advice is required [31]	Hydromorphone
Abbreviations	Abbreviations to denote modifications of release that are part of the brand name should not be changed. However, note that AMT uses 'modified release' in full as part of the medicine dose form. This includes slow release and controlled release (for example, 'tramadol hydrochloride 100 mg tablet: modified release, 10 tablets') [30]	Tramadol
Numbers	Where a product has a range of strengths that span micrograms and milligrams – it is safer for that product range to have the same unit of measure, so a microgram description that is more than 1,000 may be retained instead of converting to milligrams (for example, fentanyl lozenges 1,600 micrograms) [30]	Fentanyl
Symbols	Use the '+' separator to combine two or more active ingredients (preferred terms) within a single medicinal product (for example, paracetamol 500 mg + codeine phosphate 15 mg tablet as an example of an AMT MP) [30]	Codeine
Text	The brand name should only be displayed alone when display of active ingredient and brand names could cause confusion [30]	Morphine
Unit of measurement	For oral liquid preparations, dose should be expressed in weight as well as volume. For example, in the case of	Morphine

	morphine oral liquid (5 mg/mL), prescribe the dose in milligrams and confirm the volume in brackets; for example, 10 mg (2 mL). [30]	
Management		
Concomitant Prescribing/ Monitoring support	EMMs should support reviewing duplication of scheduled administration and PRN (taken as needed) doses [26]	N/A
	EMM should support considering therapeutic duplications [26]	N/A
Risk assessment tool	EMM should support using sedation scores and pain scores [26]	N/A
System security	EMM should support configuring administration lock-outs [26]	N/A
Calculators	Advice regarding the opioid conversion tool to be used for converting opioid doses to or from hydromorphone [31]	Hydromorphone
	Recommendation regarding the opioid conversion tool to be used for converting opioid doses. [31]	Opioids
	Support the safe use of HRMs within the EMM system by: Using sedation scores and pain scores when prescribing narcotics [25]	N/A

N/A – not applicable

Chemotherapy agents

Table 18. Strategies and recommendations for presenting, managing, and monitoring chemotherapeutic agents in EMM

Strategy	Recommendation
Presentation	
Text	To increase clarity, display both active ingredient and brand names for medicines posing a higher risk than normal, including chemotherapeutic agents [30]
Management	
Alert	Appropriate clinical decision support and prescribing alerts (including but not limited to allergies, medication interactions, maximum or cumulative dose breaches, wrong route of administration, etc) must also be incorporated into the system [32]
Automation	Where EMM Systems are in use, mechanisms should be built in to prevent inadvertent daily administration of methotrexate (oral). [31]
	Support the safe use of HRMs within the EMM system by: Limiting chemotherapy medicines to appropriate clinical settings and considering cumulative lifetime doses [25]
	EMMs should support limiting chemotherapy medicines to appropriate clinical settings and basing them on standard protocols that consider cumulative lifetime doses [26]
Concomitant Prescribing/ Monitoring support	The EMM system must be capable of managing oncology and haematology wards workflow directly or interfacing with other software products to allow clinicians to view a patient's chemotherapy treatment. [28]

Internal approval	e-prescribing systems must allow stringent controlled user access for approved staff to set-up chemotherapy protocols and allow a way to build protocols and keep them in an inactivated state until appropriate quality assurance processes have occurred to enable activation and access by prescribers. [32]
System authorisation	Security access to the e-prescribing system enabling personnel to prescribe chemotherapy in line with the prescribing section of these guidelines must only be granted to locally approved prescribers. [32]
	Security access enabling personnel to verify chemotherapy medication orders on e-prescribing systems in line with the dispensing section of the British Oncology Pharmacy Association (BOPA) and Australian Commission on Safety and Quality in Health Care (ACSQHC) guidelines must only be granted to locally approved cancer pharmacists. [32]
	Where e-prescribing systems allow electronic recording of administration, security access enabling personnel to record the administration of chemotherapy on e-prescribing systems must only be granted to approved staff who have been trained to administer chemotherapy. [32]
	Levels of access to e-prescribing systems must be determined locally and applied to different staff groups and/or individuals according to their professional roles and responsibilities after undertaking appropriate training [32]
System policy	Procedures for e-prescribing system set-up and use, scheduled and unplanned downtime and disaster recovery must be developed and maintained. [32]
User testing	Independent checking of the e-prescribing system once set-up is complete and for each individual chemotherapy protocol once built should be carried out by an experienced clinical cancer pharmacist, a consultant oncologist or haematologist and an experienced chemotherapy nurse specialist as appropriate and defined locally. [32]
Monitoring	
Audit	Appropriate ongoing monitoring of e-prescribing system performance including errors and near-misses in line with the local institution's practices must be recorded and actioned where appropriate to ensure continuous system improvement occurs and to highlight areas of risks being inadvertently introduced into practice. [32]

Heparin and other anticoagulants

Table 19. Strategies and recommendations for presenting, managing and monitoring anticoagulants in EMM

Strategy	Recommendation	Medication
Presentation		
Intuitive functions	Users should have an understanding of the 'grouping' functionality of orders, and that this is used to change the grouping of orders on 'Medication List' and 'Order' views. [33]	N/A
Layout	'Type' column is visible and education is provided on icons used [33]	N/A
Numbers	For numbers that have four or more whole-number digits, use a comma to separate groups of thousands [30]	Heparin
Position on screen	'Status' column is positioned as close as possible to the medication 'Order Name' [33]	N/A

	Status' column is positioned towards the left-hand side of the screen so that it is always visible onscreen without the need for horizontal scrolling [33]	N/A
Preferred configuration	Use of preferred configuration on default view [33]	N/A
Text	Multiple anticoagulant alert revised to include: names of the anticoagulant/s already ordered, and those intending to be ordered; bolded statement to advise prescriber of the risks; amended wording to 'Action' statement to point prescriber to review 'Alert Action' in the below section; additional wording to 'Continue Ordering' action, to ensure that if the prescriber is continuing with the order, that they confirm clinical appropriateness.[33]	N/A
	New Alert message for one or more existing heparin orders: The term 'heparin/s' has been hardcoded into the rule to cover the scenario where multiple heparins orders have been ordered.[33]	Heparin
	To increase clarity, display both active ingredient and brand names for medicines that have significant bioavailability issues, such as warfarin (Coumadin) [30]	Warfarin
Management		
Alert	Activation of multiple anticoagulant alert[33]	N/A
	Multiple anticoagulant alert revised to include: names of the anticoagulant/s already ordered, and those intending to be ordered; bolded statement to advise prescriber of the risks; amended wording to 'Action' statement to point prescriber to review 'Alert Action' ; additional wording to 'Continue Ordering' action, to ensure that if the prescriber is continuing with the order, that they confirm clinical appropriateness. [33]	N/A
	Additional logic added to multiple anticoagulant alert: If there is an existing subcutaneous heparin in an ordered status AND there are existing heparin/s ordered as part of a PowerPlan AND the clinician orders new heparin as part of a PowerPlan [33]	N/A
	Addition of new multiple anticoagulant alerts: a) that will trigger on sign order when two or more anticoagulants are ordered in the same instance, b) that will trigger on sign order when you are resuming one or more anticoagulant orders and there is already an existing inpatient anticoagulant in an ordered status [33]	N/A
	New Alert message for one or more existing heparin orders: The term 'heparin/s' has been hardcoded into the rule to cover the scenario where multiple heparins orders have been ordered. [33]	Heparin
	Addition of new anticoagulant agent (argatroban) within Multiple Anticoagulation Alert rules [33]	Argatroban
	Although desirudin and nadroparin have been discontinued, they have been retained in the multiple anticoagulant alert rule in the event of future use [33]	N/A
	Anticoagulant work in the EMM system: Discharge Summary Program: This program flags any patient that has had warfarin mentioned in their medical record or medicines list. [29]	N/A
	Tool to be built into the new EMM system: Support documentation of VTE risk assessment (including prompts) [29]	N/A
Dashboard	Anticoagulant work in the EMM system: Heparin dashboards: Available for implementation if sites choose and can be used to optimise medicines use [29]	N/A
Fields	Tool to be built into the new EMM system: Capture administration data[29]	N/A

Indicators	Standard indicators in EMM systems to improve safety of anticoagulant use [29]	N/A
Medication report	Tool to be built into the new EMM system: Enable reporting on specific information about DOACs [29]	N/A
Review of relevant result	Support the safe use of HRMs within the EMM system by: Reviewing biochemistry results when prescribing or administering heparin and other anticoagulants [25]	N/A
	In the case of warfarin, the prescriber should acknowledge that the most recent INR result has been reviewed and the next test has been ordered before the EMM system allows the next dose of warfarin to be validated for administration. In the same way, a nurse should acknowledge the most recent INR result before administering the next dose of warfarin. [28]	Warfarin
Risk assessment tool	Guidance for EMM and EMM SAT need to include in functionality specifications for VTE risk assessment and documentation. Given that VTE risk assessment is not a medication order, the assessment tool more likely needs to be included within EMR system functionality rather than EMM [29]	N/A
Automation	The EMM system should support variable-dosing regimen including loading doses – for example, heparin infusions [28]	Heparin
Monitoring		
Audit	A digital anticoagulant group has been established by the team leading the integrated medical record (IEMR) rollout. Monthly reporting and discussion provides more detail on any incidents that are potentially related to the EMM system. [29]	N/A
Dashboard	Anticoagulant work in the EMM system: Heparin dashboards: Available for implementation if sites choose and can be used to optimise medicines use [29]	N/A

N/A – not applicable; DOAC – direct acting oral anticoagulant

Results from structured interviews

In total, 33 structured interviews were conducted with participants across Australia. Table 20 lists the hospitals or organisations where participants were based.

Table 20. Hospitals or organisations of participants who took part in a structured interview

State	Hospital/ organisation
New South Wales	
	St Vincent's Hospital
	eHealth NSW
	Healthscope – Northern beaches
	South Western Sydney Local Health District
	South East Sydney Local Health District
	Northern NSW Local Health District
	Mid North Coast Local Health District
	Northern Sydney Local Health District
	Illawarra Shoalhaven Local Health District
	Sydney Local Health District
South Australia	
	Women's and Children's Health Network
	South Adelaide Local Health Network
	Central Adelaide Local Health Network
Northern Territory	
	Northern Territory Health
	Alice Springs Hospital
	Darwin Hospital
Australian Capital Territory	
	Canberra Hospital
	University of Canberra Hospital
	North Canberra Hospital
Queensland	
	Logan Hospital
	Queensland Health (Office of the Chief Clinical Information Officer)
	Townsville Hospital
	Surgical, Treatment and Rehabilitation Service (STARS) – surgical and rehabilitation services only
	Gold Coast Hospital and Health Service
	Sunshine Coast Hospital and Health Service
Western Australia	
	Fiona Stanley and Royal Perth Hospital
Victoria	
	Royal Park precinct
	Alfred Hospital
	Cabrini Health
	Safer Care Victoria
National	
	Australian Commission on Safety and Quality in Healthcare

In total, 645 strategies were described during interviews. Most strategies related to management of HRMs, with fewer strategies relating to presentation and monitoring of HRMs.

High-risk medicines

Most strategies described by participants during interviews related to specific HRMs, but a small number of general strategies (n=11) were reported (Table 21).

No impacts on clinicians or on patient safety were reported for these general strategies. One participant reported that order sets were liked by end-users and requests for new order sets were common.

Table 21. General management and monitoring strategies for HRMs, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Icon (1)	
Management	
Alerts (2)	High dose alert Allergy alert
Link to guidelines (1)	-
Message on screen (1)	Information tips
Order sentences (1)	-
Order sets (1)	-
Reports (1)	Accordion style reports to see patient trends
Monitoring	
Reports (1)	-
Dashboard (2)	-

Antimicrobials

Participants reported 95 strategies related to antimicrobials. Nine strategies related to presentation, 73 related to management and 16 related to monitoring of antimicrobials. Table 22 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 22. Presentation, management and monitoring strategies for antimicrobials, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Tallman Lettering (4)	-
Text visible on screen (2)	Renal function, patient weight
Symbol (1)	HRM symbol
Position on screen (1)	Drug is moved to bottom of screen
Highlighting (1)	Red text

Management	
Forcing function (14)	Tick for normal renal function Selection of formulation Mandatory indication Mandatory approval number Mandatory approving consultant
Order sentences (13)	-
Alert (13)	Maximum administration rate Detection of renal impairment Information on restrictions Warning that infectious diseases approval is required Timing of trough levels Dose too soon after previous dose IV to oral switch Check time of next scheduled dose
Calculator (6)	Dose calculator
Automation (5)	Automatic dose calculation Maximum dispensing of 3 days Default administration time
Order sets (4)	-
Field (3)	For approval code/number
Dashboard (2)	-
Link to guidelines (2)	-
Message on screen (2)	Additional information (e.g. TDM result) Indicating approval required
Flexible options (2)	Partnered pharmacist lead charting/adjustments
Filtering options (1)	Antimicrobial column
Electronic form (1)	Allergy de-labelling questionnaire
Flexible options (1)	Dose adjustment within one order
e-referrals (1)	To pharmacist
Monitoring	
Dashboard (7)	-
Reports (6)	-
Medication list/extract (3)	-

When asked to reflect on the outcomes of strategy implementation, no impacts on clinicians or on safety were reported for the presentation strategies.

With respect to the management strategies, some participants reported that anecdotally, some strategies were well liked, or appeared to be accepted by clinicians, even though this had not been formally assessed. This was the case for some alerts, dashboards, order sentences, order sets, forcing functions and a link to guidelines (see Appendix 5). With respect to safety, again some anecdotal improvements in safety were reported (for automation, a dashboard, and the link to guidelines). In two cases, a strategy (order set and alert) was described to be non-inferior to what was in place previously, based on the lack of an increase in reported incidents.

When asked if there had been any unintended consequences associated with implementation of management strategies, both positive and negative consequences were described. Positive

unintended consequences included a dashboard being helpful for drug recalls or drug shortages, mandatory indications reducing incorrect, absent or nonsensical indications being documented, and order sentences and messages on screen reducing the alert burden on doctors.

Negative unintended consequences included maximum administration rates and order sentences making it difficult to prescribe vancomycin in glucose, calculators sometimes recommending doses that are too high, particularly in paediatric patients, an allergy clinic being overbooked following implementation of a de-labelling form for an allergy clinic referral, and alert fatigue. Two participants also explained that a field for entry of infectious diseases approval was often worked around, and another explained that dosing times automatically defaulting to the next morning resulted in delays in therapy.

Like management strategies, monitoring strategies, including dashboards, reports and medication lists, were reported to be well accepted and liked by AMS teams, however this was anecdotal, and no formal evaluations were described.

Potassium and other electrolytes

Participants reported 78 strategies related to potassium and other electrolytes. Twenty-four strategies related to presentation, 51 related to management, and 3 related to monitoring of potassium and other electrolytes. Tables 23 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 23. Presentation, management and monitoring strategies for potassium and other electrolytes, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Highlighting (7)	Uppercase text Red text or tile
Order of options (7)	Displayed in order of prescribing (not alphabetical) Commonly used order sentences at top of list
Text visible on screen (5)	Specific text (e.g. HYPERTONIC, CONCENTRATED, etc) in special instructions
Symbol (3)	Warning High risk flag
Position on screen (1)	Bottom of medication list
No abbreviations (1)	-
Management	
Limited users (31)	Senior prescribers Within ICU
Order sentences (12)	-
Alerts (6)	Mandatory form Notifying of dangerous formulation Maximum rate of administration Warning about dilution
Order sets (5)	-
Automation (5)	Prepopulated infusion fluid Dose range based on patient characteristics Unit conversion

	Reduced choices based on patient characteristics
Limited options (4)	Routes Maximum rates Rates and concentrations
Instructions (3)	Administration instructions Dilutions Concentrations
Flexible options (3)	-
Forcing function (3)	Prescribed in mmol only Brand name for some products Mandatory infusion rate
Message on screen (2)	Tips Relevant pathology results visible
Filtering options (1)	-
Hard stop (1)	Only 1 syringe prescribed at a time
Link to guidelines (2)	-
Monitoring	
Report (32)	-

When asked to reflect on the outcomes of strategy implementation, participants noted there had been no complaints from users about some presentation strategies (highlighting, text and positioning on screen), indicating acceptance, while others were liked (order of options, symbol). Some presentation strategies were described to be non-inferior to what was in place previously, based on the lack of an increase in reported incidents, but no formal evaluation had been conducted.

With respect to the management strategies, some participants reported that anecdotally, some strategies were well liked, or appeared to be accepted by clinicians, even though this had not been formally assessed. One participant reported completing a survey to gauge clinicians' views of two strategies (a hard stop preventing more than one syringe to be prescribed at a time, and limiting prescribing of potassium chloride neat to senior doctors). Responses were mixed with consultants happy with the changes but some junior doctors and nurses frustrated by the strategies as they were seen to bottleneck workflow.

One participant explained that when infusion order sentences (with limited options, forcing functions and some flexible options) were added to an electronic system, error rates went down.

When asked if there had been any unintended consequences associated with implementation of management strategies, several negative consequences were described. One unintended consequence was an increase in the number of dosing times in a day for a patient with the introduction of automation, requiring rationalisation on discharge. Several participants described selection errors following implementation of order sentences and doctors being frustrated and confused by the large number of options being available, and some also reported confusion for staff when a hard stop had been introduced and when prescribing was limited to certain users. One participant described a number of incidents relating to duplicate potassium bags being administered as a result of the complex way in which these need to be ordered in the EMM system.

Insulin

Participants reported 114 strategies related to insulin. Eighteen strategies related to presentation, 84 related to management and 12 related to monitoring of insulin. Table 24 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 24. Presentation, management and monitoring strategies for insulin, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Text visible on screen (11)	Brand and formulation "Insulin" is prefix in all insulin orders Concentrations Order comments
Highlighting (5)	Uppercase text Red text
Tallman lettering (2)	-
Management	
Forcing function (20)	Prescribe by brand name only Only international units available Daily doses Forced look up of BGL Mandatory form Mandatory dose Mandatory blood results
Order sets (15)	-
Alerts (14)	Brand confirmation Excessive doses BGL prompt for nurses Inappropriate frequencies Duplications
Dashboard (10)	-
Order sentences (6)	-
Flexible options (6)	Sliding scale/bar
Automation (3)	Administration time defaults to meal delivery Automatic calculations Automatic substitution for 2 separate orders
Double signature required (3)	-
Message on screen (2)	Information tips BGL levels
Link to guidelines (2)	-
Concomitant prescribing support (1)	Button for glucose infusion
Hard stop (1)	No ordering possible outside of protocol
Limited users (1)	Senior prescribers
Monitoring	
Dashboard (9)	-
Medication list (1)	-

Reports (1)	-
Summary view (1)	-

Several participants reported that some presentation strategies (highlighting and text) were well liked and improved safety, but these improvements were anecdotal. One participant explained that displaying both generic and brand name was a good strategy to use at the point of ordering, but resulted in administration errors because the full order needed to be expanded by nurses to see the brand name.

Many of the management strategies for insulin were described as liked and accepted, including some order sets, forcing functions, flexible options, and dashboards. One participant described a reduction in missed doses and insulin errors following implementation of a combination of presentation and management strategies, including highlighting, an alert, automation, mandatory data entry and order sentences. Other participants reported anecdotal improvements in safety, one participant explained that incident reports for missed and double doses declined following implementation of a glucose management dashboard, and another reported a decline in hospital acquired hyperglycaemia complications following implementation of order sentences

When asked if there had been any unintended consequences associated with implementation of management strategies, both positive and negative consequences were described. A positive unintended consequence included a dashboard being helpful for drug recalls or drug shortages. Some strategies were reported to increase awareness for the endocrinology team, but this also created additional workload. Negative unintended consequences included difficulty tracking changes over time because of forced daily prescribing, and the necessity to learn new prescribing workflows within the electronic system. One participant raised a concern about doses not being administered, even when appropriate, because of high dose alerts being triggered.

More than half of the participants who described dashboards as a monitoring strategy reported sub-optimal utilization of this feature. Some participants reported anecdotical improvements in safety, but no formal evaluations were described.

Narcotics, opioids and other sedatives

Participants reported 135 strategies related to opioids and other sedatives. Thirty-four strategies related to presentation, 93 related to management and 8 related to monitoring of opioids and other sedatives. Tables 25 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 25. Presentation, management and monitoring strategies for narcotics, opioids and other sedatives, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Text visible on screen (15)	Brand name and generic Formulation and route 'high risk medicine'
Tallman lettering (7)	-

Highlighting (6)	Red text Uppercase text
Symbol (4)	High risk flag Icon
Order of options (2)	Lowest dose, safest route presented first
Management	
Alerts (25)	To highlight risk Cumulative dose warning Prompts nurses for observations Reminder for paper chart Cross-order interval checking Check for formulation Duplication Products available Slow release rate Patch removal Warning opioid naive
Order sets (22)	-
Forcing function (8)	Brand name prescribing Acknowledge sedation score Mandatory indication Mandatory PRN maximum dose
Order sentences (6)	-
Limited options (6)	Brands only Limited routes Fewer order sentences
Automation (6)	Dose calculation Automatic reconciliation of orders Product assignment for strength Patch task created Forced therapeutic substitution
Calculator (4)	Dose calculator
Link to guidelines (4)	-
Message on screen (2)	Tips Medication information
Concomitant prescribing/monitoring support (2)	Prompts for pain and sedation scores an hour after dose are part of the order Options for co-prescribing of laxatives and antiemetics
Double signature required (2)	-
Hover-over text (2)	Reference text Safety information
Flexible options (1)	15 min leeway for administration
Dashboard (1)	-
e-referral (1)	Partnered prescribing
Limited users (1)	Senior prescribers
Monitoring	
Dashboard (6)	--
Report (2)	

Several participants reported that some presentation strategies (highlighting and text) were well liked and improved safety, but these improvements were anecdotal. Similarly, safety benefits following implementation of the presentation strategies are expected, but none have been tested. One participant reported a reduction in the reported number of selection errors following redesign of order sentences to direct users to brand names, and another described a reduction in buprenorphine orders being prescribed, cancelled and re-prescribed within a short time-frame ,following the re-ordering of order sentences on a list (see Appendix 5).

With respect to the management strategies, a number of participants reported that anecdotally, some strategies were well liked, and were viewed as useful by clinicians, even though this had not been formally assessed. This included alerts, a calculator, concomitant prescribing support, flexible options, forcing functions, hover-over text, order sentences, order sets and dashboards. Similarly, many strategies were reported to improve patient safety, but no formal evaluations were described.

Perceived unintended consequences of management strategies included endless requests to have order sets added (despite there being limited capacity to do so), and users ticking all boxes in an order set (powerplan) rather than considering whether each option is needed. Several participants reported poor awareness and uptake of some management strategies, like order sets, and calculators, and others described problems with decision support when brands became discontinued

The only unintended consequence described for monitoring strategies was the lack of resourcing available for maintenance of dashboards.

Chemotherapy

Participants reported 50 strategies related to chemotherapy. Sixteen strategies related to presentation, and 34 related to management of chemotherapy. No monitoring strategies were described. Tables 26 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 26. Presentation and management strategies for chemotherapy, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Text visible on screen (9)	Includes INTRATHECAL in the drug name 'Cytotoxic' appears in order sentence Cytotoxic handling precaution information included
Symbol (2)	High risk flag
Order of options (1)	Orders grouped by administration time
Tallman (2)	
Highlighting (1)	Colour
Layout (1)	Aggregated treatments
Management	
Order sentences (7)	
Order sets (5)	
Alert (6)	Displaying local policy information

	Handling instructions Weight and height alerts (if changed >10%) Chemotherapy chart check
Automation (3)	Cap on maximum dose Invalidates future orders if dose is changed Offsets days, hours and times
Hard stop (3)	Oral methotrexate can't be prescribed daily Dose locked once dosing/manufacturing started
Forcing function (3)	Forced acknowledgement by nurses Mandatory diagnosis, height, weight and BSA
Limited options (2)	Once weekly option only, no option for daily order Can only prescribe for current treatment plan
Limited users (2)	Selected doctors, nurses and pharmacists
Double signature required (1)	
Message on screen (1)	On high risk medicine and cytotoxic handling
Link to guidelines (1)	

When asked to reflect on the outcomes of strategy implementation, no impacts on clinicians or on safety were reported for the presentation strategies. One participant reported that the cytotoxic handling advice was 'accepted' by clinicians.

With respect to the management strategies described, some participants reported that a message on screen, and order sentences were liked because they enforced mandatory policies. An order sentence and order set were also described as well-liked by users. With respect to safety, one participant explained that providing users with limited frequency options was generally seen to improve safety, but no evaluations has been done, and another said that implementation of prepopulated weekly doses for methotrexate resulted in no daily doses being ordered.

When asked if there had been any unintended consequences associated with implementation of management strategies, both positive and negative consequences were described. Positive unintended consequences included order sentences and messages on screen reducing the alert burden on doctors. Three participants from different settings described a negative unintended consequence of order sets to be the time required to build, review and maintain these decision support features.

One participant described a number of unintended consequences of a cancer system implementation, not tied to a specific presentation, management or monitoring strategy. These included challenges with the use of two separate systems, like limited decision support (e.g. drug-drug interaction alerts), because the cancer system does not have the details of non-cancer medicines, and de-skilling of the workforce,

Heparin and other anticoagulants

Participants reported 110 strategies related to heparins and other anticoagulants. Nineteen strategies related to presentation, 80 related to management and 11 related to monitoring of heparins and other anticoagulants. Tables 27 summarises these strategies and Appendix 5 provides more detailed information on these reported strategies.

Table 27. Presentation, management and monitoring strategies for heparin and other anticoagulants, as reported by participants during structured interviews

Strategy (# of times reported)	Additional details
Presentation	
Text visible on screen (8)	Both brand and generic names visible INR and doses administered Message to refer to cancer system Order comment includes word 'anticoagulant'
Location of information (3)	Warfarin displayed in variable dose section of chart Heparin part of infusion management section Warfarin in specific section
Tallman Lettering (2)	
Order of options (2)	Alphabetical listing Warfarin top of list
Layout (2)	Orders displayed with dose checks in between Infusions grouped together
Symbol (1)	High risk flag
Highlighting (1)	Uppercase text
Management	
Alerts (28)	Reminder for paper chart VTE risk assessment reminder Brand confirmation Reminder to order warfarin for patients who are on warfarin at home Duplication warning (>1 anticoagulant) Drug-class interaction alert Advice on duration of therapy at discharge Reminder to include target INR and indication Drug specific drug interactions Dose check reminder
Order sets (18)	
Forcing function (10)	Must confirm if for treatment or prophylaxis Mandatory duration of therapy Mandatory target levels (INR/APTT) Mandatory Indication Nomogram for dose adjustment INR check before next dose prescribed Each day must be prescribed individually Must order warfarin through power-plan Brand prescribing only for warfarin
Order sentences (9)	
Risk assessment tool (3)	
Automation (3)	Automatic population of dose check in order set Populates electronic NIMC Automatic warfarin check task
Limited options (2)	Reduced order options for heparin
Link to guidelines (2)	
Dashboard (2)	Warfarin tab
Message on screen (1)	Relevant lab results and related administrations
Monitoring	

Dashboard (6)	
Summary view (2)	
Report (2)	
Audit (and alert) (1)	Teams message is sent to pharmacist when new anticoagulant or concerning combination is ordered

On three occasions, participants explained that a presentation strategy (either layout or location of information), was not well liked or accepted by users.

With respect to management strategies, some were described as liked by clinicians (alerts, automation, mandatory data entry, order sentences and order sets), and some described as not liked (alerts, order sets and automation), but no formal evaluations were reported. Prompts to perform a VTE risk assessment were highlighted by several participants as not liked by clinicians, and one participants highlighted that although this strategy may increase rates of risk assessment completion, this did not translate into reduced rates of hospital acquired VTE. Other participants described safety benefits (expected to occur, especially if strategies were actually used) from a number of management strategies, but no assessment of benefits has been performed.

Perceived unintended consequences of management strategies included duplication errors, false positive alerts, and failure to prescribe warfarin (because doctors would confuse a warning for an order). Multiple participants described the workflows associated with anticoagulation management as complex.

Limited outcomes of monitoring strategy implementation were reported. One participant explained that summary views would be well liked by clinicians, but this required users to have knowledge of these features. Another participant said that implementation of a live VTE dashboard, which facilitated review of patients missing VTE prophylaxis, had reduced rates of VTE.

Site specific high-risk medicines

In addition to the 'APINCH' list of HRMs described above, some participants described additional strategies (total n= 52) used for other medicines classified as high-risk at their institution. These are summarised in the table below.

Table 28. Presentation, management and monitoring strategies for site-specific HRMs, as reported by participants during structured interviews

High risk medicine	Strategy	Additional details
Presentation		
All infusions	Layout	Gant chart style of all fluids and drug infusions
Clozapine	Symbol	High risk flag
Cannabis	Symbol	High risk flag
Neuromuscular blocking agents	Highlighting	Colour coding
Parkinson's drugs	Highlighting	Administration tile turns red when 15 min late
Paediatric and neonatal medications	Text	'Paediatric' and 'neonatal' included in order sentence

Management		
All infusions	Forcing function	Forces completion of one infusion before the next one
Infusion fluids – paediatrics	Alerts	
Anticonvulsants	Order set	
Antiepileptics	Automation	Default options
Cannabis	Flexible options	Products and substances available
Clozapine	Alerts Order sets Automation Forcing function Double sig required	Automatic email to mental health case manager Warning if blood results outside normal range Mandatory blood results check
Digoxin	Alert	Custom DDI
GTN patches	Order sentences	
Neuromuscular blocking agents	Location of information	Ordered an anaesthetics only area
Parkinson's drugs	Alerts Forcing function Message in screen	Warning that time critical Reminder to individualise admin times Prescribe by brand only Message indicating time critical
PPI	Mandatory data entry	Mandatory form
Medications on paper charts	Alerts	Paper medication chart reminder
Paediatric and neonatal medications	Dose calculator Double sig required Limited users Order sentences	
Palliative care medications	Order set Order sentences	
Monitoring		
Antipsychotics	Reports	
Clozapine	Worklist	

Participants provided very limited information about the impact of these strategies on clinicians or on safety. One participant explained that implementation of a mandatory form which asks clinicians to confirm if the PPI is a patient's usual medication led to a decline in the prescribing of PPIs, and was only overridden by 15-30% of prescribers.

EMM design requirements in an ideal world

When asked 'if you could design the perfect EMM to support any HRM use, what would you propose?', participants reported 37 strategies in total. This included: 10 presentation strategies (e.g. layout, labelling convention, highlighting), 16 management strategies (e.g. decision support, automation, filtering function, prescribing/monitoring support), and 5 monitoring strategies (e.g. medication report, dashboard integration). It also included 6 general strategies applicable to all HRMs (e.g. data driving decision support, customisability, co-design of dosing advisor tool), with the need for system integration being most frequently reported. (See Appendix 4 Tables A5-A11).

Summary of strategies

Antimicrobials

The main EMM/EMR presentation strategy we identified for antimicrobials was use of tallman lettering.

Key EMM/EMR management strategies included alerts, order sentences, and forcing functions, particularly mandatory documentation of indications and/or antimicrobial approval numbers. These strategies align with the one recommendation specific to antimicrobials we uncovered in our grey literature review, that of the EMM system supporting the approvals workflow.

We found some evaluation of these management strategies in both the international and Australian literature. In some cases, these clinical decision support features were reported to reduce antimicrobial prescribing, improve antimicrobial appropriateness, and were associated with improvements in some clinical outcomes (like reduced length of stay). However, we also found evidence of strategies being worked around or abandoned, reflecting poor alignment with end-user workflow.

Common monitoring strategies for antimicrobials included dashboards, reports and medication lists. Interview participants reported that these were well liked, especially by AMS teams, but we identified no formal evaluations of these.

Potassium and other electrolytes

Uppercase text was a frequently used strategy to present potassium and other electrolytes on screen, as was the display of special instructions (e.g. hypertonic). The main EMM/EMR strategies we identified to support management of potassium and other electrolytes included limiting EMM features to particular users (e.g. senior prescribers, ICU clinicians), order sentences, and alerts. No formal evaluations of strategies were uncovered during interviews or in our literature review.

The only strategy we identified for monitoring potassium and other electrolytes in EMM/EMR was the use of reports.

Our grey literature review identified only recommendations related to EMM supporting cardiac monitoring, but we did not identify any strategies on this via our structured interviews.

Insulin

Additional text on screen (brand, formulation, concentrations, etc) was a common approach taken to present insulin in EMM/EMR. The main EMM/EMR strategies we identified to support management of insulin included forcing functions, order sets, alerts and dashboards. The main forcing function used was restricting prescribing to brand names only, but forced entry of information like form, dose and blood results was also common. This latter finding aligns with the recommendation uncovered in our grey literature review, of prompting the review and documentation of blood glucose levels before administration in EMM/EMR. Our

interviews revealed that this was sometimes a forcing function (e.g. mandatory review or entry of blood results), and sometimes a prompt to nurses in the form of an alert.

We found no Australian evaluations of these strategies in the literature, and interview participants reported only anecdotal improvements in safety following implementation. We identified a small number of international evaluations of order sets and alerts which indicated that these were effective in improving glycaemic control.

Dashboards were the most frequent strategy used to monitor insulin in EMM/EMR.

Narcotics, opioids and other sedatives

Presenting both generic and brand names on screen was a frequently used strategy for presentation of narcotics, opioids and other sedatives in EMR/EMM.

The main EMM/EMR strategies we identified to support management of narcotics, opioids and other sedatives, included alerts and order sets. A large number of alert types were identified, such as cumulative dose warnings, duplication warnings, patch removal alerts, and paper-chart reminders. Many of these features targeted duplication and overdosing, and so align with our grey literature review, which identified several recommendations relating to minimising duplication and ensuring appropriate dosing (e.g. calculators) of narcotics, opioids and other sedatives in EMM/EMR.

Chemotherapy agents

Fewer strategies relating to chemotherapy were reported by interview participants. Presentation strategies related primarily to including text on screen to indicate medicines were cytotoxic and precautions should be used for handling. Order sentences and order sets were also used, as were alerts for handling instructions, height and weight changes, and displaying local information.

Our grey literature review identified a large number of recommendations related to chemotherapy presentation and management in EMM/EMR including alerts, set up of protocols, and system authorisation for users (who can prescribe, verify and administer chemotherapy in EMM/EMR). These are generally consistent with our fundings from structured interviews.

Heparin and other anticoagulants

The most common presentation strategy for heparin and other anticoagulants was the display of both brand and generic names on screen.

The main EMM/EMR strategies we identified to support management of heparin and other anticoagulants included alerts, order sets and order sentences. A large range of alerts were used, including reminders to complete a VTE risk assessment, brand confirmation, duplication warnings, target INR and indication reminders, and dose check alerts. Forcing functions, including mandatory entry of order elements like duration of therapy and target INR levels, were also a frequently used strategy. Like other HRMs, no formal evaluations of these strategies were reported. We identified one Australian evaluation of patient-specific

alerts to guide appropriate prescribing on discharge, and this showed that alerts improved appropriateness of warfarin prescribing.

Our grey literature review identified a large number of recommendations related to presentation, management and monitoring of heparin and other anticoagulants in EMM/EMR, including ensuring the visibility of order details (like order status), alerts, and use of a VTE risk assessment tool.

Common strategies across all high-risk medicines

Although specific details and content differed across HRMs, high-level strategies were highly consistent across all HRM classes. With respect to presentation, tallman lettering and highlighting were frequently used across all HRM types, with symbols and colour often used to indicate that a medicine was high risk. Text was also a frequent addition to communicate key information.

With respect to management strategies, alerts, order sentences and order sets were common to all HRM classes, and also emerged as recommended strategies in our grey literature review. Similarly, audits/reports and dashboards were common monitoring strategies across all HRMs, and these were also recommended in sources we identified in the grey literature.

Conclusion

Overall, our literature and environmental scan identified a large number of strategies that have been implemented to present, manage and monitor HRMs in EMM/EMR. Although specific details and content differed across HRMs, high-level strategies were consistent, with highlighting (e.g. colour), alerts, order sentences, order sets and dashboards frequently used to support use of all HRMs.

We identified very few evaluations of strategies, both in the literature and through structured interviews, making it difficult to draw firm conclusions about which strategies are more effective than others and accepted by clinicians. Systematic reviews and Australian papers revealed that some strategies can be effective in supporting safe use of HRMs, but the Australian papers also highlighted that strategies were not always accepted or used as intended, and were sometimes worked around or bypassed. This is consistent with what we uncovered via our interviews, with participants highlighting some challenges associated with strategy implementation. Participants reported that some strategies were not liked and used, and also described instances of users working around or ‘gaming’ EMM/EMR strategies when they were perceived to slow down or block workflow. In some cases, users were unaware of strategies (e.g. dashboards or order sets), resulting in low uptake of these features.

These findings suggest that for the full benefits of EMM/EMR strategies to be realised, features should be well-designed and align with user workflow, to increase acceptance and use of strategies**. We recommend adopting a user-centred approach**. Additionally, findings suggest that lack of awareness of features may hinder uptake, so **we recommend clear and effective communication and dissemination strategies** be adopted by sites when implementing a new strategy.

A small number of unintended consequences of strategy implementation, both positive and negative, were also uncovered. The main positive unintended consequence was that strategies (e.g. dashboards) were helpful for the management of drug recalls or drug shortages. The main negative unintended consequence was the additional workload required to set up and maintain the strategies described (e.g. building order sentences).

In the absence of robust evidence regarding the effectiveness of strategies to reduce adverse events, particularly comparative studies, **we recommend sites take a cautionary approach when implementing new strategies.** Initial piloting should be conducted before strategies are scaled, and **mechanisms (e.g. feedback loops) should be in place for ongoing monitoring and evaluation** of strategies.

Limitations

Limitations of this review and environmental scan should be taken into account when interpreting these results. In particular, there was large variability in interventions and methods used to evaluate strategies in the academic studies we identified. Interviewees may have not been aware of all HRM strategies, may not have perceived certain features or functions as strategies, and may not have been able to communicate information on all strategies in the limited interview time. Therefore, the strategies identified should not be considered exhaustive.

References

1. Lewis PJ, Dornan T, Taylor D, et al. Prevalence, incidence and nature of prescribing errors in hospital inpatients: a systematic review. *Drug Saf* 2009;32(5):379-89. doi: 2 [pii] [published Online First: 2009/05/08]
2. Alanazi MA, Tully MP, Lewis PJ. Prescribing errors by junior doctors-A comparison of errors with high risk medicines and non-high risk medicines. *PLoS One* 2019;14(1):e0211270.
3. Raban MZ, Walter SR, Pont LG, et al. The potential impact of an electronic medication management system on safety-critical prescribing errors in an emergency department. *Journal of Pharmacy Practice and Research* 2019;49(2):108-15. doi: https://doi.org/10.1002/jppr.1455
4. Van Dort BA, Penm J, Ritchie A, et al. The impact of digital interventions on antimicrobial stewardship in hospitals: a qualitative synthesis of systematic reviews. *Journal of Antimicrobial Chemotherapy* 2022;77(7):1828-37.
5. Zheng WY, Lichtner V, Van Dort BA, et al. The impact of introducing automated dispensing cabinets, barcode medication administration, and closed-loop electronic medication management systems on work processes and safety of controlled medications in hospitals: A systematic review. *Research in Social and Administrative Pharmacy* 2021;17(5):832-41.
6. Australian Commission on Safety and Quality in Health Care. APINCHS classification of high risk medicines: ACSQHC; 2023 [Available from: https://www.safetyandquality.gov.au/our-work/medication-safety/high-risk-medicines/apinchs-classification-high-risk-medicines.
7. Australian Commission on Safety and Quality in Health Care. High risk medicines: ACSQHC; 2023 [Available from: https://www.safetyandquality.gov.au/our-work/medication-safety/high-risk-medicines accessed 28 November 2023.
8. Baysari MT, Lehnbom EC, Li L, et al. The effectiveness of information technology to improve antimicrobial prescribing in hospitals: A systematic review and meta-analysis. *International Journal of Medical Informatics* 2016;92:15-34. doi: https://dx.doi.org/10.1016/j.ijmedinf.2016.04.008
9. Baysari MT, Del Gigante J, Moran M, et al. Redesign of computerized decision support to improve antimicrobial prescribing. *Applied Clinical Informatics* 2017;8(03):949-63.
10. Metcalfe J, Lam A, Lam SSH, et al. Impact of the introduction of computerised physician order entry (CPOE) on the surveillance of restricted antimicrobials and compliance with policy. *Journal of Pharmacy Practice and Research* 2017;47(3):200-06. doi: https://doi.org/10.1002/jppr.1227
11. Jenkins JA, Pontefract SK, Cresswell K, et al. Antimicrobial stewardship using electronic prescribing systems in hospital settings: a scoping review of interventions and outcome measures. *JAC-antimicrobial Resistance* 2022;4(3) (no pagination) doi: https://dx.doi.org/10.1093/jacamr/dlac063
12. Baysari MT, Del Gigante J, Moran M, et al. Redesign of computerized decision support to improve antimicrobial prescribing. A controlled before-and-after study. *Appl Clin Inform* 2017;8(3):949-63. doi: 10.4338/ACI2017040069
13. Cairns KA, Rawlins MDM, Unwin SD, et al. Building on Antimicrobial Stewardship Programs Through Integration with Electronic Medical Records: The Australian Experience. *Infectious Diseases & Therapy* 2021;10(1):61-73. doi: https://dx.doi.org/10.1007/s40121-020-00392-5
14. Diasinos N, Baysari M, Kumar S, et al. Does the availability of therapeutic drug monitoring, computerised dose recommendation and prescribing decision support services promote compliance with national gentamicin prescribing guidelines? *Internal medicine journal* 2015;45(1):55-62. doi: 10.1111/imj.12627 [published Online First: 2014/11/06]
15. Doukas FF, Cheong E, McKew G, et al. Antimicrobial stewardship audit and feedback rounds: the impact of electronic systems and moving beyond the restricted antibiotic list. *Internal medicine journal* 2021;51(11):1876-83. doi: https://dx.doi.org/10.1111/imj.14979
16. Khalil V. Redesign of computerized decision support system to improve Non Vitamin K oral anticoagulant prescribing-A pre and post qualitative and quantitative study. *International*

Journal of Medical Informatics 2021;152:104511. doi: https://dx.doi.org/10.1016/j.ijmedinf.2021.104511
17. Tyedin AE, Taylor SE, Than J, et al. Impact of proactive pharmacist-assisted warfarin management using an electronic medication management system in Australian hospitalised patients. *Journal of Pharmacy Practice and Research* 2020;50(2):144-51. doi: https://dx.doi.org/10.1002/jppr.1632
18. Liu S, Gnjidic D, Patanwala AE, et al. Effect of an electronic medical record design modification on laxative co-prescribing among hospitalised patients taking opioids: A before-and-after study. *International Journal of Medical Informatics* 2020;140:104172. doi: https://dx.doi.org/10.1016/j.ijmedinf.2020.104172
19. Su E, Aminian P, McMaster C, et al. Design and implementation of an electronic opioid management plan to support consistent communication of opioid analgesia prescribing intentions to patients and general practitioners. *Journal of Pharmacy Practice and Research* 2023;53(4):186-94. doi: https://dx.doi.org/10.1002/jppr.1872
20. Kinlay M, Ho LMR, Zheng WY, et al. Electronic Medication Management Systems: Analysis of Enhancements to Reduce Errors and Improve Workflow. *Appl Clin Inform* 2021;12(5):1049-60. doi: 10.1055/s-0041-1739196 [published Online First: 20211110]
21. Sly B, Russell AW, Sullivan C. Digital interventions to improve safety and quality of inpatient diabetes management: A systematic review. *International Journal of Medical Informatics* 2022;157:104596. doi: https://dx.doi.org/10.1016/j.ijmedinf.2021.104596
22. Jones JML, Feitosa ACR, Hita MC, et al. Medical software applications for in-hospital insulin therapy: A systematic review. *Digital Health* 2020;6:2055207620983120. doi: https://dx.doi.org/10.1177/2055207620983120
23. Rahimi R, Kazemi A, Moghaddasi H, et al. Specifications of Computerized Provider Order Entry and Clinical Decision Support Systems for Cancer Patients Undergoing Chemotherapy: A Systematic Review. *Chemotherapy* 2018;63(3):162-71. doi: 10.1159/000489503 [published Online First: 2018/07/04]
24. Canberra Health Services. High risk medicines policy, 2021.
25. Australian Commission on Safety and Quality in Health Care. Electronic Medication Management Self-Assessment Domain and Indicators Summary, 2021.
26. Australian Commission on Safety and Quality in Health Care. Electronic Medication Management Systems – A guide to safe implementation (third edition), 2019.
27. Victorian State Government: The Department of Health and Human Services. Policy for minimising harm caused by medicines, 2022.
28. Australian Commission on Safety and Quality in Health Care. Electronic Medication Management Systems Business Requirements – An addendum to Electronic Medication Management: A guide to safe implementation (3rd edition), 2019.
29. Australian Commission on Safety and Quality in Health Care. National Anticoagulant Incident Analysis report, 2021.
30. Australian Commission on Safety and Quality in Health Care. National Guidelines for On-Screen Display of Medicines Information, 2017.
31. NSW Health and Clinical Excellence Commission. High risk medicines management, 2020.
32. Clinical Oncology Society of Australia. Guidelines for the safe prescribing, dispensing and administration of systemic cancer therapy. In: COSA, ed., 2017.
33. eHealth NSW. Minimising Inappropriate Dual Anticoagulation in NSW, 2023.
34. Joshi M, Ashrafian H, Arora S, et al. Digital Alerting and Outcomes in Patients With Sepsis: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research* 2019;21(12):e15166. doi: https://dx.doi.org/10.2196/15166
35. Martinez-Sobalvarro JV, Junior AAP, Pereira LB, et al. Antimicrobial stewardship for surgical antibiotic prophylaxis and surgical site infections: a systematic review. *International Journal of Clinical Pharmacy* 2022;44(2):301-19. doi: https://dx.doi.org/10.1007/s11096-021-01358-4

Appendicies

Appendix 1: Database search strategy

Medline search

Ovid MEDLINE(R) ALL <1946 to October 09, 2023>
1 ((High-risk* or high-alert* or high risk* or high alert* or high-hazard* or high-chance* or high-danger* or high-peril*) adj3 (medication* or medicine* or drug* or pharmaceutical*)).mp. 3142
2 (anti-infective agent* or anti infective agent* or Antimicrobial* or Antibiotic* or Anti-Bacterial* or antibacterial* or Antifungal* or Antiviral* or Antiparasitic*).mp. 1103920
3 exp Anti-Infective Agents/ 1829876
4 (Potassium* or magnesium* or phosphorus* or phosphate* or calcium* or Hypertonic sodium chloride*).mp. 1293026
5 insulin.mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word] 469866
6 exp Insulin, Regular, Human/ 684
7 (narcotic* or opioid* or sedative* or sedating or Anaesthetic* or anesthetic* or Benzodiazepine*).mp.411762
8 exp narcotics/ or exp analgesics, opioid/ 145350
9 exp "Hypnotics and Sedatives"/ 130941
10 (chemotherapy drug* or Cytotoxic drug* or Antineoplastic*).mp. 588768
11 exp Antineoplastic Agents/ 1252551
12 (heparin* or anticoagulant* or Factor Xa inhibitor* or Direct thrombin inhibitor* or Thrombolytic*).mp. 242993
13 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 5437562
14 (decision support system* or Computer-Assisted Decision* or Clinical decision support* or electronic health record* or electronic medical record* or Medical Order Entry System* or e-prescribing system* or electronic prescribing* or computeri?ed physician order entr* or computeri?ed provider order entr* or electronic medication management*).mp. 85306
15 (CPOE or EMM or EMR or EMMS or EHR or EPS or CDSS or CDS).tw. 59392
16 exp Medical Records Systems, Computerized/ or exp Electronic Health Records/ 48825
17 exp Electronic Prescribing/ 1188
18 exp Medical Order Entry Systems/ 2472
19 14 or 15 or 16 or 17 or 18 141961
20 (hospital* or inpatient* or admitted or acute or secondary care).mp. 3417357
21 exp Hospitals/ 320506
22 exp Inpatients/ 29916
23 20 or 21 or 22 3433925

24 13 and 19 and 23 5475
25 exp "Systematic Review"/ 240843
26 Systematic review*.tw,pt. 336622
27 25 or 26 336622
28 (australia* or oceani* or "New South Wales" or sydney or queensland or brisbane or victoria or melbourne or "Australian Capital Territory" or canberra or "Northern Territory" or darwin or "South Australia" or adelaide or tasmania or hobart or "Western Australia" or perth).tw,pt. 215746
29 exp Australia/ 171735
30 28 or 29 267708
31 24 and 27 85
32 24 and 30 122

Embase search

Embase Classic+Embase <1947 to 2023 October 09>

1 ((High-risk* or high-alert* or high risk* or high alert* or high-hazard* or high-chance* or high-danger* or high-peril*) adj3 (medication* or medicine* or drug* or pharmaceutical*)).mp. 5365
2 (anti-infective agent* or anti infective agent* or Antimicrobial* or Antibiotic* or Anti-Bacterial* or antibacterial* or Antifungal* or Antiviral* or Antiparasitic*).mp. 1542023
3 exp antibiotic agent/ 1920566
4 (Potassium* or magnesium* or phosphorus* or phosphate* or calcium* or Hypertonic sodium chloride*).mp. 2016795
5 insulin.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word] 995641
6 exp Insulin/ 419221
7 (narcotic* or opioid* or sedative* or sedating or Anaesthetic* or anesthetic* or Benzodiazepine*).mp.545784
8 exp narcotic agent/ or exp sedative agent/ or exp hypnotic agent/ or exp anesthetic agent/ or exp analgesic agent/ 1827239
9 exp "Hypnotics and Sedatives"/ 543362
10 (chemotherapy drug* or Cytotoxic drug* or Antineoplastic*).mp. 614938
11 exp Antineoplastic Agents/ 3014340
12 (heparin* or anticoagulant* or Factor Xa inhibitor* or Direct thrombin inhibitor* or Thrombolytic*).mp. 463160
13 exp Heparin/ or exp Anticoagulant agent/ 831843
14 (decision support system* or Computer-Assisted Decision* or Clinical decision support* or electronic health record* or electronic medical record* or Medical Order Entry System* or e-prescribing system* or electronic prescribing* or computeri?ed physician order entr* or computeri?ed provider order entr* or electronic medication management*).mp. 178666
15 (CPOE or EMM or EMR or EMMS or EHR or EPS or CDSS or CDS).tw. 88728
16 exp Computerized provider order entry/ or exp Electronic Health Records/ 47414
17 exp Electronic Prescribing/ 4397

18 exp Electronic medical record/ or exp decision support system/ 113166
19 (hospital* or inpatient* or admitted or acute or secondary care).mp. 5530109
20 exp Hospital patient/ 247814
21 exp "Systematic Review"/ 434245
22 Systematic review*.tw,pt. 363828
23 (australia* or oceani* or "New South Wales" or sydney or queensland or brisbane or victoria or melbourne or "Australian Capital Territory" or canberra or "Northern Territory" or darwin or "South Australia" or adelaide or tasmania or hobart or "Western Australia" or perth).tw,pt. 297777
24 exp Australia/ 206613
25 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 9709535
26 14 or 15 or 16 or 17 or 18 239435
27 19 or 20 5530109
28 25 and 26 and 27 22913
29 21 or 22 531593
30 28 and 29 380
31 23 or 24 348870
32 28 and 31 418

Cochrane Search

ID Search Hits
#1 (high risk* or high alert* or high-hazard* or high-chance* or high-danger* or high-peril* or medication* or medicine* or drug* or pharmaceutical*):ti,ab,kw 898969
#2 (anti infective agent* or Antimicrobial* or Antibiotic* or Anti-Bacterial* or antibacterial* or Antifungal* or Antiviral* or Antiparasitic*):ti,ab,kw 66890
#3 MeSH descriptor: [Anti-Infective Agents] explode all trees 36447
#4 (Potassium* or magnesium* or phosphorus* or phosphate* or calcium* or Hypertonic sodium chloride*):ti,ab,kw 63644
#5 (insulin):ti,ab,kw 72887
#6 (narcotic* or opioid* or sedative* or sedating or Anaesthetic* or anesthetic* or Benzodiazepine*):ti,ab,kw 84590
#7 MeSH descriptor: [Analgesics] explode all trees 25298
#8 MeSH descriptor: [Anesthetics] explode all trees 18166
#9 MeSH descriptor: [Hypnotics and Sedatives] explode all trees 4325
#10 MeSH descriptor: [Narcotics] explode all trees 10596
#11 (chemotherapy drug* or Cytotoxic drug* or Antineoplastic*):ti,ab,kw 67978
#12 MeSH descriptor: [Antineoplastic Agents] explode all trees 16652
#13 (heparin* or anticoagulant* or Factor Xa inhibitor* or Direct thrombin inhibitor* or Thrombolytic*):ti,ab,kw 26109
#14 1-#13 1001919
#15 (decision support system* or Computer Assisted Decision* or Clinical decision support* or electronic health record* or electronic medical record* or Medical Order Entry System* or e-prescribing system* or electronic prescribing* or computeri?ed physician order entr* or computeri?ed provider order entr* or electronic medication management*):ti,ab,kw 26373
#16 (CPOE or EMM or EMR or EMMS or EHR or EPS or CDSS or CDS):ti,ab,kw 4853

#17	MeSH descriptor: [Electronic Prescribing] explode all trees 37	
#18	MeSH descriptor: [Medical Records Systems, Computerized] explode all trees 1009	
#19	MeSH descriptor: [Decision Support Systems, Clinical] explode all trees	568
#20	34-#19	29190
#21	(hospital* or inpatient* or admitted or acute or secondary care):ti,ab,kw	419482
#22	MeSH descriptor: [Hospitals] explode all trees	4973
#23	MeSH descriptor: [Inpatients] explode all trees	1408
#24	35-#23	419729
#25	#14 AND #20 AND #24 in Cochrane Reviews	262

Appendix 2. Invitation to interview

Dear (insert name),

The University of Sydney has been commissioned by Victoria Health to identify strategies that have been implemented through electronic medication management (eMM) to present, manage, and monitor the safety of high-risk medicines for inpatients.

You have been identified as a leader in this field by/as [insert referring person's name here or role of potential participant] We are writing to invite you to participate in a 1-hr interview on how high-risk medicines are managed in your eMM, and you will receive a $50 gift card for your time.

I hope you will consider sharing your experiences and views. If you feel you are not the best person to speak on this topic, you are welcome to recommend someone else within your organisation.

Kind regards,
(insert name)

Senior Clinical Pharmacist and Research Officer

The University of Sydney

Faculty of Medicine and Health, School of Medical Sciences, Biomedical Informatics and Digital Health

Appendix 3. Interview guide

Thank you for volunteering to take part in this interview about how high risk medicines are managed, monitored and presented through electronic medication management systems (eMM) for inpatients in your area of practice. This interview will take up to 1 hour and you will be compensated with a $50 voucher for your time. The interview will be audio recorded for information gathering purposes only. This recording will be deleted once data is extracted. Please let us know if you have any objections to recording the interview.

Part 1 – Background

We are defining High-risk medicines as medicines that are more likely to cause significant patient harm when they are used in error. They can include anti-infective agents, potassium and other electrolytes, insulin, opioids, and other sedatives, chemotherapy, heparin and other anticoagulants as well as other drugs. eMM supports the medication process, including prescribing, dispensing and b medication administration.

1. I will first begin by asking you about your role in the hospital. What is your role?
2. How does your role relate to managing high risk medicines?
3. Which eMM system(s) does your site use? Have you used any other eMM systems before? (If so, list which ones)

Part 2 – High Risk Medicines

These questions will be repeated for all High Risk Medicine categories:

2A - Anti-infectives, 2B - Potassium and other electrolytes, 2C - Insulin, 2D - Opioids, 2E - Other Sedatives, 2F - Heparins, 2G - Other Anticoagulants, 2H – Chemotherapy

<u>2A: Anti-infectives</u>

1. Can you describe how you present or display anti-infectives in your eMM? Do they look different to other medicines? How?
    a. If anti-infectives are not included in the eMM, why is this the case?
2. Do you know if this display is accepted and well-liked by end-users? How?
3. Do you know if this display has increased safety and reduced Adverse Drug Events? How?
4. Have there been any unintended consequences of the display? Good or bad? Can you walk me through these?
5. Can you describe how anti-infectives are managed in your eMM? for example, do you have any specific decision support or functionality in place for anti-infectives?
6. Do you know if these functions are accepted and well-liked by end-users? How?
7. Do you know if these functions have increased safety and reduced adverse drug events? How?
8. Have there been any unintended consequences of the functionality? Good or bad? Can you walk me through these?
9. Can you describe how you monitor anti-infectives in your eMM? for example, do you have any specific reports or dashboards?

10. Do you know if these functions are well liked by end-users? How? D
11. Do you know if these functions have increased safety and reduced adverse drug events? How?
12. Have there been any unintended consequences of this monitoring functionality? Good or bad? Can you walk me through these?
13. If you could design a perfect eMM system to support the safe use of anti-infectives, what would you propose?

Part 3 – Site specific high-risk medications

1. In your area of practice, are there any other medications that have been identified as high-risk which do not fit the above categories? For example: antipsychotics (e.g., clozapine), antiepileptics (e.g., carbamazepine, phenytoin, medicinal cannabis)

   If yes:

   a. Can you describe how you present or display site specific high risk medicines in your eMM? Do they look different to other medicines? How?

   If no:

   b. If site specific high-risk medications are not included in the eMM, why is this the case?

2. Do you know if this display is accepted and well-liked by end-users? How?
3. Do you know if this display has increased safety and reduced adverse drug events? How?
4. Have there been any unintended consequences of the display? Good or bad? Can you walk me through these?
5. Can you describe how site specific high risk medicines are managed in your eMM? For example, do you have any specific decision support or functionality in place for site specific high risk medicines?
6. Do you know if these functions are accepted and well-liked by end-users? How?
7. Do you know if these functions have increased safety and reduced adverse drug events? How?
8. Have there been any unintended consequences of the functionality? Good or bad? Can you walk me through these?
9. Can you describe how you monitor site specific high risk medicines in your eMM? For example, do you have any specific reports or dashboards?
10. Do you know if these functions are well liked by end-users? How?
11. Do you know if these functions have increased safety and reduced adverse drug events? How?
12. Have there been any unintended consequences of this monitoring functionality? Good or bad? Can you walk me through these?
13. If you could design a perfect eMM system to support the safe use of these site-specific high-risk medications, what would you propose?

Part 4 - Closing remarks

1. Do you have any final questions or comments?

Finally, we would also like to invite you to share any relevant documents relating these strategies, including any evaluation reports. These will be reviewed, and data extracted for our final report.

Please forward these to eHealthHRMsafety@groups.sydney.edu.au

Thank you very much for your participation it is very much appreciated. This work will inform national guidelines on the display, management and monitoring of high risk medicines in electronic medication management systems in the future.

Appendix 4. Results from targeted literature review

Results from academic papers

Table A 1. Demographics of systematic review papers

Source	Year published	Number of studies	Aim	Medication
Baysari el al. [8]	2016	45	To review evidence of the effectiveness of information technology (IT) interventions to improve antimicrobial prescribing in hospitals.	Antimicrobials
Jenkins et al[11]	2022	28	To identify interventions implemented in hospital electronic prescribing systems and the outcome measures used to monitor their impact.	Antimicrobials
Sly[21]	2022	42	To systematically appraise the recent literature to determine which digitally-enabled interventions including EMR, CDSS and data visibility solutions improve the safety and quality of non-critical care inpatient diabetes management	Insulin
Jones[22]	2020	7	To compare the efficacy in glycemic control parameters of medical inpatient hospital applications in non-critical care settings.	Insulin
Rahimi[2][3]	2018	58	To identify and classify the specifications of CPOE and chemotherapy prescription CDSS for cancer patients.	Chemotherapy

Table A 2. Demographics of Australian papers

Source	Year published	Setting	Study aim	Method
Baysari et al	2017	Teaching hospital in Sydney	To determine the impact of a decision support redesign on antimicrobial prescribing, and explore prescriber opinions of the decision support	Chart review (n=1089 antimicrobials), interviews with prescribers (n=11)
Cairns et al	2021	Princess Alexandra Hospital, Alfred Health, Concord Hospital, Fiona Stanley Hospital	To describe how four Australian hospitals have overcome practice barriers following the implementation of EMR within their institution, and to provide suggestions for AMS specific build features for new hospitals embarking on a digital transformation.	None - 4 case studies

Diasinos et al	2015	Teaching hospital in Sydney	To determine whether gentamicin was being prescribed in accordance with guidelines and why resources were efefctive or ineffective in achieving compliance with guidelines	Interviews with prescribers (n=12)
Doukas et al	2021	Concord Reptatriation Hospital	To describe and analyse the implementation of a novel AMS audit and feedback method, in the context of an eMM system.	Chart review (n=908 patients)
Khalil	2021	Multi-site teaching hospital in Victoria	To evaluate the impact of novel electronic alerts based on patients' specific physiological parameters on the appropriateness of NOAC prescribing on discharge	Prescriber survey (n=67 pre, n=58 post), Data extracted from hospital coding and data management system (n=200 patients)
Kinlay et al	2021	3 acute public hospitals in NSW	To (1) identify system-related medication errors or workflow blocks that were the target of eMM system updates, including the types of medications involved, and (2) describe and classify the system enhancements made to target these risks.	Review of updates made to EMM (Nov 2015-Dec 2019)
Liu et al	2020	Urban teaching hospital in Sydney	To examine the effect of an EMR design modification to increase laxative co-prescribing among hospitalised inpatients taking opioid analgesics	Chart review (n=1816 patients)
Metcalfe et al	2017	Metropolitan teaching hospital	To compare the performance of an EAAS and CPOE, used alone and in combination, for surveillance of restricted antimicrobials and compliance with antimicrobial restriction policy	Chart review (n=200 orders)
Su et al	2023	Metropolitan tertiary health service (Austin Health)	To describe the design and implementation of a novel electronic workflow to facilitate consistent documentation of an OMP in the EMR and discharge summary of surgical and ED patients discharged with opioid prescriptions	Chart/dashboard review (n=1523 ED patients and 490 orthopaedic patients)
Tyedin et al	2020	Major tertiary public referral hospital in Melbourne	To evaluate whether pharmacist-assisted electronic warfarin charting and monitoring reduces warfarin-related errors and improves post-discharge continuum of care	Chart review (n=130 patients) (extracted data from pre period only, post was a pharmacy intervention)

Table A 3. Strategies to present, monitor and manage HRM and outcomes from systematic review papers

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
Baysari et al	Alerts	Alerts notifying physicians of serious blood stream infections	Antimicrobials	Manage	Mixed results. Some studies found only 30-50% uptake.	Reduction in antimicrobial prescribing in all studies. More appropriate prescribing in 8/9 studies. Reduction in length of stay in 2/4 studies
Baysari et al	Alerts	Alerts pharmacy or infectious diseases staff via computer of potentially inappropriate antimicrobial	Antimicrobials	Manage		
Baysari et al	Alerts	Alerts pharmacy via page of potentially inappropriate antimicrobial	Antimicrobials	Manage		
Baysari et al	Calculators	Calculator: Initial dosing and monitoring of amikacin and tobramycin	Antimicrobials	Manage		Reduction in length of stay
Baysari et al	CDSS (all)	CDSS	Antimicrobials	Manage		
Baysari et al	Alerts	Computerised alerts	Antimicrobials	Manage		
Baysari et al	Surveillance system	Generates report of potentially inappropriate antimicrobial for pharmacy/ infectious diseases staff	Antimicrobials	Monitor		Reduction in length of stay
Baysari et al	Order set	Order sets	Antimicrobials	Manage		
Baysari et al	Guidelines	Passive information (guidelines)	Antimicrobials	Manage		
Baysari et al	Order set	pre-written order-sets for bacteremic severe sepsis	Antimicrobials	Manage	Less than a third of problems identified by the surveillance systems	Reduction in cost of antimicrobials, patients prescribed excessive

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
					led to pharmacist interventions	antimicrobial dosages, adverse drug events, mortality and patient length of stay in at least one study.
Baysari et al	Order set	Pre-written/ default orders	Antimicrobials	Manage		
Baysari et al	Mandatory data entry	Selecting indication for antimicrobial use	Antimicrobials	Manage		
Baysari et al	Surveillance systems (all)	Surveillance systems	Antimicrobials	Manage		
Jenkins et al	Automation	Automatic prescription stop when specific criteria was fulfilled	Antimicrobials	Manage		Quality outcomes: 41.2% showed a positive change and 54% showed no change (n=28 studies). Quantity outcomes: 72% showed no change, and 20% showed a positive change
Jenkins et al		CDS (overall)	Antimicrobials	Manage		All studies implementing external notification or peri-operative alerts demonstrated a significant improvement. 50% of studies show improved adherence to guidelines.

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
Jenkins et al	Order set	Complex order set: included a range of requests e.g. clinical severity scoring, dose adjustments for special population, laboratory test requests and monitoring	Antimicrobials	Manage		
Jenkins et al	Guidelines	Embedding guidelines or infection management into the EMR	Antimicrobials	Manage		Improved adherence to guidelines in 1/4 studies
Jenkins et al	Alert	Interuptive alert in patient's EMR	Antimicrobials	Manage		Improved adherence to guidelines in 4/5 studies
Jenkins et al	Mandatory data entry	Mandated documentation of indication and/or duration	Antimicrobials	Manage		Improved adherence to guidelines in 4/5 studies
Jenkins et al	Alert	Notification in background to inform pharmacist/ specialist team	Antimicrobials	Manage	An increase in the use of workarounds following implementation of mandated documentation	Improved rates of documentation, but no change to appropriateness of therapy
Jenkins et al	Order set	Simple order set: includes all essential elements for an antimicrobial prescription	Antimicrobials	Manage		
Jenkins et al	Restriction	To gain access prescribers inputted details such as indication or justification to gain approval or second healthcare professional was required to countersign the prescription to gain approval	Antimicrobials	Manage		
Rahimi et al.	Alerts	Alert for prescription error	Chemotherapy	Manage		Positive effects for Mean Patient-Day Weighted Glucose and mixed results for other glumetric outcomes.

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
						Positive and neutral results for reduced length of stay.
Rahimi et al.	Alerts	Alert for unusual parameters required for dose calculations (e.g. height or weight)	Chemotherapy	Manage		Positive effect on glucometric outcomes, on length of stay, and prescribing outcomes.
Rahimi et al.	Calculators	Automated dose calculations and adjustments	Chemotherapy	Manage		Hard stop alerts were more effective than passive alerts in reducing inappropriate prescribing
Rahimi et al.	System intraoperability	Communication with centres outside the hospital	Chemotherapy	Manage	Used in only 25% of hypoglycaemic events due to limitations of design and implementation	Increased protocol adherence compared with a paper-based protocol
Rahimi et al.	Limited or default options	Creation of particular specifications for medications (such as route and unit), date and time, and default dosages for medications based on an automatically determined treatment protocol for the patient	Chemotherapy	Manage		Positive effect on glucometric outcomes and prescribing outcomes.
Rahimi et al.	Definitions	Definition of access levels and user interface for different users (physician, nurse,and pharmacist)	Chemotherapy	Manage		Reduction in hypoglycaemia
Rahimi et al.	Definitions	Definition of chemotherapy protocols in the system	Chemotherapy	Manage		
Rahimi et al.	Definitions	Definition of solvents appropriate for any chemotherapy medication in the system	Chemotherapy	Manage		

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
Rahimi et al.	Graphical display	Diplay of the patient treatment plan and protocol graphically	Chemotherapy	Present		
Rahimi et al.	Graphical display	Display of graphical reportes for quantitatve variables	Chemotherapy	Present		
Rahimi et al.	Displaying at the point of prescribing	Displaying chemotherapy protocols at the moment of prescription	Chemotherapy	Present		
Rahimi et al.	Display of information when needed	Displaying the information needed at the moment of prescribing (summary of diagnostic information, laboratory values, the patient's vital signs, chemotherapy medications, and supportive treatments for the patient)	Chemotherapy	Manage		
Rahimi et al.	Clear distinction of medications	Distiction between chemotherapy agents and other medications	Chemotherapy	Manage		
Rahimi et al.	Tailoring alerts to users	Embedding capabilities for more flexibility in the system in relation to alerts (possibility of denying alerts by physicians and possibility of setting alerts)	Chemotherapy	Manage		
Rahimi et al.	Guidlines	Embedding chemotherapy protocols in the EMR	Chemotherapy	Manage		
Rahimi et al.	Nudging data entry	Guiding or asking the user to complete the important prescription parameters	Chemotherapy	Manage		

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
Rahimi et al.	System intraoperability	Intraoperability with other hospital systems (pathology, pharmacy)	Chemotherapy	Manage		
Rahimi et al.	Links to guidelines	Links to medical guidelines	Chemotherapy	Manage		
Rahimi et al.	Permanent documentation	Permanent documentation of the patients therapeutic information	Chemotherapy	Manage		
Rahimi et al.	Easy transfer of information	Possibility of receiving chemotherapy electronic prescriptions from a pharmacist (including information on dosage calculations in pharmaceutical forms, management of drug supply, and information on chemotherapy protocols by a pharmacist and his or her complete access to the patient's treatment history for decision making)	Chemotherapy	Manage		
Rahimi et al.	Easy transfer of information	Possibility of receiving electronic chemotherapy prescriptions from a nurse (including information on dosage calculations in nursing worksheets, displaying patient charts and information about medication administration to the nurse, and standardizing the details of the medication administration to the patient in the nurse's worksheet)	Chemotherapy	Manage		
Rahimi et al.	Modifiable	Possibility to modify, reschedule, and disable the protocol for a certain patient, including procedures such as change of the patient's parameters, the dosage of medications, or the default units by the physician	Chemotherapy	Manage		

Source	Subcategory	Strategy	HRM	Present/ manage / monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events
Rahimi et al.	Web-based prescribing	Prescribing via a web-based system	Chemotherapy	Manage		
Rahimi et al.	Workflow support	System's support of the hospital workflow	Chemotherapy	Manage		
Jones et al.	Order sets	Computer order template for support basal-bolus insulin	Insulin	Manage		
Jones et al.	Guidelines	Glycemic management protocol in CPOE	Insulin	Manage		
Jones et al.	Order sets	Insulin order sets	Insulin	Manage		
Sly et al.	Dosing algorithm	Computerized insulin dosing algorithms (GlucommanderTM, GlucoTab® and Glucostabilizer®)	Insulin	Manage		
Sly et al.	Surveillance system/ alert	Daily lists or glycaemic alert systems triggering automatic review for patient who met pre-defined glycaemic criteria	Insulin	Manage		
Sly et al.	Patient tailored decision support	Individualised patient-specific hypoglycaemia management guidance in EMR for nursing staff	Insulin	Manage		
Sly et al.	Order set	Insulin order sets: standardized insulin order sets which promoted basal bolus insulin ordering and provided weight and diet-based dosing recommendations in addition to a hypoglycaemia management protocol.	Insulin	Manage		

Table A 4. Strategies to present, monitor and manage HRM and outcomes from Australian papers

Source	Strategy	HRM	Medication	Present/ Manage/ Monitor	Clinician perspective/acceptance	Impact on safety and patient safety adverse events	Unintended consequencies (+/-)
Baysari et al	Alert (informing of restrictions and policy)	Antimicrobials		Manage	Change from alerts to order sentences had no impact on accuracy of indication documentation, appropriateness of prescribing or compliance to the hospital policy		
Baysari et al	Order sentences, including an indication	Antimicrobials		Manage	Prescribers were positive about order sentences but said long lists could lead to mis-selection		Workarounds and 'gaming' of the system because approval process did not align with workflows
Cairns et al	Mandatory indications at point of prescribing	Antimicrobials		Manage			
Cairns et al	Antimicrobial order sets	Antimicrobials		Manage			
Cairns et al	Automatic stops dates for high risk antimocrobials	Antimicrobials		Manage			
Cairns et al	Priority administration of doses for IV antimicrobials	Antimicrobials		Manage			

Cairns et al	Electronic referrals for AMS pharmacist review	Antimicrobials		Manage		
Cairns et al	Customised order sentences	Antimicrobials		Manage		
Cairns et al	Antimicrobial specific report in use	Antimicrobials		Monitor		
Cairns et al	Link to local policy	Antimicrobials		Manage		
Cairns et al	Data extraction capabilties	Antimicrobials		Monitor		
Cairns et al	Local antimicrobial dashboard	Antimicrobials		Monitor		
Diasinos et al	Alert (recommending TDM)	Antimicrobials	Gentamicin	Manage	Most users were unaware of the TDM service, and most had not noticed the alert	
Doukas et al	Progress note template to provide audit and feedback to teams	Antimicrobials		Monitor	Feedback recommendations were accepted 47%, 71% and 96% at 1 day, 2 days and 7 days post-round respectively.	Appropriatness of antibiotoc use increased from 55% to 71%.
Fujita et al	Clinician dashboard (DBI)	?		Manage		Proportion of patients who had at least one DBI-contributing medication stopped or dose reduced on discharge increased from 30% in the control period

						to 38% in the intervention period (non-sig)
Fujita et al	Link to deprescribing guidelines	?		Manage		As above (an interventuon bundle)
Fujita et al	DBI score on pharmacy patient list	?		Monitor		As above (an interventuon bundle)
Khalil	Patient-specific alerts to guide appropriate prescribing on discharge (intervention)	Anticoagulants	Non Vitamin K anticoagulant agents	Manage	More clinicians in the post intervention phase reported positively to questions assessing the usefulness, efficacy and safety of CDS. 95% of clinicians were satisfied with the new CDS (vs 48% with the old CDS)	Appropriatness of prescribing increased from 48% to 91%. Large reduction in high doses (39% vs 2%). 26% reduction in hosputal acquired complications, 29% reduction in costs associated with HACs, and 11% reduction in LoS
Khalil	Alerts (pre period)	Anticoagulants	Warfarin and enoxaparin	Manage		
Kinlay at al	Dashboard	Antimicrobials		Monitor		
Kinlay at al	Order sets	Insulin		Manage		

Kinlay at al	Alerts	Insulin		Manage		
Kinlay at al	Forced review of blood glucose results at point of prescribing	Insulin		Manage		
Kinlay at al	Diabetic dashboard	Insulin		Manage		
Kinlay at al	Order sets	Chemotherapy		Manage		
Kinlay at al	Order sets	Anticoagulants		Manage		
Kinlay at al	Tall man and red text	Opioids	hydromorphone	Present		
Kinlay at al	Forced selection of brand name	Opioids	hydromorphone	Manage		
Liu et al	Combination laxative order sentence visible on screen when ordering opioid	Opioids	Co-prescription of laxatives	Manage	Combination laxative prescribed in 13% of patients before and 15% of patients after the EMR change (non-sig), this change was sig in aged care patients (18% vs. 29%)	
Metcalfe et al	Alert prompting prescribers to seek approval for restricted antimicrobials (and	Antimicrobials		Manage	Compliance improved from 55% to 76% and failure to seek approval reduced from	Prescribers circumvented the system by documenting non-compliant entries

	enter approval number) (pre period)				70% to 0%. Documentation of clear/complete indications in EMR increased from 57% to 77%	into the approval number field
	Mandatory indications (and approval numbers) at point of prescribing (post period)	Antimicrobials		Manage	See above for post-results	
Su et al	Alert prompts prescriber to complete/update opioid management plan (OMP) in EMR (and directs user to form)	Opioids	buprenorphine, fentanyl, HYDROmorphone, methADONe, morphine, oxycodone, oxycodone-naloxone, paracetamol-codeine, tAPENTadol, tRAMadol	Manage	95% of ED patients and 96% of orthopaedic patients with an opioid prescription had an OMP completed	
Su et al	electronic OMP form, which is pulled into discharge summary	Opioids	buprenorphine, fentanyl, HYDROmorphone, methADONe, morphine, oxycodone, oxycodone-naloxone, paracetamol-	Manage	44% of ED patients and 94% of orthopaedic patients had a OMP in the discharge summary (reflecting a	

			codeine, tAPENTadol, tRAMadol		workflow issue in the ED)
Su et al	electronic OMP dashboard			Monitor	
Tyedin et al	manual entry of administration time if after the default time (1600)	Anticoagulants	warfarin	Manage	28% of patients had warfarin errors, 8% of patients had an INR>5
Tyedin et al	mandatory duration for orders	Anticoagulants	warfarin	Manage	As above (an interventuon bundle)
Tyedin et al	warfarin dose check reminder to nurses at 1400	Anticoagulants	warfarin	Manage	As above (an interventuon bundle)

Results from interviews - eMM design requirements in an ideal world

Table A 5. All high-risk medicines

Strategy	Quotes
Display	
Labelling convention	"*ability to use standard language for dispensing labels (syntax of standard directions to follow Australian recommended conventions (see CEC standard) rather than verb, qty, route, frequency)*"
Highlighting	"*More visual schematic - e.g. chemotherapy - purple circle e.g. APINCH drugs at the top of the list etc"*
Manage	
Decision support	*"Interruptive - best practice advisory - if A+B happens and pt pathology = C then do this"* *"Provide decision support for RNs that are administering if patients are presenting late - would be difficult to embed the permissions required"* *"Decision support around dosing which is complex - looking at ideal body weight, renal function etc - helping prescribers to choose correct initiating dose"* *"Dose adjustment decision support"* *"treatment vs prophylaxis issues addressed e.g surgical prohylaxis having a forced stop date/time is limiting - want a system that help clinicians to prescribe the correct way from the outset (help them make decisions rather than force actions)"* *"Interactive dashboards so you can add information to that then makes appropriate changes in the eMM medication orders"* *"don't think clozapine needs its own specific category. Think would be better to have an eMM to track across the different care profiles with regards to antipsychotic depots."* *"To make things safer - need to be monitoring the data that is being generated in real time such as dashboards with HUMANS monitoring and utilising the information we have E.g Dashboard showing realtime what is happening with BGLs of patients on insulin so hypoglycaemia can be identified timely manner"* *"This would cover across all of the HRM really, but it would be certainly decision support to be built in, which is what we have so that that clinicians can find out at the point of prescribing the best options...* *I think dose ranges are helpful certainly for high risk meds in general, if you've got it, it just depends on the on the medicine. you know the ones that come up if you are starting to get are getting beyond the if the milligram per kilogram or whatever you've got a patient who's a certain weight. There are calculators and supports there as well.* *Linking into the microbiology would be really good too, so that you're actually if you've gone with an empirical choice because you them*

	something, then you've actually got that flag of what the sensitivities, et cetera." *"Decision support to have reviews of critical moments in workflows - path of least resistance is the (right decision is the easy decision) - Smart way to provide people with natural flow of information to make the correct decisions"* *"Avoid unnecessary alerts - only flagging things that are extraordinary or unusual"* *"Clinical decision support provided at the appropriate level of the user (based on role and competence level) -* *e.g. RN - decision support on selecting and preparing the dose (reconstitution, dilution, fluids etc) and for prescribers decision support with respect to selecting the correct agent/strength/dose/dose form based on their level of experience/competence"* *"Identify and manage the risk points in process/workflow for each individual HRM"* *"Order sets that are a failsafe - including condition based to guide through parameters and select right agent/dose"* *"Real time prescription monitoring integrated within the eMM - including dashboards"*
Prescribing/monitoring support	"*closed loop medications (computer confirming and checking every step of the cycle - bar code at dispensing and scan again on deliver to ward/locker and scan at administration*)" "*Adjust doses/administration dates based on when patients present*" "*targets overuse of psychotropics esp in aged care, target excessive dosing and sedative combinations - max dose, multiple medications with sedation and respiratory depression as a side effect*"
Weight based calculator	"*Built in (uses patient data already entered), IBW, Adjusted BW, LBW calculator*"
Filtering function	"*Clozapine - easier manipulation of power plan to allow for changes to the norm for clozapine dose titration*"
Automation	"*Technical features - mathematics to provide dosing support e.g Bayesian calculations*"
Links to guidelines	"*Ensure doses prescribed are within guidelines with easy links to specific decision support - e.g. links to TG rather than MIMs*"
Barcodes	"*generation of unit dose bar codes - sachet packing individual doses*" "*System Intuitive to user workflow to optimise the human interface with the system including closed loop medicines management with barcode scanning (location, pt, medication, dose etc)"*
Standardisation	"*Standardised infusions (applies to every drug)"*
General	
Integration	**Australian PBS integration** "*EPIC - designed for American systems - no Australian PBS integration - need to maintain another system for PBS dispensing*"

	Other integration "*integration with all elements including inventory control Unit dose dispensing, just in time to the bedside"* "*Linked with pathology results"* "*Include information from other systems - pathology data, antibiograms etc. Ability to pull data out of relevant systems to an integrated platform*." "*Integration of the correct tools for calculating doses / frequencies...Integration of restricting prescribing and administration of HRM to the appropriate role (e.g. only certain prescribers/nurses can prescribe or administer a drug that requires specialised drug knowledge or to a particular patient group e.g. K in critical care/ chemotherapy in cancer care, drugs in NICU)."*

Table A 6. Antimicrobials

Strategy	Quotes
Presentation	
Labelling convention	"*An alternative way to indicate that anti-infective orders are within scope rather than use of codes*." "*Enable identification of medications by drug class - e.g ampicillin + benzylpenicillin is the same class"*
Layout	"*Allow ability to display medication orders in an alternative sequence to alphabetically"*
Highlighting	"*Would also be good to have the colours of the antimicrobials on the order sentences*"
Content	"*Display - be able to clearly to articulate the display of complex antimicrobials and intricacies around allergies*"
Tall man lettering	"*add tall man lettering"*
Colours	"*Colour coding system where anti-infectives/ other high risk meds are highlighted in their respective colours.* "
Manage	
Calculator	*"incorporate dose calculator based on local protocols."* "S*ystem to improve dose calculation for varying gestational age and include weight based and capping doses for different patient cohorts, dose calculators to consider BMI and renal function*"
Decision Support	*"Having a prompt to order TDM if required eg vancomycin in the same screen as when prescribing"* *"IF we could develop a tool to prompt the really high risk for anti-infectives - would incorporate TDM and patient factors (eg pathology - renal function) in to high risk assessment. Eg patient is on vancomycin and either has a high level or has deteriorating renal function. So something that is going to really stratify that risk because all we really have now is the fact that someone is prescribed (for eg) vancomycin plus also bring it to the attention of the clinician really clearly. The high risk*

	tools that we've got aren't specific enough and that's why people aren't using them." *"Conditionally link doses to levels/renal function available in the system e.g. gentamicin - not be able to be administered if renal function is too low at time dose due."* *"Also include decision support to link with local protocols."* *"Decision support around allergies and medication suitability. Eg does an allergy listed as nausea mean you can/can't use a certain antimicrobial for that patient."* *"Ways to flag if doses omitted or missed. Reminder for nurses"* *"In terms of AMS a flag that links to AMS so if you've got restricted antimicrobials, its easy for them to pick up. Also flag around length of course to ensure appropriate duration of therapy"* *"System is also moving towards more 'care pathways' i.e. decision support for prescribers (antibiotics are not ordered singularly but are integrated with their presentation e.g. for sepsis, the prescriber can fill in specific patient tick boxes for patient details e.g. penicillin allergy and then a power plan pops up for that specific prescribing pathway/ antibiotics/ dosing"*
Medication list	*"Clear summary of what patient has had, when levels were done"* "*all users can easily generate lists based on teams/wards and medications prescribed*"
Filtering function	*"Milenium can filter administration record by drug class (but not the medication orders). Work flow doesn't lead people to use this function because its an extra step."*
Mandatory field	*" be around the first dose (in sepsis context), once prescribed make it a mandatory field for prescriber to enter when the first dose is to be given"*
Alerts	"*having hard stops or alert that pops up after the optimum duration of therapy to alert prescribers this is the time to review*." "*Prompt for staff on floor for when staff need to take levels*." "*nursing administration alerts - if overdue it presents the same as any other alert. something targeted for urgent antibiotics however in saying that often nurses give the drug and sign it afterwards so maybe thats not helpful*"
Order templates	"*Would like to change some documentation we'd like to put in with templates - can have power plans which are groups of orders that you can integrate, laboratory tests e*tc"
Automation	"*automation in terms of identifying TDM, notifications to relevant clinicians."*
Prescribing /monitoring support	*"improve issues about the combination products - when combination products are prescribed an example is the PipTAZ it's prescribed as 4.5 grams instead of 4g piperacillin and 500mg of tazobactam whilst there are other combination drugs were only one of the active ingredient strengths is prescribed in the system. There have been incidents where*

	nurses will refer to how piptaz is charted an end up underdosing other combination drugs as a result."
Monitor	
Dashboard integration	*"Dashboards as part of the system so you don't have to jump between applications [Alluded to NSW pharmacist care page - as cerner is not an analytical system it is slow which is a trade off]"* *"Would like to see MS guidance and eMM be a two-way data transfer system but would ultimately like to see a single solution that don't require bolt-ons."* *"A system where information on sensetivities and other relevant patient data is visible to clinicians on the same screen with integration of consumer centric decision support"* *"A stewardship program integrated into the system including specific information regarding who to contact (when/how)"* *"eMM system that allows for incident reporting in the same program. The expectation that clinicians who might pick up issues to log into a external system to report incidents but also near misses like that just doesn't happen. Would be useful if clinicians could tag something based on what they're ordering, or an incident that might have happened and that sends through to a monitoring database would be useful"*
General	
System integration	"*Definitely should not be a third party system but should be integrated.*" "*eMM cusomisable and able to be used at multiple site levels but still have the ability to integrate with = other systems e.g. automated dispensing and infusion pumps and pharmacy dispensing system. NB Metavision 6 integrates with Alaris pump but not others or cabinets and pharmacy dispensing system*" "*Interoperable programs within Guidance (decision support and approvals) and other AMS monitoring systems*" "*Having the content of Guidance (AMS system) embedded in eMR."*
Data driving decision support	"*Integration of data sets - pathology, sensitivities, liver and renal function automatically informing decision support*"
Customisability	"*eMM customisable and able to be used at multiple site levels*"
Co-design of dosing advisor tool	"*Would like to see improvements to the gentamicin dose advisor tool is not user friendly and hasn't been adopted by the LHD (had originally chosen a product developed by 1 LHD so doesn't adapt well to others. Would be better if we could design this from scratch with design working groups and representative from all the different LHDs by applying native functionality that's in built into the workflow rather than something that's interruptive/requires transcription*"
Use friendliness	*"making it user friendly, proper usability testing, designed by clinicians involved at all stages of the medication process (ie doctors, pharmacists, nurses)."*
Better prioritisation of supply	*"Better prioritisation of supply (not specific to antibiotics but often is). There is currently no good system that allows for prioritization for supply. So when urgent supply is needed, currently the nurse can request electronically the pharmacist can process electronically. And then it sends*

	off to the dispensing software for the technician to dispense. So there's three people in that piece, and only the nurse can enter a priority at the point of Med requesting. And then that (the urgency of the order) gets lost in the process. Gets lost at each subsequent point, so it can end up on a list of pharmacy to do their own triaging and figure out that it's an urgent supply required, and then it just gets sent to pharmacy and on a list of medications for the technician to supply. So a better prioritization system would be good."

Table A 7. Potassium and other electrolytes

Strategy	**Quotes**
Presentation	
Icon	"*an option to have an icon with medicines to flag whether they were formulary or non formulary but this was not something that could be modified*"
Colour	*"colour coding to identify electrolytes"*
Manage	
Inclusion of infusions	"*Include infusions in eMM*"
Prescribing/Monitoring support	"*providing support for correcting electrolytes (least risky option e.g offer oral replacement)."* "*What is the best option to give e.g. potassium phos or sodium phos*" "*Would be good if system pulled across any pathology and could pre fill. That way prescribers could see at same time. Incorporate if any dose separations needed but this part comes down to clinical judgement a lot of the time*" "*Better way of prescribing sequences of different electrolytes over time."* *"Ideally, what premix bags that are available to the wards should align with the eMM to reduce the amount of preparation errors with electrolytes. This reduces the need for doctors to prescribe bespoke solutions and makes nurses more comfortable with administration esp when there is a e.g., high patient load"*
Automation	*"Automated integration with pathology results, other parameters including other meds comorbidities"* *"Capacity to automatically suggest the best option based on the relevant patient parameters"*
Alert	*"flags if patient's potassium level is high"* "*Include the restrictions that around potassium too, so you know maybe needing to have some sort of flag if someone orders potassium outside of the regular preloaded bags that we have, which would come up as a warning, "we don't have this as a preloaded bag sort of thing.*"" "*as much as I don't like alerts, I think there'd be scope for if the system could determine based on patients details, that if the clinician was exceeding an unsafe dose, like if they were charting an unsafe dose or administering an unsafe dose and if it could alert them to that, that would be helpful*"

Filtering function	*"Want to have a similar page to the AMS LIVE for each high risk drug so users can view and prioritise patients based on that"*
Decision support	*"improved access to protocols through system. Clinicians find if not something familiar with prescribing, unsure on volumes of diluents. Decision support"* *"linking to guidelines and pathology"* *"Order sets for each of the IV electrolytes available presented in such a way that the best options is the easiest option to prescribe"*
General	
System integration	*"In terms of continuity, everything should encompass everything (problems will arise if there are different charts in use)"* *"Having one system is ideal - reduced duplication of products unintentionally between paper and electronic systems"* *"eMM system that allows for incident reporting in the same program. The expectation that clinicians who might pick up issues to log into a external system to report incidents but also near misses like that just doesn't happen. Would be useful if clinicians could tag something based on what they're ordering, or an incident that might have happened and that sends through to a monitoring database would be useful"*
User friendliness	*"making it user friendly, proper usability testing, designed by clinicians involved at all stages of the medication process (ie doctors, pharmacists, nurses)."*

Table A 8. Insulin

Strategy	**Quotes**
Presentation	
Grouping of functions	"*eMR with BSLs displayed together*" "*More advanced grouping and iconography. We have to free type/override drugs names to force grouping; however, the system(s) could support another layer of grouping logic so we don't need to somewhat compromise the consistency of drug naming to keep things together*." "*links BSLs and insulin order in one spot. Good to have a spot in the order of how patient technique goes. For example does nurse administer insulin or does patient or dually managed*" "*Some people have suggested insulin having its own tab in the eMM system to allow for easy blood glucose monitoring but not sure if separating it would provide a huge difference in case e.g. they are on oral antidiabetic meds*"
Layout	"*BSLs visible in combination with the doses (accurate and able to track insulin plan, goals, escalation plan) – for example, how well it is managed on the paper chart example*"

Visual aids	"*I believe having better/large 'imagery' could be fruitfully used as a visual aid to user navigation and identifying higher/lower/classes of drugs*."
Workflow alignment	"*nursing perspective: when go to administer insulin. Should at the same time be able to enter BGL. Current system has them entering in another spot. Then go back and enter insulin administration elsewhere. Improvement in functionality*."
Corrective functionality	"*go back and check tab would be good*."
Clarity	*"It would always be very clear which insulin out talking about, so you'd make sure that it was displayed in a way that was clear to the prescriber what they were ordering"*
Manage	
Automation	"*More complex options for dose checking. The inbuilt decision support isn't designed for Australian insulin prescribing practices. Custom rules can be built, however, are laborious to create and then require constant monitoring to keep up to date and checked. The key example is that a dose check can be done on basal or bolus style doses (e.g., NovoRapid 6 units TDS; Lantus 10 units nocte), however, there's no inbuilt support for insulin infusions (e.g., Actrapid 50 units in 50 mL at 2 units per hour). Custom rules have had to be built*." "*Decision support...Linked to BGL so that can make sure you are being safe with the patient"* *"Review insulin therapy in relation to BSL efficiently e.g. dashboard to access real time results to improve reviewing BGL and insulins so can get on top outside the range quickly"* *"Incorporating smart technology to monitor BGL (including ustilise patients own monitoring system that are already in place)"* *"Clinicians have to manually type in BGL levels into the adminsitration window. If this could be autmoated and appear next to the insulin prescription, that would be great"*
Tracking functionality	"*Integrating to track for individual patient - BSL/doses and graphed over time and being able to monitor details of intake (feeds, meals) etc within the same page."*
Alerts	"*Medication reconciliation on admission – ensuring patients are given insulin if necessary e.g alert*" "I*n the process of looking into active alerts that will pop up when the dietary status is changed or when somebody is nil by mouth and a doctor is prescribing insulin. Also in the process of looking at whether we need to put some additional alerts in for diabetic ketoacidosis.*"
Dosing calculators	"*RMH don't stock vials to minimise risk – therefore have to convert to available stock while inpatient and then back on discharge would be good to be able to convert easily in the system*" "*some form of AI to use as dose predictor*"
Infusion management	"*insulin infusion pump management*"

	"*At the time that we were designing it, the kids hospital was the only place that was live with infusions and insulin pumps – would have liked both of those to have been included in the design, but the rest of the state wasn't ready and didn't have anything that they could have pulled in*." "*singular, non hybrid system (i.e. infusions go to electronic prescribing)*"
Prescribing/Monitoring support	"*daily ordering problematic – missed doses* etc" *"BSL monitoring*" "*Ensure high strength insulin do not introduce harm potential*" "*propose a link between current BSLs and patient monitoring BSLs and keytones and the prescribing of the insulins and other hypoglycaemic agents. Live data connection of latest BSLs when prescribing. Aim to reduce the amount of clocking for prescribers. In prescribing stage, stating if long or short acting or ultra or high concentration displayed*" "*specific guidance around patient monitoring – BGLs"* *"Active ingredient prescribing in combination with brand name"*
General	
User friendliness	*"making it user friendly, proper usability testing, designed by clinicians involved at all stages of the medication process (ie doctors, pharmacists, nurses)."*
Standardisation	"*Standardised system for all sites so prescribers are familiar between institutions"*
System integration	*"the paper and electronic is what causes most issues here. So Having One single system for all insulin would be the best thing that we could do. Endocrine don't want emr for infusion due to so much cross referencing in different pages. Way of combining all info required for safe insulin prescribing together in one place "* *"eMM system that allows for incident reporting in the same program. The expectation that clinicians who might pick up issues to log into a external system to report incidents but also near misses like that just doesn't happen. Would be useful if clinicians could tag something based on what they're ordering, or an incident that might have happened and that sends through to a monitoring database would be useful"*

Table A 9. Narcotics and opioids

Strategy	**Quotes**
Presentation	
Layout	*"Include visibility around anaesthetics etc in theatre space"* *"Customised M page in ieMR that summarises everything so user can easily view - patient sedation scores, history of cumulative doses given per day, bowels, if aperients have been ordered"* *"ability to quickly see a morphine equivalent dose in the previous 24 hours, particularly at the point of discharge to ascertain what if any opioids are required for the patient to take home, opportunities to*

	modify pain prescriptions based on pain scores (more directly like with insulins and BGLs),"
Grouping functionality	"*opioids should be grouped together on the patient's screen, or at least they're sort of medicines for pain so that people can be more aware of treatment modalities that are being prescribed for that patient before they add in new things or take things away*"
Naming convention	"*brand names where its appropriate, where there might be confusion about different types of different formulations of the same opioid or combination products.*"
Symbol	"*Include a symbol to notify all users that it is an opioid/ colour coding*"
Manage	
Inclusion of infusions	"*Infusion module"* "*include infusions*"
Prescribing/Monitoring support	"*Potentially something that could show the basic, perhaps even modelled, overlapping release profiles of the short and long acting preparations. A way to show over "24 hours" how the doses given and to be given will have their peaks and troughs overlap. May lead to better timing of doses and reduce net need of opioid.*" "*Improving ability for end users to comply with safety measures. also time of discharge, support over what to prescribe. opioid clinical care standard, how much to prescribe based on use in last 24 hours. Link this into eMM at point of discharge*" "*Link in Real time prescription monitoring.*" "*linking of patch placement and a patch removal order in EMM"*
Mandatory fields	"*Mandate indication*"
Alert	"*Flags for opioid use - monitoring and managing adverse effects, monitor use and requirements*" "M*aximum cumulative dose alerts especially for PRN orders (current system does not trigger any alerts)"* *"ranges are difficult with opioids because people have such wide ranges. Eg palliative care. So I guess the flags with doses that are outside what you would expect are helpful. You don't want to stop people getting appropriate pain relief if they do need to."* *"targeted alerts, patient specific and product specific. Consistency across the builds across the state."*
Automation	*"Opioids need to be tailored to pain of patient. The ceiling is patient dependent. Would be good if Interaction checker incorporated. Or if pain score is populated when prescriber goes to prescribe. In summary a way of Linking patient criteria"* *"introduction of linked orders e.g. when an opioid is prescribed, maybe suggesting or creating orders for e.g. bowel monitoring"*
Decision support	"*decision support tools at time of prescribing eg opioid age range into eMM.*" "*Clarity around forms around dosing and formulations. Weight based guidelines especially for kids*"

	"*would like to introduce dashboards to allow data to export e.g. for a specific facility more quickly (currently takes about 20 minutes which is not practical for clinicians)"* *"pain scores built in so that your actually assessing if that patient needs it or not"* *"Continuous real time monitoring of patient data - e.g. O2 sats and sedation scores etc to identify deteriorating paitents in ra timely maner Linking other paraemeters that are relevant opioid use including gastrointestinal and pain scores...Ability to include consumer centred care alowing them to be involved in the eMM system e.g with respect to monitoring intervals"*
Warnings	"*warnings where appropriate but not so people get alert fatigue*"
Fields	*"Patches - be able to Document application and to what part of body, checking it and removal."* *"PCAs still on paper charts - Had a design about 80% complete and could not move forward with it (funding ran out) and now NSW is moving to EPIC so no incentive to finish project"* *"The use of pre built order sentences have the potential for causing more risk than be beneficial for some of these. eg oxycodone. If the doctor searches for oxycodone, they see like maybe 40 different oxycodone options in a list, maybe it would be simpler to keep it without a dose or without a frequency and letting them actually input that."*
Monitor	
Interface linking with national reporting	"*An interface to national reporting software (alert) - e.g SafeScript adjunct for users to access*" "*script check (state wide mandatory checking system for drugs that have potential for misuse). there is a link in sunrise to it but its difficult*."
Minimise duplicate documentation	"*Improve some of functionalities around monitoring. At the moment nursing staff have to document in a few different places*."
Medication list/report	"*Integration with closing the loop with regards to safe (as in controlled drug safe) management. Being able to cross reference x medication was taken out and given to x patient*"
General	
System integration	*"Integrated system across whole hospital (ICU and ward)"* *"the specific problem in QLD at the moment is Q Script (real time monitoring system for opioids and other sedatives). However this system doesn't talk to dispensary (ipharmacy) or ieMR. Greater integration of QLD Health systems within QLD Health"* *"Integrated system - simplification of complex protocols"* *"Ideally, all PCAs and oral in one electronic system, having infusion pumps talk to the electronic administration application"*
Clearer instructions	*"provide more clear instructions to nursing staff about the algorithm by which to offer those medicines to a patient (i.e. analgesic ladder)"*

Table A 10. Chemotherapy

Strategy	Quotes
Presentation	
Sharing function	"*Sharing information - so is presented in generally eMR so*"
Manage	
Medication list	"*Interface with other eMM so can view orders and protocols and what has already been given*"
Prescribing/monitoring support	"*Strategy to ensure oral methotrexate only given weekly (instead of daily).*" "*everything you need to know ties in. Could add in cycle info and duration of therapy*"
Decision support	"*Decision support, including links to protocols; restrictions on who can prescribe; dose capping (maybe – sometimes causes issues); power plans to include adjuvant therapy; high risk flags"*
Monitor	
Medication report	"*Frequent reports of daily dose errors*"
General	
Integration	*"Integration with eVQ - appropriate resourcing for maintenance"* *"would prefer to have this* [Mosaic] *integrated as one system with eMM and with pharmacy to reduce the risk of transcription errors"*

Table A 11. Heparin and anticoagulants

Strategy	Quotes
Presentation	
Clear display	"*I think there is a better way to present and view heparin infusions. For example, Insulin is a lot clearer now. Would be nice if heparin could be like insulin*" "*display all information in one, centralised place, keeping VTE Prophylaxis displayed clearly at the top of the MedCart"*
Layout	"*summary type view that pulls info for anyone reviewing to see all clinical data in one spot. Customised M page in ieMR that summarises everything so user can easily view*" "*Visible intended duration of therapy - is it going to be purely an inpatient thing or do we need to educate the patient for dosing at home once discharged*" "*Clear way to display information about with holding, duration, that sort of information*"
Grouping function	"*Re IV heparin - having anticoagulants groups together"*
Manage	
Prescribing/monitoring support	"*the ability to see the basic/modelled overlap of anticoagulants where many are in play (e.g., warfarin bridging).*" "*A way to avoid unnecessary duplication (over anticoagulating) e.g. Identifying patients that are at greater risk of bleeding; Easily identify if*

	patient is on an anticoagulant prior to admission (sites sentinel event around missed warfarin) e.g. link past Hx or diagnoses that are associated with anticoagulant use e.g. AF" "*Guidance easily available on frequency and max doses and patient monitoring*" *"incorporating monitoring requirements you need for that patient according to what anticoagulant they are prescribed eg APTT, INR, platelet counts"* "*Reliable identification of inappropriate dual therapy"*
Decision support	"*More advanced decision support that factors in the condition being treated, without needing custom rules, would be good*." "*In terms of VTE Prophylaxis, a system that links to risk factors to the order so greater visibility as to why prescribers have chosen something*." "*Link with order for appropriate reversal agents e.g. Opioids + Naloxone, Heparin and protamine"* *"Decision support: Flagging dual anticoagulants. Warfarin brand and daily dose ordered"*
Alert	"*Some way of flagging assessment VTE risk*" "*alert to remind prescribers about prescribing of warfarin dose. Automatic presentation of INR for warfarin.*"
Automation	"*heparin infusion along with APTT and corresponding indication automated in ieMR*." "*logic that is required is very complex. Would be hard to build into an eMM. There is standard decision support, there are so many pop ups and so there is alert fatigue. Building smarter decision support within the system would help. But designing that level of logic is very complex and not easy to build in*" *"automation/ message centre that goes out to notify the prescriber that they need to review the infusion (since there is often a delay between aptt orders coming back to the prescriber). More system automation to prompt where there's not a loading dose/ higher dose recommendations (that are not loading doses)/ indication specific prescribing e.g. PE vs DVT*"
General	*"Easier way to manage heparin infusions within eMM"*
Co-design of the system	*"comes down to the design. Ensuring that it with any design that you've got the right people at the table, you know from prescribers to people administering people dispensing because there have been instances where they had all of these systems in place and yet something went and got through the gaps because they didn't have a nurse involved in the design"*
Monitor	
Audit	"*Standardised electronic auditing protocols for VTE risk etc as per standards*"
Documentation	*"improvements on documenting VTE risk assessment and management"*

General	
Standardised process	"*Having a standardised and approved VTE prophylaxis process - prescribers don't agree across the territory*"
System integration	"*We did have a project for ~18 months to build the Chemo requirements in the ieMR/EMM which was unsuccessful, mostly due to a lack of interfaces that the existing system have, to the iPharmacy (dispensing) application. The pharmacists and oncologists involved would not accept a manual process of manufacturing chemo due to the transcription risk, and the project was not funded enough to afford new interfaces. Ideally, Oncology (and Intensive Care) would all be in the EHR/EMM. The fewer points of 'interface' the better*." "*More integration with pathology results because some of our incidents are when patients deteriorate during an inpatient admission and their medicines are not adjusted accordingly."* *"Interfacing with laboratory data visible in a way that is not interuptive and automated alert for abnormal values...Integration of rapid VTE risk assesment (automatic or timely) and in combination with managment (if indicated ensuring its prescribed)...The system that includes a complete picture to identify where consumers have been given an anticoagulant in another area (hospital, department etc)"* *"eMM doesn't talk to the laboratory result application (clinical workstation)so the system cannot automatically flag if the patient is 'high alert'. Ideally this would be integrated in one system"*
Improved handling of non-bioequivalent brands	"*One possible improvement is improved handling of non-bioequivalent brands (eg. Coumadin/Marevan) – by default our drug data vendor considers these as being equivalent, so we need to do manual work to "break" these apart and this needs to be done each time we update this data (usually once a month) as the updates try to "fix" our "broken" configuration. I note that this is tricky as the data vendors supply this data internationally and we are the only country that considers these brands to be non-equivalent*."

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