

Electronic Medication Management Systems

Specialist Functions



AUSTRALIAN COMMISSION ON
SAFETY AND QUALITY IN HEALTHCARE

Electronic Medication Management Systems: Specialist Functions

**A supplement to Electronic Medication
Management Systems: A Guide to Safe
Implementation**

AUSTRALIAN COMMISSION ON
SAFETY AND QUALITY IN HEALTHCARE

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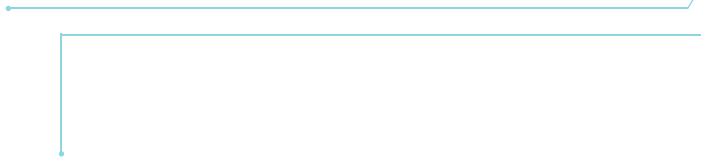
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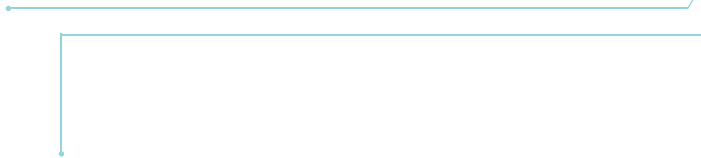
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Acronyms and abbreviations

ACSQHC	Australian Commission on Safety and Quality in Health Care
CIS	clinical information system
EMM	electronic medication management
HL7	Health Level 7 (a type of messaging format)
IV	intravenous
NEHTA	National E-Health Transition Authority
NIMC	National Inpatient Medication Chart



Introduction

Electronic Medication Management Systems: Specialist Functions is intended to be read in conjunction with *Electronic Medication Management Systems: A Guide to Safe Implementation*¹ (the Guide), developed by the Australian Commission on Safety and Quality in Health Care (ACSQHC) and the National E-Health Transition Authority (NEHTA) from 2009 to 2010. The Guide addresses the five main stages of electronic medication management (EMM) implementation:

- Stage 1 – project initiation
- Stage 2 – implementation planning
- Stage 3 – EMM system build and configuration
- Stage 4 – implementation and go-live activities
- Stage 5 – ongoing operations.

The Guide also includes functional and technical specifications, and discusses future considerations.

Electronic Medication Management Systems: Specialist Functions is intended to summarise, for those planning for or procuring EMM systems for hospitals, findings from the Guide that apply to specialist functions. It explores and provides analysis of the issues to be considered when incorporating these specialist functions into an EMM system implementation, and should be read in conjunction with the Guide.

1.1 Background

Medication errors remain the second most common type of medical incident reported in hospitals and, of all medication errors, omission or overdose of medicines occurs most frequently. Reducing all errors will significantly improve patient safety and the quality use of medicines.

A hospital EMM system enables prescribing, supply and administration of medicines to be completed electronically. EMM covers the entire hospital medication cycle including prescribing by doctors, review and dispensing of medication orders by pharmacists, and administration of medications by nurses. EMM reduces medication errors through improved prescription legibility, dose calculation and clinical decision support. It enables best practice information to be more readily available to prescribers and improves linkages between clinical information systems. It can also improve efficiency in the medication management process, such as reducing the time required to locate paper medication charts or to supply non-impres medicines.

¹ The Guide is available on ACSQHC's website at: www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/PriorityProgram-08_ePrescribing2 (accessed 21 July 2011).

EMM systems can reduce medication errors, but they also have the potential to adversely affect safety and quality of care if the system is inadequately designed and implemented, and under-resourced. This risk is highlighted in a number of studies that show increased medication errors after poor implementation of EMM systems. With many Australian hospitals planning to implement EMM systems, it is essential that this risk is minimised by considering the international literature and learning from the experiences of early Australian EMM system implementations.

ACSQHC maintains the National Inpatient Medication Chart (NIMC)², related specialist and ancillary charts, and tools and materials to improve the safety and quality of medicines use nationally.

However, ACSQHC's *National Medication Safety and Quality Scoping Study Committee Report*³ recommended the following actions:

- Recommended action 29: Advocate the safety and quality benefits of implementing electronic medication management systems in all care settings.
- Recommended action 31: Develop a guidance document on the requirements for safe e-medication management systems (including safe design features, use of safety alerts, clinical decision support systems) and the safe introduction of the technology into workplaces.

As a result of these recommendations, ACSQHC and NEHTA developed two documents to help Australian hospitals safely specify and implement electronic medication management systems:

- *Electronic Medication Management Systems: A Guide to Safe Implementation* provides advice on specifying and implementing safe EMM systems.
- *Electronic Medication Management Systems: Implementation Plan* is an implementation plan template, which hospitals can use as the base planning document for EMM system implementation.

The Guide was informed by a review of publicly available literature, the experiences of previous Australian EMM system implementation sites and extensive stakeholder consultation to provide guidance on the activities required for a safe and effective EMM system implementation.

A reference group of clinical, academic and implementation experts provided advice. The reference group included representatives from ACSQHC and:

- hospitals that have implemented EMM systems
- the National Prescribing Service
- the National E-Health Transition Authority (NEHTA)
- state and territory health departments
- the Health Informatics Research and Evaluation Unit, University of Sydney.

2 www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/NIMC_001 (accessed 21 July 2011).

3 ACSQHC. *National Medication Safety and Quality Scoping Study Committee Report*. Sydney: ACSQHC, 2009. [www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/com-pubs_NIMC/\\$File/25185-Report.pdf](http://www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/com-pubs_NIMC/$File/25185-Report.pdf) (accessed 21 July 2011)

At the time of the Guide's publication, a number of prescription and management specialist functions were excluded, which reflected the experience of the main EMM implementations in Australia at the time. However, targeted expert consultation in the hospital medical, nursing, pharmacy and informatics communities further informed the Guide. During the extended consultation, specific experiences and aspirations were identified with the following specialist functions:

- infusions and fluid balance
- chemotherapy
- renal dialysis
- paediatrics.

1.2 Approach

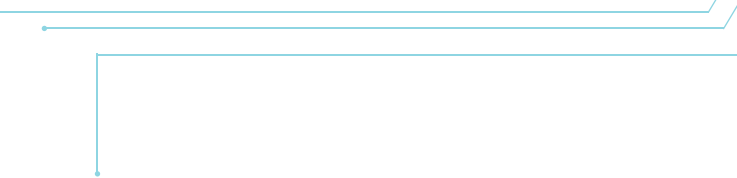
ACSQHC and NEHTA ran a series of targeted stakeholder consultations (see Appendix) to assess the readiness of incorporating the specialist functions outlined in Section 1.1 into EMM systems. These consultations allowed early EMM system implementers and EMM software vendors to share their views on the clinical and EMM software requirements, and whether these specialist functions could be effectively prescribed and managed.

The stakeholders then assessed the challenges and benefits for incorporating these specialist functions into EMM systems. The resulting key themes are presented in this document, along with a summary of the necessary requirements to incorporate the specialist functions into EMM systems.

1.3 Document structure

Sections 2–5 present the outcomes from the stakeholder consultations on infusions and fluid balance, chemotherapy, renal dialysis and paediatric medication management. Each section includes the following subsections:

- **Background** provides an overview of the specialist functions, including reasons to date why it may have been difficult to include them in an EMM system.
- **Analysis** presents the key themes and assesses the current capabilities of EMM systems.
- **Summary** provides an assessment of the current capabilities of EMM systems, and the recommended requirements for incorporation of the specialist functions within an EMM system.



Infusions and fluid balance

2.1 Overview

Prescriptions for infusions are currently managed separately from other medicines prescribed on the National Inpatient Medication Chart (NIMC). Reasons for this include:

- Hospitals use ancillary paper charts for infusion orders. The ancillary charts come in many formats depending on the ward or unit requirements, or individual infusion requirements. For example, the chart may be
 - a large flow chart (such as those used in intensive care units)
 - a specialty chart for theatres or anaesthetics
 - individual drug-specific charts (such as those used for heparin, insulin or patient-controlled analgesia)
 - a double-sided chart, where one side is used for the infusion orders and the other side is used to record fluid balance.
- Generally, the ancillary paper chart is applicable for only 24 hours – orders for infusions are managed and prescribed on a daily basis, and records of the 24-hour fluid balance (input and output) are documented and tallied. Specialised ancillary paper charts (such as those for patient-controlled analgesia) may be used for 48 hours.
- The ancillary chart contains sections for duration of infusion, rate of infusion and start/stop times for the infusion. Some locally developed, drug-specific ancillary charts may also contain policy and procedure instructions for preparation of the infusion, dosage or infusion rate calculation charts, and guidance on rate adjustment according to changes in patient clinical parameters.
- The practice of ordering two administration routes on the same order is not considered safe, as some medicines (e.g. ranitidine) have different doses depending on the route of administration.⁴

2.2 Simple infusions

2.2.1 Background

For the purposes of this document, simple infusions are defined as those consisting of a single carrier solution or a single additive in a carrier solution being administered at a constant rate over a specified period of time.

⁴ ACSQHC. *Guide to Auditing the National Inpatient Medication Chart*. Sydney: ACSQHC, 2011. www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/com-pubs_NIMC-userguide (accessed 21 July 2011)

The administration of simple infusions differs from other medications because they are usually delivered continuously over a defined period of time as opposed to a single dose (e.g. swallowing a tablet).

The rate of administration of a simple infusion is not generally influenced by patient clinical parameters or 'events', such as a change in blood pressure, weight or activated partial thromboplastin time (APTT).

See the following table for examples of simple infusions.

Examples of simple infusions

Simple infusion	Example	Administer
Single carrier infusion	1 L 0.9% sodium chloride	At x ml/h
	1 L Hartmann's solution	Over 12 h
Single additive in a carrier solution	10 mmol potassium chloride in 100 ml 0.9% sodium chloride	Over 1 h
	20 mmol magnesium sulfate in 100 ml 0.9% sodium chloride	Over 1 h

h = hour; L = litre; ml = millilitre; mmol = millimole

Most intravenous (IV) medication orders administered as an IV bolus or small-volume infusion over a short, defined period of time are not classified as simple infusions for the purposes of this document, but they do fall into this category under other definitions. These are generally prepared in a syringe, bag, flask or burette with a small volume (less than 50 ml). Some examples include:

- pantoprazole 40 mg IV (in 10 ml 0.9% sodium chloride) administered by IV bolus over 2 min
- ceftriaxone 2 g IV (in 50 ml 0.9% sodium chloride or 5% glucose) administered by IV infusion over 30 min.

Where hospitals, wards or units require these small-volume IV medication infusions to be included in fluid balance management, consideration should be given to including them in the electronic medication management (EMM) system as simple infusions.

2.2.2 Analysis

The stakeholders noted that it is possible to manage simple infusions with current EMM systems. From a prescribing perspective, this typically involves creating one order for the single carrier solution or two separate orders for a simple infusion containing an additive (one for the carrier solution and one for the additive).

One stakeholder noted that at times only the additive was prescribed formally and the carrier solution was 'ordered' by noting it in a 'comments' field within the EMM system. This workaround suggests that the requirement to place two separate orders for a single infusion was not acceptable to all prescribers, potentially due to the additional time required or a reluctance to complete the same task twice for what would be considered a single order if prescribed on paper.

Order sets and clinical decision support have been used in EMM systems to facilitate prescribing of simple infusions, and to provide reconstitution and dilution advice for additives to carrier solutions.

Compliance with state or territory legislation and regulations is required for the prescribing of some infusions. For example, NSW Health Policy Directive PD2005_3425 states that the prescribing of all IV potassium chloride should be in millimoles (mmol) and that the maximum hourly rate and daily limits of potassium chloride that a patient may receive, as well as recommended infusion rates, are specified on the prescription.

With respect to administering simple infusions, it was noted that the current EMM systems are able to manage linear (or constant) rates of administration.

2.2.3 Summary

The EMM systems currently in operation in Australian hospitals have the capability to manage simple infusions. Use of 'order sets' in the EMM system, which facilitate the prescribing process for simple infusions and those containing single additives, should prevent the adoption of potentially unsafe workarounds.

2.3 Complex infusions

2.3.1 Background

Although there is no clinical definition of a complex infusion, there was consensus among the stakeholders that there are two primary reasons why infusions may be complex in nature – they are complex in formulation and administration.

Complex in formulation

These infusions may be complicated to prescribe for the following reasons:

- They comprise a single additive or medicine in a carrier solution (similar to a simple infusion) but are prescribed in a variety of concentrations, infusion volumes or allowable infusion rates. They are used in different wards or units within a hospital and therefore require clear protocols and guidelines to ensure appropriate and safe use. For example, potassium chloride can be administered at higher concentrations if given by a central venous catheter compared to a peripheral catheter, or it may be infused at a higher rate if the patient is situated in a critical care area where cardiac monitoring is available, depending on local policies and guidelines.
- They comprise more than one ingredient. Multi-ingredient infusions are often prescribed according to the 'attributes' of the infusion, as opposed to the specific product. For example, total parenteral nutrition may be prescribed according to the relative proportions of salts, glucose, amino acids, lipids and vitamins, not as defined amounts of individual ingredients.
- They require dosage calculations based on patient weight, renal function or other clinical parameters.

5 NSW Health. *Safe Handling of Intravenous Potassium Chloride in Health Care Facilities – Policy (PD 2005_342)*. Sydney: NSW Health, 2005.
www.health.nsw.gov.au/policies/PD/2005/pdf/PD2005_342.pdf (accessed 21 July 2011)

Infusions that are complex to prescribe may not necessarily be complicated in their administration.

Complex in administration

These infusions may be complicated to administer for the following reasons:

- The nonlinear nature of the rate of infusion. Infusion rates may be influenced by patient 'events' and altered according to 'point-in-time' patient clinical parameters. An example of a group of medicines that may be complex in their administration is inotropic infusions. Inotropes must be given by continuous IV infusion because they have a very short half-life.⁶ When administering inotropes, it is essential to constantly monitor and record the patient's heart rate, heart rhythm and blood pressure, and adjust the rate of administration according to clinical response. For example, dobutamine might be started at an infusion rate of 2.5–5 µg/kg/min and increased gradually by 5 µg/kg/min to a maximum of 40 µg/kg/min.
- The requirement to administer an initial bolus or loading dose at one infusion rate, which is then adjusted to a maintenance (second) infusion rate according to policies or recommendations, and/or patient clinical parameters or response. For example, an infusion of levosimendan may start with a bolus dose of 12 µg/kg administered over 10 minutes, then change to a continuous infusion of 0.05–0.2 µg/kg/min.
- The requirement to halt or pause an infusion, then restart it later.
- The requirement to administer (and sign-off according to local policies) more than one preparation or bag of the infusion against a single daily prescriber's order. For example, heparin infusion concentrations are often standardised within a hospital to avoid errors. If the rate of administration increases such that a second or third bag of the infusion needs to be hung, nurses will require the ability to document and sign-off these bags against an original prescriber's order.

Infusions that are complex in administration may not necessarily be complex in their formulation.

2.3.2 Analysis

Complex in formulation

The key issue identified for managing infusions that are complex in formulation in current EMM systems was the need to 'construct' the infusion using multiple orders – that is, a separate order for each constituent of the infusion. It was noted that, like simple infusions, it would be possible to streamline the prescription of infusions that are complex in formulation by developing prescription order sets that include all constituents of the infusions. However, it was noted that in EMM systems currently implemented in Australia, these would still be viewed as individual orders on the medication chart. This would make the medication chart confusing and potentially unsafe from an administration and pharmacy review perspective.

6 Great Ormond Street Hospital for Children NHS Trust. Inotropic Infusions (Intravenous): Method for Safe Changeover, 2009. www.gosh.nhs.uk/clinical_information/clinical_guidelines/cpg_guideline_00252 (accessed 30 June 2011)

In order to effectively manage infusions that are complex in formulation within EMM systems, it should be possible to combine multiple orders into a single 'product' while retaining the full prescription details for each constituent. This infusion product should then be seen as a single order for the purposes of administration, and pharmacy compounding and dispensing.

Most stakeholders agreed that infusions that are complex in formulation are usually simple in administration, and therefore anticipate that their administration could be managed similarly to simple infusions (e.g. by using a constant administration rate).

Complex in administration

Some infusions may have nonlinear administration rates. For example, the rate of administration may need to be altered based on patient clinical parameters (e.g. heart rate, blood pressure). When using paper charts to manage IV infusions, it is possible to record a change in the rate of administration while retaining the original order.

The key limitation of current EMM systems is the need to stop an existing order and reorder the infusion at the new administration rate in order to effect a change in the rate of administration. Using EMM systems in this way would constitute a significant change in standard medications management work practice.

Where the rate of administration of an infusion is influenced by a patient's clinical parameters, the EMM system should have the capability to record these parameters and trigger reminders or alerts to clinicians in the EMM system to adjust administration rates accordingly. Alternatively, it could be managed by other patient clinical information systems (CISs), and this information be accessed via bidirectional Health Level 7 (HL7) messaging to allow the CIS to display changes or updates made to physiological information in the EMM system.

2.3.3 Summary

Complex infusions are still managed primarily on paper in Australia, even in hospitals operating EMM systems. The management of complex infusions on paper can be difficult and these complexities also make them difficult to manage electronically. Although current EMM systems have the technical capability to manage such infusions, the processes required to do so do not align with current work practices. In some cases, it may introduce additional clinical risks. For example, in the case of infusions that are complex in formulation, the display of all of the infusion constituents as separate orders on the medication chart has the potential to be confusing and increase the likelihood of medication errors.

Where locally developed ancillary charts contain information sections with policy and procedure guidance, and dose or infusion rate calculation charts, there is a user requirement that this information be made available electronically so it can be referenced by clinicians as they prescribe, review and administer these infusions.

It was noted by stakeholders currently operating EMM systems that the ability to prescribe complex infusions has been identified by clinicians as a core function. Where EMM systems have been implemented in areas where complex infusions are frequently used, such as intensive care units and high dependency units, the management of complex infusions remains paper based. Both EMM software vendors implementing EMM

in Australia reported that the development of improved complex infusion functions is of high priority, with the respective function testing being currently done, and is anticipated to be completed before the end of 2011.

At a minimum, an EMM system should be able to do the following in order to manage complex infusions:⁷

- combine multiple orders into a single 'product' when prescribing (while retaining the detail of each individual order)
- allow administration rates to be changed 'at points in time' (including pausing of administration) without needing to cease the existing order and restart a new order to adjust the administration rate
- allow the prescriber to look up relevant policy and procedure guidance information, and dose or infusion rate calculation charts
- allow recording of clinical parameters that may impact the rate of administration of IV infusions, and display alerts or reminders to alter the rate of administration if the clinical parameters are outside a defined range (e.g. where a patient's recorded blood pressure is below a given threshold, the system may alert the clinician to increase the rate of administration of dopamine). The most appropriate system in which to record these clinical parameters and how this information is made available to the EMM system require careful consideration and integration with other clinical monitoring systems in use.

2.4 Fluid balance

2.4.1 Background

Recording of fluid balance is traditionally a separate function to medication management, fluid ordering and fluid administration.

The aim of fluid balance monitoring is to ensure the amount of fluid going into the patient is equivalent to the amount coming out of the patient, which helps to maintain constant blood volume and electrolyte balance. The fluid balance management is typically recorded on a specific fluid balance chart that documents:

- the volume and nature of fluids going into the patient (e.g. intravenous, oral and nasogastric fluids)
- the volume and nature of fluids leaving the patient (e.g. urine, vomit, wound drainage)
- the time over which the fluids have been tallied (generally 24 h)
- fluid restriction information, where a patient is to be limited to a total intake of x ml/day.

⁷ These requirements have been derived through the consultation process and are not meant to constitute an exhaustive specification. Detailed functional specifications for IV infusions are outlined in: National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007. www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)

The monitoring of the fluid balance of patients is essential to avoid conditions such as:

- hyponatraemia (elevated sodium concentration in the blood)
- hyponatraemia (low sodium concentration in the blood)
- hypervolaemia (increased blood volume)
- hypovolaemia (dehydration or contraction of blood volume).

2.4.2 Analysis

Stakeholders noted that fluid balance is still managed primarily on paper charts and as a separate clinical process to medication management or even fluid ordering. Some of the current EMM software packages in Australia are able to record fluid balance. However, this function did not appear to be widely used, potentially due to the lack of integration with other electronic systems such as CISs.

It was noted that, ideally, either the EMM system could manage the fluid balance for patients where infusions have been prescribed, or it could be managed by other patient CISs.

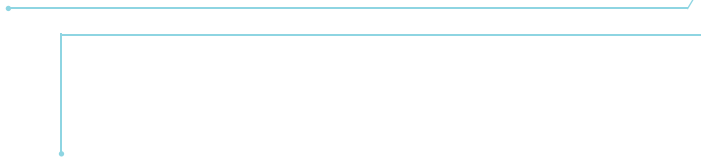
In addition to recording IV infusion volumes, maintenance of patient fluid balance also involves monitoring oral and intragastric hydration, urine, surgical drains, colostomies, ileostomies, dialysis and haemorrhages. This information would need to be accessed via bidirectional HL7 messaging or integration to allow the CIS to display changes or updates made to physiological information in the EMM system.

In addition, the interfacing of 'smart pumps' to either an EMM system or CIS (or both) to automatically update the volume of IV infusions the patient had received was seen as an opportunity to reduce the amount of manual recording required.

2.4.3 Summary

The management of fluid balance in EMM systems is not widely used in Australian hospitals, despite this function being available in some systems.

However, stakeholders highlighted the potential for such function to reduce the amount of manual fluid balance recording required for patients receiving IV infusions. This would require increased levels of integration with 'smart' electronic delivery and monitoring devices, which allow automatic recording of a patient's IV fluid intake.



Chemotherapy

3.1 Background

The treatment of cancer using chemotherapy usually involves multiple medicines and supportive pre and post-procedures, or medicines that are not typically required when giving other medicines (e.g. antiemetics to prevent chemotherapy-induced nausea and vomiting). These therapeutic combinations are alternatively known as regimens or protocols. The best Australian reference for chemotherapy protocols is the eviQ program run by the Cancer Institute NSW.⁸

Chemotherapy protocols for cancer are generally administered in cycles. The cycles may vary in their duration, frequency and number according to the treatment protocol prescribed. For example, the duration of a cycle may be minutes, hours or days depending on the protocol. The cycles may be repeated weekly, fortnightly or monthly, and the total number of cycles may be influenced by the type of cancer, the responsiveness to the chemotherapy treatment and the overall health of the patient.

The delivery of a particular cycle may also be influenced by the patient's health or pathology results at the time (e.g. a cycle may be delayed or rescheduled if the patient is too sick to have the treatment or their blood cell counts are below a certain threshold).

The administration of chemotherapy and supportive medicines in a treatment cycle is interdependent. Medicines are administered in a defined sequence or concurrently, depending on the treatment regimen. For example, medicine A is given first, 30 minutes before medicine B, which is an infusion that runs for 2 hours. Medicine C can be administered via another IV line at the same time as medicine B. Medicine D administration starts after medicine B has been completed.

Another aspect of some chemotherapy that differs from most other medicines is the accumulation of the chemotherapy in the body over time, which can influence future prescribing decisions.

All of these factors make prescribing and management of chemotherapy complex, both on paper as well as in electronic medication management (EMM) systems.

In Australia, some cancer services use oncology-specific EMM systems, or cancer clinical systems that support radiotherapy, chemotherapy and patient care pathways.

8 Cancer Institute NSW. eviQ Cancer Treatments Online (version 1.4.0). www.eviq.org.au (accessed 1 July 2011)

3.2 Analysis

3.2.1 Management of chemotherapy in specialised electronic chemotherapy systems

A number of hospitals have adopted stand-alone electronic systems that have been specifically designed to manage chemotherapy and protocols.

These systems are generally designed around treatment pathways or standardised protocols for the treatment of specific conditions. These protocols allow the rapid ordering of complex order sets of medicines, the scheduling of their administration (including the order of administration), and the automatic scheduling of all future cycles of chemotherapy required.

Specialised electronic chemotherapy systems incorporate dosage calculators that can automatically adjust prescription doses or trigger alerts based on the clinical parameters entered for the patient (e.g. weight, body surface area, serum creatinine, cumulative lifetime dose) and allow the automatic recalculation of individual chemotherapy doses by varying the percentage of 'normal' dose prescribed. For example, if the patient is sick, the prescriber may decide to order a lower proportion (e.g. 70–80 per cent) of the normal dose for a defined number of cycles until the patient's health improves to a level where a full normal dose could be tolerated. This capability makes it easy for the prescriber to adjust orders without doing complex recalculations.

A limitation of a specialised chemotherapy system is the lack of support for other 'general' medicines that chemotherapy patients may also be prescribed. This creates a lack of continuity in medication management and prevents clinicians receiving a consolidated view of all of a patient's medicines.

To date, specialised electronic chemotherapy systems do not provide for electronic administration of medicines. A printed paper chart that contains the list of the medicines ordered by the prescriber for the treatment cycle is used to record administration of medicines in the cycle. Potential risk is introduced when orders are maintained in an electronic format but the administration of medicines is done on paper charts (e.g. where the printed paper chart includes medicines that have been cancelled or have had dose changes made in the electronic system after the paper chart was printed).

3.2.2 Management of chemotherapy in general EMM systems

To date, Australian hospital implementations of EMM systems have focused on the inpatient setting and have not incorporated outpatient settings where most treatment of patients requiring chemotherapy now takes place (e.g. specialist cancer units). As a result, development of chemotherapy protocols in general EMM systems has not been a priority.

Some guidelines specify that chemotherapy should be prescribed on a separate dedicated chart.⁹ Where a separate paper chart for chemotherapy is used in hospitals

9 Clinical Oncological Society of Australia (COSA). *Guidelines for the Safe Prescribing, Dispensing and Administration of Cancer Chemotherapy*. Sydney: COSA, 2008.
www.cosa.org.au/cosa_assets/files/About%20us%20-%20publications/Guidelines%20for%20Safe%20Prescribing2008.pdf
(accessed 21 July 2011)

using a general EMM system for all other medicines, there is a risk of missed doses of chemotherapy with serious consequences. Experienced EMM system implementers commented that some specialist clinicians have altered the practice of maintaining separate chemotherapy paper charts, and instead manage chemotherapy in the EMM system.

It is important to note that most chemotherapy is provided as an outpatient service in a dedicated ambulatory care unit. For the inpatient setting, usually only one cycle of the chemotherapy regimen is required (the remaining cycles being done in the outpatient setting). General EMM systems can manage chemotherapy when prescribed one cycle at a time.

A limitation of general EMM systems is that each medication order must have a defined start date and time determined at the time of prescribing. A chemotherapy cycle has different timing requirements to other medicines in that its start time is determined by administration of the first medicine in the protocol, from which the interdependent sequential medicines must follow.

The inability of the current EMM system implementations to effectively manage the complex scheduling of future cycles of chemotherapy is one of the key limitations to the management of chemotherapy in these systems.

3.2.3 Management issues relevant to both systems

Stakeholders noted that the development of standardised protocols requires a substantial investment in time and resources, including extensive testing and sign-off by the appropriate clinicians involved. In addition, it was noted that it is vital to get these protocols right the first time, as the complexity of the protocols often makes it difficult to detect configuration errors later on. There is also an ongoing human resource requirement to constantly refine the protocols based on feedback from clinicians and also to develop new pathways for the management of new medicines.

One potential drawback of the protocol approach to chemotherapy ordering is that, once set, it can be cumbersome to alter the protocols for one-off changes to individual prescriptions (e.g. to change or add an individual medicine) or to all protocols containing a medicine, such as an anti-nausea agent, when newer agents become available.

The lack of integration between chemotherapy and general medicines, when managed in separate systems, prevents the full benefits of clinical decision support being realised. For example, alerts would not be triggered if there are drug interactions between the general medicines prescribed and any of the medicines prescribed for the chemotherapy protocol. In addition, the dose ranges used for general medicines may be influenced by the patient receiving chemotherapy (e.g. it may be necessary to use higher or lower doses of medicines due to the altered physiological conditions of the patient following or during a chemotherapy cycle). This suggests that there may be significant benefits to managing chemotherapy medicines and general medicines in a single electronic system.

A common problem now is the loss of continuity of a patient's treatment record when a patient may have had three out of six cycles of chemotherapy administered in one centre as an outpatient, but then requires hospital admission (either locally or remotely) where the fourth cycle of chemotherapy is administered and documented

in another medication management system. This issue poses a dilemma for hospitals looking to manage chemotherapy across their outpatient and inpatient environment if different EMM systems that are not interfaced are used in these settings.

3.3 Summary

There are five key aspects of chemotherapy that make it complex to manage in EMM systems:

- the complexity of the protocols and orders, and their ongoing management
- the requirement to hold orders in the system then start the cycle when the first medicine is administered
- the complicated scheduling regimens for the delivery of the cycles
- more complex dosing calculations
- the high propensity for scheduled cycles to be delayed or skipped on the basis of patient clinical parameters or pathology results.

In order to effectively manage chemotherapy, an EMM system should:^{10, 11}

- allow multiple medicines to be prescribed as an order set and in a specific administration order
- allow the scheduling of different administration times and dates for medicines prescribed at the same time (preferably scheduled automatically as part of a defined protocol or order set)
- include dosage calculators that can automatically adjust prescription doses or trigger alerts based on the clinical parameters entered for the patient (e.g. weight, body surface area, serum creatinine, cumulative lifetime dose) and allow the automatic recalculation of individual chemotherapy doses by varying the percentage of normal dose prescribed
- allow importation of standard referenced chemotherapy protocols, such as the eviQ program, to reduce error and configuration maintenance
- include the ability to 'lock' medication orders so that changes cannot be made (e.g. when pathology results have been checked or manufacturing authorisation has been given)
- allow the start time of a cycle to begin when the first medicine starts administration
- electronically record the administration of chemotherapy medicines
- calculate cumulative doses of certain drugs and alert healthcare professionals when the maximum cumulative dose is reached
- allow the automatic rescheduling and updating of all future related administration events for a patient (e.g. other cycles) if a cycle is delayed, stopped or changed

10 These requirements have been derived through the consultation process and are not meant to constitute an exhaustive specification for chemotherapy management in EMM systems. Detailed functional specifications for oncology and haematology are outlined in: National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007.

www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)

11 Clinical Oncological Society of Australia (COSA). *Guidelines for the Safe Prescribing, Dispensing and Administration of Cancer Chemotherapy*. Sydney: COSA, 2008.
www.cosa.org.au/cosa_assets/files/About%20us%20-%20publications/Guidelines%20for%20Safe%20Prescribing2008.pdf (accessed 21 July 2011)

- enable access to up-to-date pathology results, which should be accessible either by integrating the pathology results system with the EMM system, or through external links to the pathology results system.

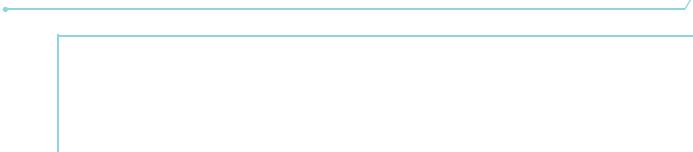
There are currently three options for hospitals wishing to manage chemotherapy electronically:

1. Implement an EMM system that handles all medicines, including chemotherapy.
2. Implement a stand-alone specialised electronic chemotherapy system that does not integrate with a separate EMM system managing general medicines. One variation of this option is to use the dedicated oncology EMM system in outpatient clinics, and the general EMM for admitted cancer patients receiving chemotherapy.
3. Implement a stand-alone specialised electronic chemotherapy system integrated with a separate EMM system managing all other medicines.

Option 1 is the safest approach and provides the greatest continuity of medication management, given that all medicines would be handled in the same system. This option allows the benefits of integrated clinical decision support, completes patient cycle profiles and reduces the need for interfacing to other systems. Option 1 would be most suited to hospitals that need to manage high volumes of general medicines in addition to chemotherapy.

Option 2 is currently the preferred approach in hospitals with a specialist cancer unit where there is no EMM system in place for general medicines.

Option 3 would require substantial additional work to develop the interface between the stand-alone chemotherapy system and the separate general EMM system. This would require a significant degree of planning. It would also require that decisions be made about which elements and functions – such as formularies, clinical decision support databases, pathology results and medicines information – need interfacing and to what degree.



Renal dialysis

4.1 Background

Although renal dialysis is a specialist procedure, it is based upon a prescription that could be generated via an electronic medication management (EMM) system and the administration of the prescription could also be supported within an EMM system. The different types of dialysis (e.g. haemodialysis, peritoneal dialysis) also have their own specific prescribing and management requirements.

There is no Australian experience of clinical data exchange between renal dialysis machines and EMM systems. In South Australia, renal dialysis machines are linked to the Oacis Programme (Oacis), which contains the prescription, although the South Australian implementation of Oacis does not include EMM functions.

The following principles apply to the medication management of renal dialysis patients:¹²

- dose adjustment may be required due to poor renal function
- medicines may be specifically contraindicated
- renal function monitoring will often be linked to prescribing and administration decisions
- there are differing types of dialysis, which have specific requirements, that require specific prescription and administration
- changes need to be made to the dosing of systemic medicines due to the effect that dialysis may have on them
- fluid restriction and monitoring may be linked to prescription and administration.

4.2 Analysis

Renal dialysis EMM functions should include:¹³

- consideration of renal function and relevant diagnostic results when prescribing all medicines for patients receiving renal dialysis, as some medicines may require an alternative dose, alternative medicines or spacing of doses when given concurrently with renal dialysis
- support for all of the required elements for the prescription of renal dialysis, including type of dialysis, fluid type, flow rate, concentration and time
- support for the prescription of additives to the dialysis fluid (e.g. heparin, antibiotics) and allow calculations or recording for additives such as potassium,

12 National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007. www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)

13 These requirements have been derived through the consultation process and are not meant to constitute an exhaustive specification. Detailed functional specifications for renal dialysis are outlined in: National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007. www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)

where the total daily dose of additive is distributed over the total number of dialysis bags to be administered (which may also be of varying volumes and dialysate concentration)

- support for the prescription of line locks
- dose calculators that take into account relevant diagnostic results and other clinical data required when
 - additives are included in the dialysis bath (e.g. considers the patient weight)
 - dose calculators administering STAT doses of some medicines; where a sliding scale is used, mechanisms are required to validate the manual entry of the dose required against known parameters (e.g. previous doses for the patient)
- allowance for flexible scheduling of haemodialysis days or times, which commonly change from week to week
- medicines scheduling in relation to dialysis, including medicines required before dialysis, at the start of dialysis, during dialysis, during the last hour(s) of dialysis and at the end of dialysis; for example, erythropoietin is administered during the last five minutes of dialysis and vancomycin is administered at the end of dialysis.

4.3 Summary

In terms of its prescription and management in an EMM system, renal dialysis contains similar requirements to those discussed in infusions, fluid balance and chemotherapy.

In order to manage renal dialysis in EMM systems, the following should be included:

- The ability to combine multiple orders when required into a single product or order set when prescribing renal dialysis (e.g. including the dialysate and all additives).
- The capacity for dialysis administration rates to be changed 'at points in time' (including pausing of administration) without needing to stop the existing order and start a new order.
- The ability to record clinical parameters that may impact the rate of dialysis, and display alerts or reminders to alter the rate of dialysis if the clinical parameters are outside a defined range. For example, where a patient's recorded blood pressure is above a given threshold, the system may alert the clinician to decrease the rate of dialysis. This could also be managed by other patient clinical information systems (CISs), and this information be accessed via bidirectional Health Level 7 (HL7) messaging to allow the CIS to display changes or updates made to physiological information in the EMM system.
- The ability to flag patients undertaking dialysis and trigger reminders to ensure the prescriber takes into account the time, duration and impact of the dialysis on other medicines that are prescribed. This might also be achieved via bidirectional HL7 messaging to other clinical systems that record patient clinical information and diagnoses.
- Dose calculators that provide additional support for renal dialysis nurses who need to adjust the dialysis 'bath' based on changes to patient clinical conditions.
- The ability to access pathology results, either by integrating pathology results with the EMM system using HL7 messaging, or through external links to the pathology results system.
- The ability to share clinical data between the renal dialysis machine and the EMM system using bidirectional HL7 messaging, or provide this via integrated links to CISs.

Paediatrics

5.1 Background

Paediatric medication management is already in use in electronic medication management (EMM) system implementations within Australia. Although paediatrics is a subspecialty with particular requirements, almost all of the general function and implementation considerations for EMM systems are also applicable to paediatric EMM.

Paediatric medication management is complicated by a number of factors including:

- the age and clinical characteristics of the patient
- the extent to which the patient reflects child growth pathways from neonatal through early childhood to adolescents (Australian-specific child growth charts have been developed by some jurisdictions¹⁴), which may influence the required medicine or dose
- the requirement for complex medicine dose calculations
- the paediatric experience of the prescriber and the need for clinical interpretation of the required medicine dose in some patients
- access to general medicines for paediatric prescribing, including medicines not approved for paediatrics.

5.2 Analysis

The *ePrescribing Functional Specifications for NHS Trusts*¹⁵ identify the following principles for paediatric medication management:

- The prescribing, dispensing and administration of medicines for children differs from adult practice significantly.
- Dose of medicines relates to size – which, in contrast to adulthood, changes rapidly and over a wide range – and dosing. Dose also has to take into account altering physical maturity.
- Choice of dose, formulation and dilution is heavily based on calculations that are open to error. Small errors can have greater impact in paediatrics than in adult practice.
- Errors or inappropriate adjustment of dosage can be dangerous, or can lead to ineffective therapy or avoidable side effects.
- The evidence base and general expertise in prescribing and dispensing is significantly less than for adults, which creates a need for more support during the medicines prescribing process in children.

14 www.education.vic.gov.au/ecsmangement/mch/childhealthrecord/growth/charts.htm (accessed 16 June 2010)

15 National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007. www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)

- Information provided to patients, carers and healthcare professionals needs to be geared to their particular needs, as well as be communicated to, and available in, all locations of care to support medicines administration.
- Where systems support both adult and paediatric prescribing, access to pathways that meet the differing needs of practice must be demonstrably separate and ensure that only appropriate medicines can be prescribed. This means that suitable formulations, dosing and guidance must be seamlessly visible and accessible when medicines are being prescribed or administered to children. There should be access controls to ensure that adult pathways are not available inadvertently. The opposite must be true if adult pathways are being accessed.

Paediatric-specific EMM functions should include:^{16, 17}

- paediatric order sets (developed by age and/or condition)
- age-appropriate order sets; for example, for term newborns or premature newborns
- drug-dosing decision support that is contextual for paediatric-specific health issues, which includes specialty-specific decision support for neonatal, renal, oncology and so on
- drug dictionaries with paediatric-specific dose ranges and alerts that include single-dose, daily-dose and cumulative-dose decision support, and incorporate lifetime cumulative dose calculations for chemotherapies
- weight or body surface area-based dosing, which is based on population data (with standard and consistent units of measurement to prevent conversion and calculation errors)
- the ability to check weight entered against standard nomograms in paediatric patients to ensure that it is sensible
- prompts for re-entry of weight if this information has not been updated within a defined period
- alerts for recalculation of dose based on changes to weight or body surface area
- automated calculations and automatic dose limits or caps for larger patients
- automated calculation of drug doses that avoids manual computation errors
- precalculated charts as an alternative to automated dose calculators, where clinical parameters such as weight and height are known
- paediatric or age-specific norms for the reporting of diagnostic tests, which are critical where EMM is integrated with diagnostic results reporting.

16 Kim GR, Lehmann CU and the Council on Clinical Information Technology. Pediatric aspects of inpatient health information technology systems. *Pediatrics* 2008;122(6):e1287–e1296.

17 Walsh KE. Medication errors related to computerized order entry for children. *Pediatrics* 2006;118(5):1872–1879.

5.3 Summary

Within Australia, there are currently two approaches to EMM support for paediatric medication management:

1. A system where paediatric medicines are managed separately to adult medicines, with separate prescribing pathways, prescribing order sets, decision support and alerts.
2. A system where paediatric medicines are managed in the same way as adult medicines, with differentiation of paediatric medicines relying on alerts and prompts within the EMM system.

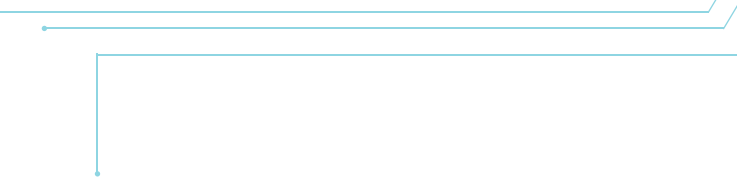
Option 1 is tailored to the needs of paediatric clinicians and is well suited to paediatric hospitals or paediatric units within general hospitals. However, option 1 provides less support where paediatric patients are being managed by nonpaediatric specialists in general wards and emergency departments in general hospitals where there are no specialist paediatric services.

Option 2 may better support general units or general wards receiving paediatric patients.

The preferred approach would be a combination of both option 1 and option 2, where specialist paediatric EMM function is readily available wherever a paediatric patient presents, irrespective of the clinical expertise of the clinician. The *ePrescribing Functional Specifications for NHS Trusts* recommends the following approach if options 1 and 2 are to be combined:¹⁸

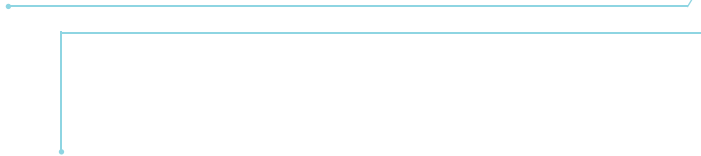
- There must be clear separation of the prescribing function using a combination of access controls and decision support to ensure that prescribing is undertaken using the right pathway – that is, the system should default to a paediatric or neonatal formulary when prescribing for children to avoid prescribers being presented with adult drugs and doses.
- There must be an option for prescribers to decide whether to treat adolescents with paediatric or adult doses or regimens.

18 National Health Service (NHS). *ePrescribing Functional Specification for NHS Trusts*. London: NHS, 2007. www.connectingforhealth.nhs.uk/systemsandservices/eprescribing/baselinefunctspec.pdf (accessed 21 July 2011)



Appendix List of stakeholders

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Mr Michael Cooney	Peter MacCallum Cancer Centre, Melbourne, Victoria
Ms Jenny Darby	Cerner Corporation, Melbourne, Victoria
Mr Tony Firth	iSOFT, Sydney, New South Wales
Ms Kylie Herman	Port Augusta Hospital, Port Augusta, South Australia
Dr Charles Kilburn	Royal Darwin Hospital, Darwin, Northern Territory
Ms Sue Kirsas	Peter MacCallum Cancer Centre, Melbourne, Victoria
Ms Connie Lo	Concord Repatriation Hospital, Sydney, New South Wales
Ms Bhavini Patel	Royal Darwin Hospital, Darwin, Northern Territory
Ms Rosemary Richman	Concord Repatriation Hospital, Sydney, New South Wales
Ms Louise Robertson	Concord Repatriation Hospital, Sydney, New South Wales



Glossary

clinical decision support	Clinical decision support includes any function that provides guidance or incorporates knowledge to assist the clinician in making the most appropriate clinical decisions for patient care.
cumulative lifetime dose	Refers to the cumulative dose of a particular chemotherapy that a patient has received over the course of their life. As some chemotherapies accumulate in the body (i.e. they are not cleared), the cumulative dose may influence future prescribing decisions.
electronic medication management (EMM)	The entire electronic medication process from the prescriber's medication order, to the pharmacist's review of the medication order and supply of medicine, to the nurse's documentation of medication administration of the medicine, and all the processes in between.
general EMM	For the purposes of this document, this refers to an EMM system managing the majority of medicines in the hospital, but not including the specialist functions discussed in this document.
order set	A group of individual medication orders commonly prescribed together at the same time.
smart pumps	Medical devices that manage the delivery of infusions to patients, typically with the capability to monitor, display, control and record the volume of fluid delivered and the rate of delivery. Some smart pumps also have the ability to transfer and receive messages to and from other electronic systems such as EMM systems or clinical monitoring 'dashboards'.

