ePRaSE
Electronic Prescribing and Safety Evaluation

ePLearning Lab

NHS

Electronic Prescribing **Learning Lab**

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December 2025

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Introduction

Foreword

Electronic prescribing or EP systems have become a cornerstone of modern clinical practice, offering the promise of safer, more efficient, and more accountable medication management.

Yet, as the findings from the Electronic Prescribing Risk and Safety Evaluation (ePRaSE) tool make clear, the reality of local EP system configuration across the NHS is far from uniform – and in many cases, far from optimal. Despite widespread implementation, significant variation persists in how systems are configured to mitigate known prescribing risks, with fewer than half of trusts demonstrating robust strategies for high-risk medication errors.

This is a sobering reflection of the gap between implementation and impact. It reminds us that digital transformation is not a single event, but a continuous journey – one that demands ongoing learning, adaptation, and collaboration.

The disappointment with current configurations is not a failure of technology, but a call to action: to engage more deeply with users, to respond more effectively to emerging risks, and to unlock the full potential of EP systems in supporting safe, high-quality care.

The EP Learning Lab has been developed in response to this challenge. It offers a structured, evidence-informed resource to support trusts in optimising their EP systems – regardless of platform or configuration. Drawing on international literature, lived experience, and the insights of frontline professionals, this document provides practical guidance, thematic learning, and case studies to help teams move beyond implementation toward meaningful and ongoing optimisation and improvement.

Optimisation is not a luxury – it is essential. It is the mechanism by which systems evolve to meet the needs of patients and professionals alike. And it is through this process that we can transform disappointment into progress, variation into consistency, and potential into performance.

We are grateful to all those who contributed their time, expertise, and insights to the development of this resource. Your commitment to safer prescribing and improved care is what makes this work possible – and what will drive its success.

Jamie Coleman, Ann Slee, Neil Watson

December 2025

Background

Electronic prescribing system optimisation is the ongoing process of interactive learning and adjustment that takes place after system implementation.

This process should be recognised as continuous, rather than finite. Optimisation is essential, as the mere acquisition and implementation of a system does not guarantee successful adoption or the realisation of anticipated benefits.

The optimisation process encompasses four key activities:

1. Resolving discrepancies between system functionality and organisational needs
2. Enhancing system capabilities
3. Improving data utilisation
4. Advancing user proficiency and engagement.

Together, these measures ensure seamless integration of the system within clinical workflows and promote effective utilisation in practice.

Optimisation ensures that systems are not only sustained but also progressively enhanced to bolster safety and reduce risk. This requires a structured approach to incorporating user feedback, addressing unforeseen challenges promptly, and fostering long-term commitment to improvement. Significantly, the most substantial benefits from optimisation frequently emerge well beyond the initial system deployment.

The ePRaSE tool, sponsored by the NHS, assists trusts to self-assess how effectively their EP systems have been configured locally to minimise known national prescribing risks. It also provides trusts with comprehensive national benchmarking data. The insights gained inform both local and national strategies for EP system configuration and optimisation. Findings have revealed notable differences in the configuration of EP systems. For instance, among five high-risk medication errors, fewer than half of trusts have implemented robust mitigation strategies.

The results from ePRaSE underscore significant opportunities for further EP system optimisation. The EP Learning Lab offers a toolkit focused on approaches to enhance and improve electronic prescribing systems.

Developed to consolidate available information and best practice guidance, the EP Learning Lab enables trusts to establish and implement effective strategies for optimising decision support and system configuration. The resource is intended to facilitate collaborative learning – acknowledging the dynamic nature of digital solutions, evolving user requirements, and new technologies. It highlights core themes and presents case studies to support teams in maximising the potential of their EP systems to deliver high-quality and safer clinical care.

How to use this resource

This resource has been developed to aid organisations to focus on approaches to enhance and improve electronic prescribing systems.

- It is arranged into chapters (tabs), each designed to capture the different aspects of EP system optimisation through a theme-specific lens.
- The key learning points within each section are not arranged in any specific order or hierarchy.
- It is designed to be 'system agnostic' – independent of a particular EP system – allowing its applicability to a wide range of platforms, hardware, and clinical protocols.
- It cannot possibly provide a solution to every high-risk prescribing scenario or optimisation task. It is designed to provide an anthology of evidence-based learning and to describe a collective approach to the continuous improvement and optimisation of EP systems.
- As the learning is developed from an international literature review, it potentially includes words, comments and configurations that may seem slightly foreign to the UK market. Where possible, we have endeavoured to use UK-specific language.
- For the purposes of this document, the term 'electronic prescribing' is considered to be synonymous with electronic prescribing and medicines administration (ePMA/HePMA) and computerised prescriber order entry (CPOE).

Electronic prescribing definition

(Updated October 2025)

This is defined as the use of digital platforms that replace traditional paper-based methods – enabling healthcare professionals to prescribe and record administration of medicines electronically. EP systems support informed decision-making regarding medication selection, administration, and supply – enhancing safety and convenience for both patients and staff. It also offers a comprehensive audit trail throughout the entire medication management process, helping to reduce waste and improve care efficiency.

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October 2025

Optimisation themes

Implementation and adoption

Implementing electronic prescribing systems is a complex journey, aiming to enhance patient safety and healthcare efficiency.

Success relies on robust leadership, sustained stakeholder engagement, comprehensive training, and user-centred optimised clinical workflows. Effective adoption requires continuous optimisation, addressing usability issues like alert fatigue, and a long-term strategic approach beyond initial deployment to fully realise anticipated benefits and integrate systems seamlessly into practice.

The following section contains **12 learning points.**

Learning points

Comprehensive stakeholder engagement and collaborative governance

Successful implementation and sustained adoption of EP systems hinge on robust, multidisciplinary stakeholder engagement from the very outset. This includes clinicians (doctors, nurses, pharmacists), IT specialists, administrative leaders, and critically, a patient perspective.

Collaborative governance ensures that strategic goals, timelines, and policies are established with realistic clinical input, addressing potential conflicts and fostering a sense of ownership and value among users. Without active involvement and strong leadership support, systems – regardless of their technical sophistication – are prone to user resistance and failure to achieve their full potential.

User-centred design and seamless workflow integration

Systems must be user-centred, prioritising ease of use, efficiency, and seamless integration with optimised clinical workflows. Clinicians consistently report that systems perceived as time-consuming, requiring too many clicks or introducing cumbersome workarounds, are significant barriers to acceptance and can negatively impact patient safety and efficiency. Solutions must support clinical reasoning and decisions at the point of care without disrupting clinical practice. This ensures that the technology genuinely enhances, rather than impedes, care delivery.

Continuous optimisation and sustained post-implementation support

Implementation is merely the beginning of a prolonged journey towards realising benefits. Systems require continuous optimisation, refinement, and adaptation to evolving clinical needs and technological capabilities, which can extend for many years after go-live. This includes robust technical support, continuous training for staff, and responsive mechanisms for logging and actioning change requests. The commitment must extend beyond the initial go-live, evolving from an episodic view of engagement to continuous, holistic efforts that respond to feedback from the end-user.

Robust training and skill development

Adequate and ongoing training is frequently cited as a facilitator for system acceptance. This includes initial training, ongoing education on system changes, and opportunities for users to enhance their ‘technological competence’. The sources highlight that sufficient investment in training and technical support, especially ‘at the elbow’ support during go-live, is crucial to mitigate resistance and ensure competent system use. Lack of adequate training is consistently identified as a major barrier.

Data standardisation and interoperability

A fragmented digital health landscape, characterised by a lack of data standardisation and interoperability between disparate systems, severely limits the potential for comprehensive data utilisation. This is a barrier to aggregation of data for secondary uses such as audit, research, and population health management, which are vital for achieving a truly ‘learning health system’. Efforts to standardise terminologies and facilitate seamless data exchange are therefore essential for unlocking the full value of digital systems.

Effective management of clinical decision support content and alerts

While CDS features such as alerts and reminders can significantly improve patient safety and guideline adherence, their provision does not guarantee uptake. A critical challenge is alert fatigue, which arises from excessive, irrelevant, or redundant alerts – leading to overrides and potentially missing critical information. Effective CDS requires designing concise, relevant, actionable, and evidence-based alerts and recommendations that are seamlessly integrated into the clinical workflow. Balancing specificity with clinical utility is an ongoing optimisation challenge.

Clear vision and realistic expectations for strategic planning

Establishing a clear, shared vision for the EP implementation, articulated from the highest levels of the organisation, is crucial. This vision must be coupled with realistic expectations regarding timelines, resource allocation, and the scale of organisational change involved. Overly ambitious timelines and a failure to anticipate the complexities of integration into daily practice are common pitfalls that can lead to significant problems and strained relationships between stakeholders and vendors.

Benefits realisation and robust measurement

Despite the potential of EP systems to improve safety, quality, and efficiency, it remains a challenge to consistently measure these benefits and establish clear metrics for success. Robust evaluation frameworks and systematic data collection are needed to assess impacts on patient outcomes and productivity. This demonstrates value, identifies areas for improvement, and justifies ongoing investment.

Strategic procurement and collaborative vendor relationships

Hospitals often lack the internal expertise to adequately assess their needs, select appropriate commercial products, and negotiate complex contracts with system vendors. This can lead to strained relationships, systems ill-suited to organisational needs, and difficulties in achieving interoperability and future development. A more formalised procurement framework, fostering synergistic and collaborative partnerships with vendors from the outset, use of external peer support and central guidance on standards, are essential to mitigate these risks and ensure long-term system viability.

Contextual adaptation and understanding organisational culture

Every implementation is unique and highly context-dependent, deeply influenced by local clinical practices, user preferences, existing policies, and the prevailing organisational culture. Successful adoption is not achieved through a ‘one size fits all’ approach but by acknowledging and adapting to these local nuances. This includes understanding existing ‘hidden cultural assumptions’ and power dynamics within the organisation, which can significantly impact user acceptance and system embedding.

The complexity of EP system implementation

The procurement, implementation, and adoption of EP systems are extremely challenging, often requiring more time and resources than initially anticipated. Significant barriers include integration and interfacing challenges with existing systems, an immature supplier market (in some regions), lack of local expertise, and unrealistic user expectations. These complexities often mean that initial focus remains on getting systems operational, with less attention given to crucial optimisation or secondary data uses until later stages.

Local configuration leads to variability in impact and safety performance

Even when deploying the same commercial EP system, there is substantial variability in its performance and effectiveness across different hospital trusts. This largely stems from local configuration decisions, organisational culture, and the extent to which CDS features are activated or suppressed. Simply acquiring a well-regarded system does not guarantee optimal safety outcomes – careful, context-specific customisation and ongoing local optimisation are paramount.

Configuration

Configuration is a critical process for the ongoing adaptation of generic electronic prescribing platforms to optimise hospital workflows and local policies, thereby enhancing patient safety, quality, and efficiency.

Thoughtful configuration allows for the tailoring of CDS, such as drug–drug interactions (DDIs), to be more contextually relevant and precise, reducing inappropriate notifications and potential errors. It is also instrumental in preventing the proliferation of unofficial workarounds that can compromise safety.

However, over-customisation can introduce challenges, including increased local training burdens and difficulties with vendor updates. Poor system configuration may conversely lead to significant usability issues, user dissatisfaction, and new types of medication errors.

Therefore, a judicious, user-centred approach, often involving close collaboration with system vendors and informed by local clinical expertise, is paramount for successful implementation and ongoing optimisation.

The following section contains **10 learning points.**

Learning points

Prioritise user-centred design and robust stakeholder engagement

From a clinical standpoint, this is the bedrock of successful EP implementation. Systems are not merely tools – they are integral to daily clinical practice. Active and meaningful involvement of clinicians – doctors, nurses, and pharmacists – along with administrative and IT professionals, is crucial from the very first conceptualisation phase through design, implementation, and ongoing optimisation. Without this collaborative, multidisciplinary approach, systems risk being perceived as impositions rather than aids, leading to low user acceptance and hindering the realisation of anticipated benefits.

Clinicians possess invaluable insights into real-world workflows and cognitive processes that must be integrated into the system's design for it to be effective, usable, and truly fit for purpose. Furthermore, bringing in patient and carer perspectives, though often overlooked in the literature, is also essential to ensure patient-centred outcomes. This engagement fosters a sense of ownership and trust, which is far more impactful than any top-down mandate.

Ensure seamless integration to transform clinical workflows

EP systems must augment, not obstruct, the natural flow of clinical activities. If a system introduces friction or requires clinicians to adopt cumbersome new cognitive models, it inevitably leads to inefficiencies, increased workload, and the emergence of workarounds. While often devised by clinicians to maintain efficiency, these workarounds can inadvertently introduce new safety risks or inaccurate documentation.

Optimal design dictates that decision support, for instance, should be delivered in real-time, at the precise point of decision-making, and with minimal interruption to the clinician's thought process. Systems should be flexible enough to accommodate the nuances of various specialties and roles, whilst supporting transformation and the utilisation of standard approaches.

Actively manage and optimise CDS to combat alert fatigue

Alert fatigue remains one of the most significant threats to patient safety in computerised prescribing. When clinicians are bombarded with excessive, irrelevant, or poorly timed alerts, they learn to override or ignore them – increasing the risk of missing truly critical warnings.

Effective CDS should be highly specific, context-aware, and tailored to the individual patient and user. This means moving beyond generic warnings to provide succinct, actionable advice with clear justifications, offering alternatives where appropriate, and employing visual cues (such as colour-coding and prominent positioning) to indicate severity. Regular review of alert trigger rules and performance logs is essential to refine their specificity and reduce unnecessary interruptions.

Optimise interface design for clarity and efficiency

The user interface (UI) is the clinician's direct point of interaction with the system, profoundly impacting usability and cognitive load. A well-designed UI presents information clearly, concisely, and logically, minimising the risk of errors and frustration.

Key recommendations include:

- Avoid information overload by carefully managing content density and logically grouping related elements.
- Use consistent terms and text formats throughout the system. Visually distinguish active elements, employ 'tall man lettering', and use colour sparingly but consistently to highlight important information.
- Minimise layers of screens to facilitate navigation. Optimise 'pick lists' and drop-down menus to reduce scrolling and selection errors, perhaps by limiting their length based on typed input. Ensure adequate space for free-text entries to prevent workarounds.

Commit to ongoing optimisation and continuous evaluation

EP implementation is not a finite project – it is an iterative process of continuous improvement. Hospitals must establish mechanisms and resource for ongoing monitoring, evaluation, and refinement of their systems to adapt to evolving clinical needs, new evidence, and unforeseen consequences.

This includes:

- Systematically identifying and classifying new types of prescribing and technology-related error mechanisms (TREMs), which are unique to electronic environments.
- Evaluation methods such as cognitive walkthrough and think-aloud protocols can be invaluable for identifying usability problems and their potential to cause medication errors.
- Data-driven approaches, like analysing prescribing patterns and user behaviour, can inform targeted modifications to enhance safety and efficiency.

Tall man lettering is the approach of writing part of a drug's name in upper case to help distinguish sound-alike or look-alike names from one another in order to avoid medication errors.

Cognitive walkthrough is a usability evaluation method that simulates a new user's thought processes as they work through a set of tasks.

Think-aloud protocols are where participants verbally express thoughts, feelings, and decision-making processes as they perform a set of tasks.

Ensure high quality, complete, and integrated patient data

The efficacy of CDS and overall system safety is intrinsically linked to the quality and completeness of underlying patient data. Inaccurate, outdated, or fragmented information (such as allergies, problem lists, or weight) can lead to inappropriate alerts or flawed clinical decisions.

Inadequate integration between disparate systems within a hospital or across the wider healthcare ecosystem can hinder a comprehensive view of the patient's record and complicate data sharing between different care settings. Organisations should strive for a 'source of truth' data model with standardised terminologies such as the dictionary of medicines and devices (DM+D) to ensure interoperability and consistency, enabling robust CDS functionalities.

Provide comprehensive training and continuous support

The complexity of EP systems necessitates dedicated and continuous training for all user groups. Initial training should cover not just the mechanics of the system but also explanations of jargon and software commands to minimise frustration and misinterpretation between different systems. Ongoing training is crucial to accommodate software changes and updates, and the establishment of 'super users' can provide invaluable peer-to-peer support. Without adequate training, staff discomfort with the technology can reduce adoption and increase the risk of errors.

Leverage order sets and templates for standardisation and efficiency

Well-designed order sets, pre-written orders, and clinical pathways are powerful tools that can standardise prescribing practices and improve adherence to clinical guidelines. They can also reduce variation in care and significantly save time by pre-populating recommended values for dosage and frequency. When dynamically tailored to patient-specific data or linked to alerts, their effectiveness is further amplified. However, their content and structure must align with actual clinical workflows and user preferences to ensure uptake and avoid selection errors or poor usability.

Implement indication-based prescribing for enhanced safety and communication

The explicit documentation of a medication's clinical indication offers significant patient safety benefits. It directly links the medication to its purpose, improving prescribing appropriateness, reducing errors (for example, wrong-patient or wrong-drug errors stemming from name confusion if indication is present), and enhancing communication among the multidisciplinary team and with patients. EP systems can facilitate this through features like selection from lists, pre-defined order sentences, or prompts for indication. Addressing barriers like time constraints or long drop-down lists is crucial for successful adoption.

Address system complexity, interoperability, and vendor relationships

Hospitals often face challenges with the diversity of EP systems, including standalone systems, modules within integrated systems, and functionalities spread over several modules. The use of multiple EP systems within a single hospital – often not strategically planned – can lead to issues related to access, staff training, workflow, work duplication, and system interfacing.

Fragmentation of patient documentation due to disparate systems is a major patient safety concern. Many systems available in the UK originated overseas, posing problems due to differing workflows and medicine practices, leading to a protracted implementation process and continuous system redevelopment efforts. Vendor–client relationships and internal governance play a crucial role in managing system modifications.

While extensive customisation can meet local needs, it can lead to individual sites bearing greater responsibility for training and potentially missing vendor updates. There is increasing caution regarding extensive customisation, favouring standardisation and leveraging networks of users. The lack of agreed national guidelines has resulted in diverse procurement strategies and ad-hoc vendor responses. The use of hybrid systems (paper and electronic, or multiple electronic systems in different units) is a contributing factor to technology-related errors. Understanding these complexities is vital for effective system deployment and long-term sustainability.

Effectiveness and cost effectiveness

Electronic prescribing with clinical decision support significantly enhances prescribing accuracy and patient safety, reducing medication errors and adverse drug events by up to 92%. These improvements translate into measurable clinical and economic benefits, including reduced hospital admissions, shorter lengths of stay, and fewer litigation risks.

Cost-effectiveness is maximised when systems are locally optimised, target high-risk areas, and integrate pharmacists into workflows.

However, poor usability, alert fatigue, and inadequate configuration can undermine value. Strategic implementation, continuous refinement, and advanced CDS features – such as indication-based prescribing – are essential to ensure both clinical impact and return on investment.

The following section contains **8 learning points.**

Electronic prescribing with clinical decision support significantly enhances prescribing accuracy and patient safety, reducing medication errors and adverse drug events by up to

92%

Learning points

Improving patient safety by reducing medication errors and adverse drug events

The evidence consistently demonstrates that the implementation of EP systems, particularly when integrated with robust CDS, leads to a statistically significant decrease in medication errors and ADEs. Pooled studies in inpatient settings show relative risk reductions ranging from 54% to 92% for medication errors and 35% to 53% for ADEs.

This is a core objective of EP and its consistent achievement across various settings, including intensive care units and emergency departments, underpins the continued drive for widespread adoption and now optimisation. The shift from paper-based prescribing to electronic systems inherently addresses issues like illegibility, transcription errors, and missing information – leading to more complete and standardised orders.

Alert fatigue is a threat to patient safety

Despite the proven benefits, a critical and recurring challenge is alert fatigue. Clinicians override (click past) drug alerts as frequently as 49–96% of the time. This phenomenon stems from an excessive generation of alerts, many of which are irrelevant or lack specificity. Low positive predictive value of alerts, often between 20% and 40%, means many warnings are false positives, leading prescribers to disregard both important and unimportant alerts.

Optimising alert relevance, severity, and clinical evidence strength is crucial to improve acceptance. Strategies must focus on refining the knowledge base to generate fewer, more relevant alerts, potentially by incorporating patient-specific characteristics and providing explicit recommendations or alternatives.

Local system configuration and ongoing optimisation

The effectiveness of an EP system is not solely dependent on the software itself but critically on how it is implemented and continuously optimised within a specific clinical environment. Studies highlight considerable variability in system performance, even between different hospitals using the same commercial system – attributed to disparate local configuration decisions. Simply acquiring an advanced system is insufficient – dedicated time and expertise are required for tailoring CDS functionality, selecting which errors to target with alerts, and determining the appropriate level of alert interruptions. A thoughtful approach to implementation (particularly of CDS capabilities), mindful of alert fatigue, is beneficial.

Integrating clinical decision support for high-risk areas

Targeted CDS interventions in specific high-risk clinical areas have demonstrated notable success. For instance:

- Systems supporting antimicrobial stewardship have been shown to reduce inappropriate antibiotic prescriptions and consumption and improve compliance with guidelines.
- CDS for renal dosing adjustments significantly improves appropriate prescribing for patients with kidney impairment, particularly for new prescriptions.

These successes highlight the value of focusing CDS on specific clinical problems where the risk of harm is high and the benefit of precise guidance is clear.

Clinical pharmacists maximise EP safety and effectiveness

Pharmacy professionals play a pivotal role in identifying and preventing medication errors – which is significantly enhanced when their knowledge is combined with CDS tools. Their expertise is crucial in developing recommendations for dosage adjustments, validating prescriptions, and providing direct feedback to prescribers. The sources suggest that active involvement of the pharmacy team can improve compliance with CDS recommendations and reduce inappropriate drug dosages. Furthermore, pharmacists contribute to the design and implementation of these systems, increasing their performance and reliability. This collaborative approach – integrating clinical pharmacy with EP – is essential for achieving optimal medication safety.

Unintended consequences of EP systems

While EP systems significantly reduce traditional prescribing errors, their implementation is not without potential downsides. New error types can emerge, such as duplicate prescriptions, erroneous selections from drop-down menus, or misinterpretations of on-screen text. Issues related to the process of entering and retrieving information, and fragmentation of displays, can also lead to communication and coordination errors. Therefore, ongoing 'technovigilance' and monitoring of local patient safety incidents are vital to identify and mitigate these novel risks post-implementation.

The importance of usability and workflow integration for user adoption and system effectiveness

The success of EP systems hinges on their usability and seamless integration into clinical workflows. Poor usability leads to workarounds, alert overrides, and diminished effectiveness. Clinicians prioritise aspects like clear presentation of information, easy navigation, and elimination of unnecessary clicks or complex calculations. Involving healthcare professionals – particularly clinicians – in the design process is paramount to ensure the system aligns with their workflow and encourages utilisation. When systems create additional work or clash with existing practices, compliance and accuracy can suffer.

The potential of advanced CDS features such as indication-based prescribing

The summary from the literature suggests that beyond basic DDI or allergy alerts, more sophisticated CDS functionalities offer new avenues for improvement. Indication-based prescribing (where medications and doses are explicitly linked to the treated condition) has demonstrated reductions in prescribing errors and improved efficiency and user satisfaction in simulated environments. 'Look-back' alerts, which monitor changes in parameters (such as renal function) for patients already on medications, represent another advanced feature – although they may have less impact than prospective alerts at the time of initial prescribing. Many of these so-called 'advanced' CDS functions are now commonplace in many systems, and developments are now focusing on using holistic patient factors to drive decisions about optimal treatment and care – often using approaches driven by artificial intelligence (AI).

Workforce and culture

The published literature on this topic points to the profound influence of organisational and workforce culture on the optimisation of electronic prescribing technologies.

Professional identities, inter-professional hierarchies, and fear of litigation can create significant barriers – leading to resistance or the development of workarounds. Successful optimisation necessitates sustained user engagement, strong and supportive leadership, and clear communication of the system's benefits.

Addressing workflow misalignments, ensuring adequate training, and incorporating continuous feedback are vital. Recognising these systems as profound socio-technical transformations allows for iterative design and adaptation, moving beyond initial implementation to truly embed the technology and realise its full potential.

Standardise where possible, customise when necessary.

The following section contains **10 learning points.**

Learning points

Prioritise ongoing comprehensive user engagement and feedback

It is crucial to involve end-users (clinicians, nurses, pharmacists, and administrative staff) throughout the system lifecycle – from the conceptualisation and design phases through to ongoing optimisation. Merely soliciting feedback post-implementation is insufficient – continuous, iterative engagement helps identify nuanced workflow variations, user needs, and potential pain points early, to foster acceptance and reduce resistance.

Without this deep involvement, systems risk being perceived as inadequate, leading to disengagement and the development of unsanctioned workarounds, which can undermine safety benefits. User-centred design is not a one-off event but an ongoing process that is critical for tailoring systems to specific contexts and enhancing their perceived value. Studies consistently show that collaborative efforts with end-users lead to more usable and widely adopted systems.

Mitigate clinician burden through system usability, efficiency, and information quality

Clinicians consistently rank the usefulness, relevance, ease of use, and efficiency of a system as primary determinants of its acceptance. Systems that are difficult to navigate, time-consuming, or rigid often lead to frustration, decreased productivity, and resistance. Poor usability directly contributes to clinician burden and can exacerbate burnout.

Conversely, systems that offer streamlined workflows, reduce clicks, provide clear and concise information, and are intuitively designed are highly valued. The presentation of information, including screen layout, density, and the visibility and placement of alerts, significantly impacts how users perceive and interact with the system. Investing in user interface (UI) design, based on user input and human factors principles, is crucial for system adoption and safety.

Ensure robust training and sustained support beyond go-live

Initial training sessions, often conducted at the point of implementation, are frequently deemed inadequate by users. A common theme across successful implementations is the provision of intensive, ‘at the elbow’ support during and immediately after the system’s launch. This hands-on, real-time assistance allows the implementation team to directly observe what is and is not working well – enabling rapid adjustments and addressing immediate user queries. Beyond the initial phase, continuous training and ongoing support are essential to develop user competencies, address changes in software or clinical practice, and prevent skill deterioration as users become overly reliant on the technology. The lack of sustained training can lead to suboptimal system use and increased risk of errors.

Embrace customisation and configuration while balancing standardisation and workflow integration

While commercial, off-the-shelf systems offer benefits, they often require significant customisation and configuration to align with local workflows, national requirements, specific patient populations, and clinical policies. A ‘one-size-fits-all’ approach to EP is largely ineffective. Tailoring system features, such as order sets, to match local guidelines and interdisciplinary workflows is vital to avoid workarounds and ensure clinical relevance.

However, over-customisation can introduce complexity, hinder future updates from vendors, and complicate central governance. The ‘sweet spot’ lies in strategically balancing customisation with the benefits of standardisation, often achieved through close collaboration with vendors and learning from other users. Seamless integration of the system into optimised clinical workflows is a critical success factor.

Cultivate strong organisational leadership and a culture of trust and collaboration

Successful EP implementation and ongoing optimisation is not merely a technical project but a significant organisational change that requires robust leadership and a supportive culture. Top-level commitment from both administrative and clinical leaders is mandatory, providing moral and financial support. A high level of trust between administration and clinicians is essential, alongside open communication channels and a readiness to implement.

Collaborative project management, involving multidisciplinary teams of clinicians, leaders, and IT staff, is a consistent theme in successful organisations. Fostering a common vocabulary and ensuring respectful treatment among team members can significantly enhance collaboration.

Use continuous evaluation and learning mechanisms post-implementation

EP implementation is an ongoing, iterative effort rather than a finite project. Continuous improvement depends on robust mechanisms for collecting user feedback and modifying the system accordingly. Organisations must be capable of learning from their ongoing experiences, identifying unintended consequences, and adapting strategies over time. Metrics for measuring success in various areas – including patient safety, efficiency, and user satisfaction – should be established and regularly reviewed. This iterative process – often spanning years – is crucial for realising the full benefits of complex health information technologies.

Ensure information quality and clinical relevance of decision support alerts

The effectiveness of CDS, particularly alerts, hinges on their quality, relevance, and clinical utility. Irrelevant, redundant, or excessive alerts are a significant cause of alert fatigue, leading to clinicians overriding or ignoring critical warnings, thereby negating safety benefits. Alerts must be patient-specific, timely, concise, and provide clear, actionable recommendations or justifications. Trust in the CDS is directly correlated with the accuracy and reliability of the information it provides. Designers must understand clinicians' decision-making processes to develop alerts that truly support workflow, rather than interrupt it.

Recognise and address the impact on professional identity and autonomy

Clinicians can perceive EP as a threat to their professional control, autonomy, and established skills – which can lead to significant resistance and impede adoption. Some clinicians may view the system as being used 'against them' in medico-legal contexts or as an encroachment on their clinical judgment. Effective implementation strategies must acknowledge these concerns and actively involve healthcare professionals in the design and decision-making process to mitigate perceived threats and enhance their sense of professional identity and ownership. Framing the system as a supportive tool that complements their expertise, rather than replacing it, can improve acceptance. As the workforce becomes more technologically capable and experienced and the system matures, threats to professional identity have become less of a concern.

Acknowledge and proactively manage the complex change processes involved

Implementing and optimisation of EP is far more than a technical upgrade – it's a profound socio-technical and cultural transformation within the organisation. The introduction of these systems triggers wide-ranging changes – not just in individual practice but across entire organisational structures and interdisciplinary interactions.

Policymakers and implementers must adopt a holistic view, understanding the breadth and depth of these interconnected changes, and design strategies that explicitly address these complex processes. Anticipating difficulties and skilfully managing the organisational upheaval from the outset, with a recognition that the process is ongoing and transformative, is key to smooth implementation and realising benefits.

Leverage the evolving role of pharmacists

Pharmacists play a vital role in enhancing medication safety and optimising EP and CDS systems. Their expertise is crucial for medication reconciliation, assessing the clinical importance and relevance of DDI alerts, and identifying potential discrepancies between CDS recommendations and clinical practice. Pharmacists can contribute significantly to improving data completeness and accuracy within the electronic health record (EHR). Their involvement in system design and continuous feedback loops can ensure that decision support is clinically meaningful and tailored to practical medication management – bridging gaps between system logic and real-world clinical scenarios. Many organisations are investing in specific pharmacy informaticists to lead system optimisation relating to medicines and beyond.

Integration

Both the integration and the interoperability of electronic prescribing systems present challenges for system optimisation, including ineffective information transfer and increased user workload, requiring robust governance and infrastructure to support data sharing.

Achieving optimal EP systems often requires a blended approach, balancing the benefits and drawbacks of both integration and interfacing to ensure safe, efficient, and continuous patient care across various settings.

The following section contains **7 learning points.**

Learning points

Prioritising patient safety as the core driver and outcome

The fundamental motivation for implementing EP systems, and most profound benefit, is the enhancement of patient safety and reduction of medication errors. These systems improve legibility by eliminating handwritten prescriptions, provide vital audit trails of medication-related activities, and offer CDS at the point of care to prevent adverse drug events. However, it is crucial to recognise that poorly implemented systems – particularly those lacking integration – can introduce new safety risks. These risks can include fragmented patient records, reliance on assumptions about decision support, and the creation of workarounds.

The importance of interoperability and seamless integration

Achieving the full benefits of EP systems hinges on their seamless integration and interoperability with other hospital systems, such as EHRs, laboratory data, imaging systems, and even external systems like primary care records. The prevalence of multiple, disparate EP systems within single hospital organisations leads to fragmentation of the patient's journey, workflow inefficiencies, and significant safety concerns due to miscommunication and missing information.

Robust strategic planning and coherent governance frameworks

The successful adoption and scaling of EP systems necessitates clear strategic planning and strong governance at national, regional, and organisational levels. Lack of organisational IT planning, fragmented adoption models (organisation-led, clinician-led, clinical network-led), and insufficient involvement of IT departments in strategic choices can lead to a proliferation of disparate systems and hinder effective integration and optimisation.

Demonstrating a clear value proposition

For clinicians to adopt and consistently use EP systems, they must perceive a tangible value or relative advantage compared to traditional methods. This value can manifest as enhanced ability to work effectively or efficiently, improved workflow, time savings, or contributions to positive patient outcomes. If the system is not seen as useful or fails to deliver a clear benefit, its acceptance will be low.

Navigating the tension between customisation and standardisation

A key challenge lies in balancing the desire for systems to be flexible and customised to meet local clinical and specialty-specific needs (for example, personalised order sets and clinical pathways) with the overarching requirement for standardisation to ensure interoperability and coordinated care across different organisations and settings. While beneficial for usability, localised innovation risks increasingly divergent systems if not managed within a broader standardisation framework.

Ensuring high data quality and standardisation

The effective functioning of CDS and seamless information exchange is critically dependent on standardised documentation and a common, consistent vocabulary across systems. The reliance on free-text entries and inconsistent data formats significantly hinders the ability to reliably distil and interpret information for decision support – leading to potential miscommunications and errors.

Access to patient medication histories and clinical information is essential to prevent prescribing errors – particularly for complex patients

A significant contributor to prescribing errors, even with EP, is the unavailability or inaccessibility of a complete and accurate medication history, especially during out-of-hours periods or upon hospital admission. Difficulties in sharing information between hospital and primary care sectors, outdated discharge summaries, and lack of access to essential laboratory results can lead to inappropriate prescribing decisions, medication omissions, or incorrect dosing. This underscores the critical need for seamless interoperability between different digital systems and improved information transfer to ensure continuity of care.

Workarounds and unintended consequences

Electronic prescribing systems are lauded as core building blocks for safer healthcare, with potential to significantly reduce errors and improve efficiency.

However, the literature consistently highlights numerous unintended consequences that can impede their success and even introduce new risks. Workarounds are informal deviations from intended work processes, often employed to overcome obstacles or perceived EP system shortcomings.

While sometimes used to maintain workflow or address immediate problems, workarounds can bypass safety features, introduce new risks, generate errors (such as juxtaposition errors), and create communication gaps or inefficiencies. Their persistence highlights a mismatch between system design and clinical workflow – demanding careful optimisation.

The following section contains **10 learning points.**

Learning points

The pervasiveness and risks of workarounds

Clinicians frequently resort to workarounds – both informal and formal – to navigate perceived system deficiencies, usability issues, and legitimate clinical workflow. An example is using free-text fields for medication information. These workarounds are particularly concerning as they often bypass crucial built-in safety features including decision support, allergy alerts, and medication interaction checks.

This leads to communication gaps, inefficiency (for example, in real-time information transfer), and a significant increase in the risk of medication errors – including duplicate prescriptions, discrepancies, and omitted or extra doses, especially with high-risk medications like opioids or heparins. It is crucial to identify, understand the root causes of, and then remediate these workarounds.

Impact on interdisciplinary communication and coordination

A major unintended consequence is the reduction in face-to-face communication and an 'illusion of communication' – where staff mistakenly assume electronic documentation is sufficient without verbal follow-up. This breakdown in communication – especially between doctors and nurses – directly contributes to delayed medicine initiation and execution, misinterpretations, and an increased likelihood of errors.

Systems can enable prescribers to enter orders remotely, without direct coordination with nursing staff at the patient's bedside – exacerbating these issues. Proactive strategies, including education on effective communication and reinforcing direct verbal exchanges for critical orders, are essential.

Alert fatigue undermining clinical decision support effectiveness

Excessive and poorly designed CDS alerts lead to alert fatigue. This can cause clinicians to override or disregard warnings, thereby negating the intended safety benefits of EP systems. Many alerts are perceived as inconsequential, non-specific, or lacking patient-specific context.

To improve their efficacy, CDS alerts must be highly relevant, specific, and prioritised to focus on critically important issues, with fewer, higher-quality warnings. Customisation, tiering by severity, and involving end-users in their design are recommended strategies.

Clinical workflow and workload impact

Far from simplifying work, EP implementations often introduce 'more work' or 'new work' – disrupting the established pace, sequencing, and dynamics of clinical activities. This can manifest as slow system response times, increased steps for non-standard cases, difficulties in task completion, and the necessity for staff (for example, nurses) to dedicate more time to system interactions rather than patient care. Addressing these workflow disruptions by balancing new work with system-based reductions in old work, and ensuring systems accommodate comprehensive workflows, is crucial for user adoption and ongoing functionality.

Perceived loss of professional autonomy and shifts in power structures

The introduction of EP systems – particularly those with mandatory data entry fields that enforce specific clinical practices – can reduce the autonomy traditionally cherished by clinicians. This can be because it limits their choices in ordering or forces compliance with guidelines they may not fully embrace. This often results in a shift of power towards administrative and information technology staff – creating discomfort among clinicians and blurring of role boundaries within the healthcare team. Recognising these shifts and involving clinicians in the system's design and customisation can help mitigate resistance and foster acceptance of consistent clinical workflows.

Continuous, user-specific education and training

User satisfaction, familiarity, and effective system utilisation are directly correlated. Initial training at the time of implementation is often insufficient, as system changes occur, and users' roles and experiences evolve. Ongoing, user-specific training sessions that address evolving functionalities, common pain points, and emphasise the rationale behind EP (such as patient safety goals) are vital. Training should also focus on appropriate diligence when using an EP system – not just on how to use it.

Usability and thoughtful system design

Poor usability – characterised by confusing interfaces, excessive navigation, long lists of options, inconsistent terminology, and small fonts – is a major barrier to successful EP integration and can actively contribute to errors. Systems that are not intuitive or that poorly reflect organisational policy and procedure lead to frustration, disuse, and the development of unsafe workarounds. Prioritising a user-centred design approach that ensures clarity, consistency, and a seamless fit with actual clinical practice is crucial for optimising safety and efficiency.

Emerging error types and the need for vigilance

While EP systems reduce traditional errors such as illegibility and transcription mistakes, they introduce new and unique risks that require ongoing attention. These subtle, often silent errors reflect a fundamental shift in clinical risk and underscore the continued need for vigilance – regardless of the system in use.

For example, EP systems tend to increase the prevalence of duplicate orders and selection errors. Duplicate orders often arise from the ease of generating repeat prescriptions or from system designs that fail to clearly display active medications. Selection errors – such as juxtaposition errors i.e., choosing the wrong item from a drop-down list or due to, for example, adjacency or inadvertent scrolling – are also common and can lead to prescribing the wrong drug, dose, or formulation.

These evolving error patterns highlight the importance of targeted system safeguards, including 'tall man lettering' to distinguish look-alike drug names, indication-based alerts, and improved interface design to reduce cognitive load and selection risk. Ultimately, while EP systems offer significant safety benefits, they also demand a reimagined approach to risk management and clinical oversight.

Adopting a sociotechnical approach with deep interdisciplinary involvement

EP systems are not merely technical tools – their success fundamentally depends on a harmonious interrelation or fit with the complex human and organisational aspects of healthcare work. Implementing these systems effectively requires active and sustained engagement from all relevant healthcare professionals (clinicians, nurses, pharmacists, and clerical staff) – not just in the initial design phase but throughout implementation and ongoing evaluation. This collaborative approach helps uncover and address issues from diverse perspectives, ensuring the system supports comprehensive, integrated workflows.

Optimisation is an ongoing, iterative, and adaptive process

Implementation of an EP system is the starting point, not the culmination, of its journey in a healthcare setting. There is a need for continuous monitoring, gathering of user feedback, and iterative refinement of both the system's functionalities (configuration and customisation) and the clinical workflows it supports. This adaptive approach is crucial to ensure the system evolves along with local needs, policies, and specialisation requirements, striving for an optimal balance between standardisation and local customisation. Over-customisation, however, carries risks related to training burden and missing out on vendor updates.

Governance and reporting

Effective governance and secondary use of data from electronic prescribing systems is pivotal for patient safety, quality improvement, and medication management.

Secondary uses of data should be considered at the point of system procurement and implemented at inception as it facilitates crucial functions like audits and risk management. Clear clinical and technical governance structures are essential for providing strategic oversight, defining clear responsibilities, and ensuring appropriate data usage. This encompasses establishing data quality standards, privacy policies, and security – while balancing customisation with standardisation for interoperability.

The following section contains **10 learning points.**

Learning points

Robust governance and comprehensive stakeholder engagement are essential

Effective implementation and ongoing optimisation of EP systems demand clear clinical and technical governance structures. This includes establishing high-level ownership – ideally with 'hands-on' involvement from senior hospital staff – to integrate EP as an essential component of the overall organisational information strategy. Multidisciplinary governance committees – comprising clinicians, pharmacists, nurse informaticists, and analysts – are vital for discussing and approving system changes such as alert modifications.

Furthermore, engaging all key stakeholders – from policymakers to frontline clinicians and even patients – is critical for ensuring user-centred design, addressing diverse perspectives, and building a shared vision. This should be done throughout the system's lifecycle – from design to implementation and ongoing review.

Secondary use of data is a powerful, under-utilised resource for quality improvement

EP and hospital pharmacy systems contain a potential wealth of medication-related data for secondary use. This data can be leveraged for numerous purposes, including audits, risk management, quality improvement projects, and performance benchmarking. It enables real-time monitoring of quality indicators, identification of process gaps, and evaluation of interventions at a scale impossible with paper records. However, extracting data can be a complex or tedious process, often requiring specialist informatics support, and vendors need to provide greater functionality to facilitate streamlined secondary use of data generation.

High-quality data, standardisation, and interoperability remain significant challenges

The full power of data from EP systems for secondary use is dependent on the quality, completeness, and consistency of the information input. Ambiguous phrasing in policies, verbal approvals without proper documentation, and a lack of required fields (such as indication for antibiotic use) can severely impede accurate data collection and analysis.

Moreover, national consensus on data standards, standardised terminology, and robust interoperability between different systems are crucial for effective data generation, exchange, and interpretation across various organisations and care settings. Relying on unstructured data like free-text fields or PDFs significantly hinders digital manipulation and seamless information flow.

When delivered effectively, targeted and personalised feedback can drive behaviour change

Provision of feedback is enhanced when recipients perceive the data as valid, credible, and timely, and when the feedback is personalised and sustained over time. While email feedback was found to have limited impact in some studies, in-person conversations about prescribing practices and policy requirements appeared to be much more effective in improving awareness and understanding. Clarity and tailoring feedback to individual cases are also crucial for its perceived helpfulness.

Alert fatigue and balancing automation with clinical autonomy remain significant challenges

Over-reliance on interruptive CDS alerts can lead to alert fatigue and clinician burnout, resulting in a high rate of alerts being overridden or ignored. This undermines the intended benefits of CDS. To mitigate this, CDS design must strike a balance between clinical autonomy and innovation, considering technical, organisational, system, and social factors. Critically, alerts need to be tailored to the right person with the right information at the right time in workflow to maximise utilisation and effectiveness, as demonstrated by resident-driven improvements.

Organisational capacity and digital health literacy are critical enablers

Many healthcare organisations – particularly smaller ones – often lack the necessary IT resources, financial investment, and skilled personnel to consistently support high-quality CDS and effective data management. There is a recognised need to develop digital health literacy as an essential skillset for healthcare professionals, integrating it into medical and nursing education and continuous professional development. Equipping the clinical workforce with this dual clinical and digital skillset is vital for navigating increasingly digitised workflows.

Procurement processes and vendor relationships require significant improvement and centralised guidance

Hospitals frequently face challenges during the procurement of EP systems – including inadequate assessment of their own needs, rushed processes, and ambiguities in contracting – which can lead to strained relationships with vendors. Vendors themselves highlight that hospitals often lack expertise in negotiating large-scale IT contracts. A degree of centralisation in procurement guidance and a more formalised framework with value-based product specifications are suggested to overcome these issues and foster more synergistic, collaborative working relationships between providers and vendors.

Understanding human factors and the role of accountability in culture change is key

Successful interventions acknowledge the 'social complexities' of information and communication technologies in healthcare organisations. Improvement initiatives must consider human factors that influence user behaviour, addressing challenges such as suggestions that the 'computer is always right'. Approaches that emphasise personal accountability alongside systemic improvements can drive cultural shift - for example, making omitted medicines unacceptable.

Continuous monitoring, iterative evaluation, and organisational learning are imperative for sustained improvement

The implementation of EP systems and associated interventions is an iterative process that requires ongoing monitoring and evaluation to assess their impact on clinician behaviour and patient outcomes. Automated monitoring of system usage (for example, rule firings, user responses to alerts) provides continuous feedback to guide necessary changes and additions. Organisations must learn from both successes and unintended consequences – such as alert fatigue or focusing too narrowly on measurable indicators at the expense of other important safety aspects.

Standardised evaluation tools and shared learning across sites are crucial for advancing EP safety

The significant variations in study designs, outcome measures, and reporting observed in the literature limit the ability to compare the effectiveness of different EP systems or interventions. The development and wider adoption of standardised tools, such as the ePRaSE tool and IMPACT indicators, are vital for objective, comparative data collection on clinically important errors. They enable national benchmarking and shared learning opportunities – across trusts and even internationally.

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Clinical decision support

CDS Strategy

An effective clinical decision support strategy centres on delivering timely, relevant, and actionable guidance to prescribers while minimising alert fatigue.

Key components include prioritising high-risk prescribing scenarios, tailoring alerts to patient-specific factors, and integrating decision support seamlessly into clinical workflows.

Governance structures must oversee the CDS strategy, including use of alerts, maintenance and performance, supported by multidisciplinary collaboration and user feedback. Advanced features like indication-based prescribing and passive alerts enhance usability and reduce disruption. Strategic focus on high-volume alerts and standardised terminology further improves system efficiency.

The following section contains **15 learning points.**

Ultimately, a well-designed CDS strategy enhances safety, supports clinical decision-making, and delivers measurable value across healthcare settings.

Learning points

Prioritise alert fatigue mitigation

Alert fatigue, resulting from the excessive presentation of alerts, remains the primary reason for clinicians overriding computerised alerts – sometimes at rates as high as 95%. This phenomenon significantly limits the potential benefit of CDS systems in enhancing medication safety and reducing errors.

The core principle for optimising these systems is 'the fewer alerts the better', as an overload can lead to alerts being unread or overridden out of habit, irrespective of their clinical significance. Strategies must therefore focus on reducing the volume of alerts to ensure that critical warnings are not missed. This includes careful selection of which alerts to retain – such as allergy and intolerance alerts, which are consistently rated as highly useful by prescribers.

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95%

Enhancing efficacy with alert usability and design

The design and presentation of alerts significantly influence their acceptance and impact. Suboptimal design – including inappropriate content, excessive text, and poor visibility – can render alerts ineffective.

Effective design principles include:

- **Concise and actionable text:** Alert text should be short, to-the-point, and clearly indicate the problem and required actions.
- **Visual distinctions:** Ensure appropriate contrast, positioning, colours (for example, red, orange, yellow), and icons (for example, stop octagon, triangle) to distinguish between alert types and severity levels, making them easily noticeable.
- **Information placement:** Present critical information directly on the primary alert interface, with options for on-demand access to more detailed background or evidence via embedded links.
- **Workflow integration:** Alerts should appear at the most opportune moment in the workflow to support decision-making, ideally before the clinician has progressed too far down an erroneous prescribing path.
- **Intelligent corrective actions:** Systems should offer intelligent, corrective actions that automatically facilitate appropriate changes – reducing manual effort for the user.

Implementing robust governance and continuous maintenance

The effectiveness of CDS alerts is heavily reliant on a well-defined governance process for their selection, optimisation, and ongoing maintenance. This involves a multidisciplinary committee, often including pharmacists and doctors, to regularly review alert logs and decision rules. Without such a structure, alerts can quickly become outdated, irrelevant, or misconfigured – leading to nuisance alerts and user frustration. The process should encompass setting clear criteria for inclusion/exclusion, validating content against clinical evidence, and adapting to new drugs, guidelines, and workflow changes.

Emphasising multidisciplinary collaboration and user feedback

The development and optimisation of CDS alerts benefit immensely from the involvement of diverse stakeholders, including prescribers, pharmacists, clinical information system staff, and human factors experts. User feedback, whether formal (for example, surveys, interviews, feedback links) or informal, is critical for identifying specific problem areas and discussing constructive solutions. This collaborative approach ensures that alerts are not only technically sound but also align with clinical workflows and user expectations – fostering trust and acceptance.

Leveraging 'soft' decision support and optimised workflow integration

Not all decision support needs to be interruptive. Passive or 'soft' alerts, presented as non-interruptive messages, hyperlinks, or integrated 'on-demand' information, can provide valuable guidance without contributing to alert fatigue.

The effective placement of an alert within the clinician's workflow is paramount – for instance, venous thromboembolism assessments were more likely to be acted upon when presented during non-ward round prescribing activities, aligning with the actual workflow for these tasks. Utilising pre-written order sets can also reduce the need for alerts by guiding appropriate prescribing choices from the outset.

Standardisation of terminology and knowledge base content

Inconsistent terminology across medication knowledge bases and lack of standardisation in how information is presented pose significant challenges. This makes it difficult to consistently display critical information to clinicians who may work across multiple systems. Recommendations include consistent use of terminology for medicines, severity of potential harms, clinical effects, mechanisms, and recommended actions – alongside clear and consistent visual cues and formatting.

Defining and measuring alert effectiveness beyond override rates

While alert override rates are commonly reported, they are often an insufficient measure of alert effectiveness. Clinicians may override alerts for various reasons, including irrelevance – rather than making a conscious decision to proceed with a potentially harmful order.

A more comprehensive evaluation of alert effectiveness requires looking at:

- **Clinical outcomes:** Assessing the impact on actual medication errors, adverse drug events, and patient outcomes.
- **Acceptance rates:** Measuring the proportion of alerts that lead to a beneficial change in prescribing behaviour.
- **Reasons for overrides:** Collecting and analysing override reasons to identify systematic issues with alert design or appropriateness.
- **Workflow impact:** Evaluating the time spent managing alerts and their integration into clinical workflow.

Analytical systems and dashboards can provide a more accurate understanding of prescriber behaviour and interactions with CDS.

Optimising alert content and clinical relevance through contextualisation

Alerts must be highly specific and clinically relevant to the patient's context to be effective and accepted. Factors such as the patient's clinical status, age, weight, renal function, co-morbidities, and recent laboratory values are crucial for tailoring alerts and filtering out irrelevant ones. For instance, dose adjustments for renal function should be dynamic – suggesting discontinuation or therapeutic alternatives when appropriate. Context-aware alerts significantly reduce the number of irrelevant warnings, improving perceived usefulness.

The clinical necessity and up-to-date logic of each alert must be continuously assessed by subject matter experts.

Prioritise high-volume alerts for improvement

Given the substantial effort involved in reviewing and refining CDS alerts, a strategic approach is to first target the highest-volume interruptive alerts within the system. A Pareto analysis often reveals that a small number of alerts account for a very large proportion of total alert firings (for example, top 25 alerts accounting for 90% of volume). Prioritising these 'heavy hitters' could yield the largest potential impact on reducing overall alert burden and improving system usability for a wider range of clinicians.

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The impact of standardisation of high-risk medication practices on electronic prescribing systems

Beyond system design, specific clinical practice changes can synergistically improve safety within EP environments. The adoption of standard concentration infusions in paediatric intensive care, facilitated by smart-pump technology and electronic ordering, was associated with significant reductions in infusion-related prescribing errors.

This demonstrates that standardising high-risk medication practices, especially those involving complex calculations or multiple manipulations, can be a powerful strategy for error reduction. This learning point suggests that alongside technological interventions, re-engineering clinical processes themselves is crucial for maximising patient safety.

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Enhance data integration and contextual presentation for maximising CDS benefit

The effectiveness of CDS is significantly amplified when it integrates various patient-specific data, such as laboratory findings, medical history, and concomitant medication orders, and presents this information contextually to assist clinical decision-making.

Horizon scanning and continuous improvement

Optimisation of EP systems should include horizon scanning to identify the research and innovation opportunities that have the potential to transform and positively impact patient care.

Due to the dynamic nature of digital health technologies, continuous research and adaptation are key to ensuring long-term effectiveness and safety. Despite considerable research, there remain significant knowledge gaps regarding the optimal design and implementation of CDS alerts.

Addressing potential prescribing omissions

Current computerised interventions, as identified in systematic reviews, have predominantly focused on identifying and reducing potentially inappropriate medications, which generally result from over-prescribing or inappropriate drug choices. However, there is a clear absence of computerised interventions designed to identify and prompt for potential prescribing omissions – instances where older patients could benefit from additional, clinically indicated medications but are not receiving them.

Addressing medication underuse is equally important for optimising care for multimorbid older adults. Systems should strive to target both potentially inappropriate medications and potential prescribing omissions, integrating criteria such as the Screening Tool to Alert doctors to Right Treatment (START) to promote comprehensive medication optimisation.

Paediatric prescribing

Paediatric prescribing presents distinct challenges, including the constant need for weight- and surface area-based dosing, complex unit conversions, and rapid physiological changes. Dosing errors are particularly common and high-risk in this population. Effective EP for paediatric patients must include sufficiently flexible, weight-based dose calculators (including appropriate dose rounding), continuous adaptation for weight changes, and robust dose range checks to mitigate these specific risks.

Continuous monitoring and dynamic reassessment

Patient conditions, especially in cases like kidney disease, are dynamic. Traditional static assessments of renal function are often insufficient. Dynamic re-assessment is crucial for managing complex patients with multimorbidity and changing physiological states, ensuring that medication regimens remain appropriate throughout the patient's care trajectory.

CDS Categories

This section provides a summary of learning points regarding the design, implementation, and optimisation of clinical decision support arranged into specific categories.

The information is presented as ‘hints and tips’ to provide practical insights to support optimisation activities.

The following section contains **12 learning points.**

Learning points

Drug and patient age

Enforcing appropriate dosing and identifying unsuitable medications based on age-related physiological vulnerabilities to prevent prescribing errors. Especially critical for paediatric and elderly populations.

1. **Dose calculation and validation based on age-related metrics:** CDS must incorporate age-based parameters (and related patient characteristics such as weight and organ function) into dose calculation and validation logic. This is critically important for preventing prescribing errors, especially in complex areas like paediatrics, where dose errors can result from failures in human–computer interaction.
2. **Customisation and specialisation of CDS for age groups:** Rule sets, alert thresholds, and alert volume must be customised for specific age groups (for example, elderly, paediatric) to ensure clinical relevance. For example, the use of specialised clinical guidelines (such as STOPP/START) within CDS is valuable for managing polypharmacy and potentially inappropriate medication in older patients.
3. **Avoidance of age-specific error mechanisms:** Different pathways should be available to mitigate the risk of adult dosing being used for paediatric patients.

Drug allergy

Alerting prescribers to known patient allergies to prevent adverse drug reactions.

1. **Comprehensive and accurate allergy data:** Accurate and standardised documentation of allergies and drug sensitivities is essential for safe CDS. The effectiveness of drug allergy checking is highly dependent on the quality and completeness of allergy information in the electronic health record (EHR). Efforts are needed to ensure patient allergy lists are accurate, are enforced for real-time documentation, and are maintained with consistent coding.
2. **Mandatory prompts and structured processes** for updating allergy records are crucial, particularly when medications are discontinued due to allergic reactions and drug sensitivities.
3. **Manage alert fatigue:** Drug allergy alerts are a significant contributor to alert fatigue, with high override rates. Strategies to address this, such as improved specificity and contextualisation, are crucial.
4. **Consistent and clear presentation:** Alerts must clearly indicate the level of severity and provide non-ambiguous information.
5. **Tailored alerts:** Alerts should be tailored to individual patients and users, taking the patient's specific circumstances into account.
6. **Use of free-text:** Free-text entry hampers system interoperability and CDS effectiveness, highlighting the need for standardised terminology and structured documentation.

Drug brand and look-alike, sound-alike (LASA) drug names

Eliminating confusion between drug names that look or sound similar to prevent potential prescribing errors.

1. **Proactive prevention in pick lists:** Items in drug selection lists, especially medications, must be clearly distinguishable to minimise misreading of look-alike and sound-alike drug names.
2. **Visual differentiation:** Employing visual cues such as 'tall man' lettering (for example, predniSONE and prednisoLONE) can make similar drug names more visually distinct.
3. **Standardisation of abbreviations:** Avoid using abbreviations that can be easily confused (for example, IU and IV) in system displays or small fonts.
4. **Operational LASA alerting:** Relevant LASA warning capabilities should be operational in EP systems, targeting frequently confused drug pairs.
5. **Indication-based prescribing:** Incorporating the 'indication for use' as part of medication orders can help prevent drug name errors (for example, prescribing penicillin for bacterial infection versus penicillamine for rheumatoid arthritis).

Drug–disease contraindication

Prevent the prescribing of medications that are contraindicated or pose a high risk, given a patient's existing medical conditions.

1. **Contextualised patient data:** Alerts for drug–disease contraindications require accurate and up-to-date patient data, including diagnoses and co-morbidities. Displaying relevant patient information directly on order screens enhances clinical context.
2. **Prominent but unambiguous warnings:** While drug–disease warnings should be prominent, their wording must be clear and avoid confusion with other warnings, especially regarding severity levels. If not carefully designed, the way these warnings are displayed can contribute to alert fatigue.
3. **Integration with problem lists:** Organisation of orders by clinical problem or goal can make drug–disease alerts more relevant and intuitive within the workflow.
4. **Variable alert generation:** There is wide variability in how different EP systems generate these alerts, depending on system configuration and the rules embedded. Trigger rules should be regularly reviewed to maintain specificity and relevance.

Drug duplication (same drug)

Preventing accidental re-ordering of the same medication for a patient, which can lead to overdose.

1. **Timely duplicate checking:** Lack of timely duplicate checking, particularly when a new dose of the same medication is ordered, when the same medication is ordered in a different form, or when a medication previously prescribed by another clinician is re-ordered, can result in duplicate medication orders.
2. **Visualisation of current medication:** A suboptimal display of a patient's current medications can create uncertainty for prescribers, increasing the likelihood of overdoses or drug–drug interactions. Fragmented or multi-screen displays that prevent a complete view of a patient's medication record contribute to this risk. Clinicians should be kept aware of existing orders through clear visualisation of previously carried out orders and ordering steps, ideally on a single screen.
3. **Order sets as checklists:** Order sets can function as checklists for the completeness of a clinical intervention, helping to prevent omission or duplication of orders.

Drug dose

Ensuring patients receive appropriate medication doses to prevent both sub-therapeutic dosing and toxicity.

1. **Automated dose range checking:** EP systems could incorporate decision support for sensible dosing, including algorithms to check prescribed doses against recommended ranges.
2. **Weight-based and patient-specific dosing:** Systems must effectively support weight-based dosing/rounding – especially in paediatrics – and provide appropriate dosing based on formulation and patient characteristics (such as kidney and liver function, gender, and age).
3. **Transparent calculation facilities:** While automated dose calculation facilities are beneficial, their algorithmic basis should be transparent. If the reasoning is unclear, users may resort to manual calculations to validate the system – complicating interaction.
4. **Accurate documentation and defaults:** Pre-written orders can guide clinicians towards appropriate doses by pre-populating recommended values. However, inaccurate documentation of dose and frequency (even when mandated) can occur if prescribers prioritise other tasks, or if the system design is poor. Default settings in order sets should be carefully considered, as they influence cognitive workload and safety.

Drug frequency

Ensuring medications are administered at the correct intervals to maintain therapeutic levels and prevent harm.

1. **Pre-populated and recommended values:** As with dose, pre-written orders that pre-populate recommended frequencies can guide prescribers towards appropriate selections during the ordering process. Highlighting recommended frequencies can positively influence ordering behaviour.
2. **Clarity and context in administration:** Nurses can be confused by exact administration times being displayed (for example, for Parkinson's medications) without clues about their criticality, highlighting the need for clear visual cues and communication of the prescriber's intention.
3. **Proximity warnings:** Systems should provide information when dosing frequency may be higher or lower than recommended – for example, when a dose is given late in relation to a subsequent dose or a stat dose is given without consideration of the scheduled dose time.

Drug and laboratory data

Facilitating dynamic medication monitoring and safe dose adjustment based on the patient's current physiological status.

1. **Integration of relevant patient data and context:** CDS must retrieve and display relevant patient-specific laboratory and demographic information (for example, kidney or liver function, therapeutic drug monitoring) directly within the ordering workflow or alert screen to provide essential clinical context. This contextualisation is crucial for making drug monitoring, dosing advice, and consequent orders (for example, ordering necessary follow-up tests) credible and actionable, fostering clinician trust. Design must account for missing or erroneous data (for example, prompting for weight if absent) to prevent incorrect calculations and ensure safe function.
2. **Corollary laboratory orders:** CDS should support the multidisciplinary aspects of medication monitoring by capturing the clinical context and status of patient monitoring. This includes providing prompts for necessary consequent orders (for example, subsequent lab tests).

Drug route

Ensuring medications are administered via the intended and safest route.

1. **Minimise selection errors:** Ambiguous or closely proximate selection items for drug routes in drop-down lists can lead to selection errors. Proximity of selection items on the screen, for instance for order routes, may cause juxtaposition errors.
2. **Clear visual cues:** In multiple selection menus, visual cues should consistently indicate that multiple selections are allowed. Enough space between selectable items is important to prevent accidental selection of undesired options.
3. **Standardised terminology:** Use of consistent terminology for drug routes across the system helps to minimise errors of misidentification and delays in interpretation.
4. **Minimise available routes:** Hard coding certain drug forms to drug routes may avoid incorrect selection. However, certain nuanced situations in clinical practice should be considered (for example, avoiding the ability to give oral medication intravenously, while recognising that intravenous medication is sometimes given orally).

Drugs and pregnancy or the potential for pregnancy

Preventing medications being given which have the potential for significant harm to both the expectant mother and foetus.

1. **Integrating mandatory, high-priority safety checks:** Incorporate mandatory checking of pregnancy status or potential status (based on demographics or history) to trigger alerts for contraindicated medications. This safety check must be integrated seamlessly into the order entry workflow to deliver support at the point of decision-making. Given the severity of potential harm, hard stops or stringent approval requirements are necessary for drugs with known absolute contraindications during pregnancy.
2. **Integrating patient-specific and contextual data:** It is anticipated that effective CDS for pregnant patients would demand dynamic, patient-specific information to enable personalised risk assessment. EP systems could then integrate relevant demographic and clinical data from electronic medical records, such as real-time pathology results (for example, renal function, which can fluctuate in pregnancy), and comprehensive comorbidity lists. Incorporating 'clearance-modifying drug interactions' and quantitative information on drug combinations can further personalise risk identification and alerts. Such adaptability may prove helpful for guiding appropriate medication adjustments throughout the various stages of gestation and post-partum.
3. **Comprehensive targeting of high-risk prescribing scenarios relevant to pregnancy:** EP systems must be configured to identify and flag pertinent high-risk prescribing errors that extend beyond simple teratogenicity to include potential drug allergies, drug–drug interactions (DDIs), and drug–disease contraindications where pregnancy is a key factor. Furthermore, systems should address incorrect dosing (accounting for physiological changes in pregnancy), omission errors of essential pregnancy-related medications, and inadvertent therapeutic duplication. The implementation of 'indications-based prescribing' has the potential to prevent such errors by ensuring medications are prescribed for appropriate, documented indications.

Therapeutic duplications (same class, different drug)

Preventing concurrent prescribing of multiple medications from the same therapeutic class without appropriate clinical justification, which can increase the risk of adverse effects.

1. **Ingredient and class checking:** Effective duplicate checking should extend beyond drug names to include ingredient and drug class checking – especially for combination drugs.
2. **Specificity of warnings:** Systems should provide warnings for individual drug duplicates versus class duplicates, as there are situations where two drugs from the same class may be appropriately prescribed concurrently.
3. **Address alert fatigue:** Therapeutic duplication alerts, if non-specific, can contribute to alert fatigue. It is crucial to filter and contextualise these alerts based on patient needs and clinical context.

Drug omission

Reducing the risk of medication being erroneously omitted at the point of prescribing.

1. **Leveraging order sets and prescribing defaults to enforce inclusion:** A mechanism against drug omission is the use of comprehensive order sets where orders (for example, prophylaxis, ancillary care) are set as defaults.
2. **Designing order sets for efficiency and clinical fit:** Order sets should be designed based on evidence and clinical workflow to ensure they match current usage and minimise cognitive workload. Complex order sets that incorporate medicines, monitoring, and appropriately timed laboratory tests are viewed as more efficient and result in higher rates of positive outcomes compared to simple order sets – encouraging higher uptake and reducing the need for ad hoc ordering which risks omission. Conversely, removing potentially harmful options from templates actively discourages omission of safer alternatives.
3. **Integrating checklists and mandatory documentation fields:** To minimise omission errors, CDS functionalities (such as documentation templates or automated forms) should serve as explicit checklists to guide systematic consideration of all necessary components of care. Mandatory fields within EP systems can reinforce policies and guidelines to ensure essential patient safety-related documentation is completed – a significant benefit over paper-based systems. However, mandatory fields must be implemented judiciously, as they can lead to prescribers using workarounds or entering inaccurate information if the field's purpose is unclear or if completing it would be time-consuming.
4. **Providing contextual reminders for ongoing monitoring and follow-up:** To prevent omission of necessary actions related to long-term care, CDS should incorporate timely reminders for critical non-prescribing tasks. This includes prompting – for example, periodic laboratory tests that are essential for safe therapeutic monitoring. In order to be effective, decision support must be delivered at the optimal time and place within the clinical workflow.
5. **Transfer of care omissions:** It is hoped that making use of shared, interoperable, comprehensive medication information will reduce the risk of omission and other errors when care is transferred.

Drug–drug interactions

Drug–drug interactions pose a considerable patient safety concern. These interactions are highly prevalent, particularly in hospital inpatients receiving polypharmacy, and can culminate in serious adverse drug events.

CDS is designed to mitigate these risks. The collective insights from the literature in this section underscore the complex interplay between system design, clinical workflow, patient safety, and **the crucial need for ongoing refinement of DDI alerts.**

The narrative is consistent – while DDI alerts are fundamental to patient safety in EP systems, their implementation often leads to alert fatigue.

The following section contains **9 learning points.**

Effective DDI management requires patient-specific, clinically relevant alerts to enhance safety and reduce the alert burden.

Learning points

Alert fatigue is a critical patient safety issue, driven by excessive, non-specific alerts

This is the most consistently articulated problem across the literature. Clinicians – including prescribers and pharmacists – are overwhelmed by the sheer volume of DDI alerts, leading to desensitisation and a high propensity to override them, often without proper consideration. This significantly diminishes the potential patient safety benefits of CDS, as clinically relevant alerts may be ignored amidst the 'noise'. The problem is so widespread that override rates consistently exceed 90% in many settings.

Contextualisation and patient-specificity can enhance the relevance of DDI alerts and minimise alert fatigue

Making alerts more intelligent and patient-specific is the most effective way to combat alert fatigue. Incorporating clinical context such as laboratory values, concomitant medications, patient demographics (for example, age, renal/hepatic impairment), administration times, and workflow considerations can drastically reduce the number of irrelevant alerts. Studies demonstrate significant improvements in positive predictive value and reductions in alert burden when alerts are contextually aware – leading to more appropriate interventions.

Variation in commercial DDI knowledge bases and alerting practices undermines standardisation and effectiveness

There are substantial differences in the content, size, and severity classifications across commercial DDI knowledge bases, as well as in how healthcare organisations implement and configure DDI alerts within their EHR/EP systems. This lack of standardisation means that even high-priority DDI lists are not consistently implemented across institutions or EHR vendors, leading to inconsistent patient safety protection. Such variations necessitate careful local review and customisation – a resource-intensive task.

Multidisciplinary collaboration and ongoing governance are key for effective DDI alert optimisation

Successful DDI alert refinement and management require continuous input and consensus from an interdisciplinary team, including pharmacists, prescribers (clinicians, nurse practitioners), and IT specialists. This collaborative approach is vital for evaluating alert relevance, refining rules, and ensuring local applicability, given the unique patient populations and treatment guidelines of different institutions. A national consensus panel with centralised oversight has been recommended to develop and maintain a standard set of DDIs.

Many potential DDI triggering alerts are not clinically relevant

A critical finding suggests that current DDI alerts often flag interactions that, while 'potential', do not pose a clinically relevant risk or lead to actual harm in the patient's specific context.

One study found that only 27% of identified potential DDIs were clinically relevant, and actual harm was rare (<1% of patients experiencing probable/certain harm). This highlights a fundamental disconnect between system-generated alerts and true clinical risk – questioning the value of broadly implemented DDI alerts without sufficient contextual filtering.

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Alert refinement strategies can significantly reduce alert burden and improve acceptance

Empirical studies have shown that systematically suppressing low-value alerts and implementing contextually aware filtering can substantially decrease the number of interruptive DDI alerts (reductions ranging from 40% to 93%). While these efforts increase alert acceptance rates, the overall acceptance still often remains low – indicating that volume reduction alone is insufficient.

Current alert metrics provide limited insight into clinical value and appropriateness

Simply tracking alert frequency and override rates is insufficient to understand the true clinical utility or appropriateness of DDI alerts. More sophisticated metrics and clinician feedback are needed to truly evaluate the quality and value of alerts.

Optimising DDI alerts requires significant time, expertise, and financial investment

The development, implementation, configuration, and ongoing maintenance of effective, context-aware DDI alerting systems are resource-intensive endeavours. This includes the time invested by pharmacists, informaticians, and other clinical experts in evaluating DDIs, building rules, and training staff. The return on investment for such efforts, while ultimately beneficial for patient safety, may be long-term.

Defining and standardising high-priority or contraindicated DDIs remains a challenge

Despite attempts to establish lists of ‘high-priority’ DDIs that should always trigger an alert, there is no universally accepted standard. The term ‘contraindicated’ itself is inconsistently used and should be reserved only for drug pairs where co-administration is strictly prohibited under any circumstances. This lack of clarity further contributes to the difficulty of developing effective and trust-worthy alerting systems.

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High-risk therapeutic areas

This section synthesises learning points from the literature regarding specific therapeutic areas (like drugs and drug classes) that can cause high risk medication harms.

The following section contains **5 learning points.**

Learning points

Valproate: Mandatory and robust reproductive risk mitigation

The prescribing of valproate to patients of childbearing age is an extremely high-risk scenario requiring specific and effective mitigation within EP systems. This reflects the severe teratogenic risks associated with valproate exposure during pregnancy, which can lead to serious congenital malformations and neurodevelopmental disorders.

The system should ideally flag the patient's reproductive status and enforce a 'hard stop' or require a documented override rationale – this in the context of a shared decision-making process with the patient regarding the risks and benefits, and alternative treatment options.

Where possible, this should be linked to educational resources or consultation requirements and reflect any national risk minimisation schemes in place through regulation, such as the UK annual risk acknowledgement form.

Insulin: Effective CDS for safe and effective therapy management

As insulin prescribing errors can have immediate and severe patient consequences, the integration of robust CDS and well-designed EP functionality is paramount to enhancing patient safety in this complex therapeutic area.

Effective CDS for insulin prescribing must go beyond basic alerts, be highly sophisticated and context-aware. Key features include standardised naming, dose range checks, calculators for weight-based adjustments, timing-specific alerts that consider a patient's nutritional intake, and integration with real-time physiological data.

Standardised insulin order sets are also key features that can contribute to a reduction in prescribing errors, improve glycaemic control and processes of care. Order sets should incorporate mechanisms to account for nutritional intake and individual patient requirements and have the flexibility to ensure seamless transitions between various insulin regimens (for example, from intravenous infusion to subcutaneous doses).

The integration of glycaemic monitoring and comprehensive review tools within the EP workflow provides clinicians with timely access to glycaemic control information and other pertinent data, to facilitate safe and informed clinical decision-making.

Methotrexate: Safe dosing

Methotrexate is an immunosuppressant, normally administered once a week. Critical errors occur when it is prescribed and administered more frequently. EP systems must follow national safety regulations, encourage safe prescribing practices, and prompt for necessary safety checks for this high-risk medicine.

This mandates robust CDS that makes the once-weekly administration unequivocally clear and difficult to change. EP systems should, at minimum, present 'once weekly' as the primary or default option for oral methotrexate and implement 'hard stops' if an alternative, unsafe frequency (for example, daily) is attempted. They should require selection of a specific day of administration and integrate this information within the medication administration record. The oral route should be clearly visible.

To ensure critical DDIs are prevented (for example, with trimethoprim), alerts should be 'hard stops' or, at the very least, 'interruptive alerts' that require explicit acknowledgment and justification before proceeding.

Anticoagulants: An holistic approach to optimise safety

Anticoagulants are high-risk medicines due to their narrow therapeutic index and the severe consequences of dosing errors and/or unintended omission leading to life-threatening bleeding or thrombotic events.

Effective CDS should focus on avoiding duplicate prescriptions, optimising dosing (for example, computerised advice on drug dosage), and integrating patient-specific information such as pathology results and renal/hepatic impairment to tailor recommendations and alerts.

Implementation of standardised order sets and protocols is fundamental for safe anticoagulant prescribing and helps to reduce errors and ensure consistency. These sets should be regularly reviewed and improved based on feedback and user experience.

The integration of robust data monitoring and analysis within EP systems helps detect risks, guides targeted interventions and ensures adherence to clinical protocols through real-time and retrospective review.

Examples include:

- Monitoring the incidence and duration of anticoagulant duplications and assessing the impact of interventions.
- Identifying patients at risk of medication-related harm (for example, those with renal impairment).
- Real-time versus asynchronous monitoring – which detects patients in need of drug monitoring outside the immediate prescribing encounter and thereby improves adherence to monitoring protocols.

Opioids: Stewardship and well-designed CDS for patient safety

Opioids are high-risk medicines due to their potential for causing severe harm, including life-threatening adverse drug events.

To mitigate these risks, effective CDS strategies should include:

- DDI management that reliably alerts prescribers to significant interactions, particularly with other opioids, benzodiazepines, and anticonvulsants, using evidence-based recommendations and clinical severity data.
- Prevention of therapeutic duplication to warn against duplicate opioid prescriptions, utilising a tiered alert system based on morphine milligram equivalents (MMEs) to reduce overdose risk. For example, non-interruptive alerts below 50 MMEs and interruptive alerts above this threshold.
- Personalised, context-aware support that accounts for patient-specific factors such as renal function.
- Strategies to reduce incorrect selection of strength.

Antimicrobial stewardship

The sources in this section collectively examine the implementation and effectiveness of clinical decision support in the context of antimicrobial stewardship. Benefits include improving appropriate antibiotic prescribing, reducing therapy duration, and lowering costs, while challenges include barriers to adoption, such as alert fatigue, lack of user trust, and poor system usability.

The evidence highlights various methodologies for evaluating these systems, including usability testing, pre-post interventional studies, and systematic reviews. User-centred design and iterative development are essential to ensure successful integration and impact on patient outcomes.

The following section contains **8 learning points.**

Learning points

Multidisciplinary collaboration is foundational for effective development and implementation

The successful design and implementation of sophisticated EP and CDS tools for AMS necessitates a robust multidisciplinary team. This team must bring together IT specialists with development expertise, alongside infectious diseases clinicians, pharmacists, nurses, and microbiologists who understand 'real-life' clinical processes.

Clear communication among all stakeholders from the outset is vital. Their combined expertise is essential for identifying key stewardship priorities, translating complex clinical guidelines into functional algorithms, and anticipating potential challenges during implementation. Without this integrated approach, systems may not adequately meet the nuanced needs of clinical practice, as highlighted by experiences where a lack of stakeholder involvement led to systems with limited practical utility.

Harnessing data for enhanced surveillance and feedback is crucial

EP systems are invaluable sources of routinely collected data that can underpin effective AMS programmes through enhanced surveillance, audit, and feedback mechanisms. The ability to extract and analyse this data in a timely manner allows for the monitoring of antimicrobial usage, assessing compliance with guidelines, and identifying areas for improvement.

However, the full potential of EHR data for AMS remains underexploited due to significant challenges in data extraction, accuracy, completeness, and the complexity of integrating data from diverse systems. Establishing clear reporting mechanisms – such as automated daily reports of antimicrobial use or positive culture alerts – is essential for optimising AMS team efficiency.

EP systems are invaluable sources of routinely collected data that can underpin effective AMS programmes through enhanced surveillance, audit, and feedback mechanisms.

Utilisation of data requires standardised terminologies and structured data entry

The utility of data derived from EP systems for AMS is significantly enhanced by the consistent use of standardised terminologies and structured data entry. Actions such as limiting free-text fields and promoting the selection of indications from pre-defined lists drastically improves the quality of data for subsequent analysis and the generation of accurate alerts.

While some users may initially find pre-defined lists restrictive, studies suggest that an outcome can be achieved where the advantages for data analysis outweigh the perceived effort of structured input. This structured data is fundamental for comprehensive reporting, benchmarking, and the development of more sophisticated CDS functionalities.

Interventions should be multifaceted and seamlessly integrated into workflow

Relying solely on technological solutions, such as alerts or order sets, often proves insufficient to drive significant behavioural change in antimicrobial prescribing. The most effective AMS interventions are typically multifaceted – combining technology with other strategies such as education, regular audit and feedback, and direct person-to-person interactions.

Interventions should be designed to optimise clinical workflows. For instance, a system that reorganises relevant clinical information to facilitate post-prescription review, supported by references and severity scores for prioritisation, has demonstrated sustained positive impact on antimicrobial use.

Ensure consistency between hospital policy and system functionality

Discrepancies between hospital antimicrobial policies and the logic embedded within CDS can lead to confusion, undermine trust, and reduce compliance. It is essential that all information presented to prescribers, whether through formal policies, computerised alerts, or pre-written orders, is consistent and up to date. Regular review and synchronisation of decision support content with evolving hospital guidelines are vital to ensure prescribers receive accurate and coherent guidance – thereby improving adherence to local AMS policies.

Automatic stop functions and timely review prompts are effective tools

Features such as ‘antibiotic time-out’ alerts or ‘IV to oral switch reminders’, which prompt clinicians to reassess empiric antimicrobial orders after a set period (for example, 48–72 hours), are valuable components of EP systems for AMS. These functionalities can enforce compliance with policy, reduce inappropriate prolonged therapy, and promote timely review of prescriptions, ultimately contributing to a reduction in the overall duration of antimicrobial therapy and associated costs. Their presence can significantly improve adherence to institutional performance measures for antimicrobial management; however, the risk of inappropriate cessation should be mitigated.

Continuous evaluation and adaptability

EP and CDS are not static deployments. Specifically in the context of AMS, they require ongoing validation, maintenance, and adaptation. This includes continuous surveillance to ensure the system functions as expected, addressing newly identified usability problems, and updating the knowledge base to reflect the latest clinical evidence and guidelines. The environment and clinical context are dynamic, and systems must evolve to remain relevant and effective. Flexibility in system design, allowing for adjustments to specific conditions and patient cases, and the provision of mechanisms for user feedback, are key to this continuous improvement cycle.

The environment and clinical context are dynamic, and systems must evolve to remain relevant and effective.

EP and CDS demonstrate tangible positive impacts on clinical and economic outcomes

Despite implementation challenges, numerous studies provide strong evidence that well-designed and properly implemented EP and CDS interventions can significantly improve critical clinical and economic outcomes. The benefits include increased rates of appropriate antibiotic therapy, reductions in all-cause mortality, decreased overall volume of antibiotic use, shorter lengths of hospital stay, and lower antimicrobial expenditures. These tangible benefits underscore the strategic importance of investing in and optimising these systems as core components of modern AMS programmes.

AI and machine learning

The integration of artificial intelligence and machine learning into electronic health records and electronic prescribing systems has driven a significant evolution in the landscape of medication safety.

Medication-related problems remain a leading cause of patient harm. While advances in EHR and EP with clinical decision support (CDS) have reduced prescription errors and improved outcomes, their effectiveness is often limited by problems of usability, perceived usefulness, relevance, and efficiency.

Alert fatigue is a persistent challenge with traditional, rule-based CDS – particularly for drug–drug interactions (DDIs). Clinicians are often overwhelmed by excessive and clinically unimportant alerts, leading to high override rates and the potential to miss critical warnings. This issue is exacerbated by low specificity and sensitivity of DDI software, and the resource-intensive nature of establishing and maintaining customised DDI lists – especially for smaller hospitals.

Critically, even with activation of alerts for high-severity DDIs, high override rates persist. Studies have shown that these alerts may reduce potential DDIs but not necessarily those which are clinically relevant. This highlights that a blanket approach to alerts, without tailoring, can increase cognitive burden with limited patient safety benefits.

In response, AI and machine learning are gaining interest as a solution to alert fatigue and to enhance medication-related CDS. Unlike traditional rule-based CDS, which relies on clinical guidelines or human expertise, AI generates recommendations and predictions from machine learning, neural networks, or statistical analysis. These systems can harness large datasets from patient health records to recognise patterns and provide more personalised recommendations.

Opportunities for AI in medication safety include:

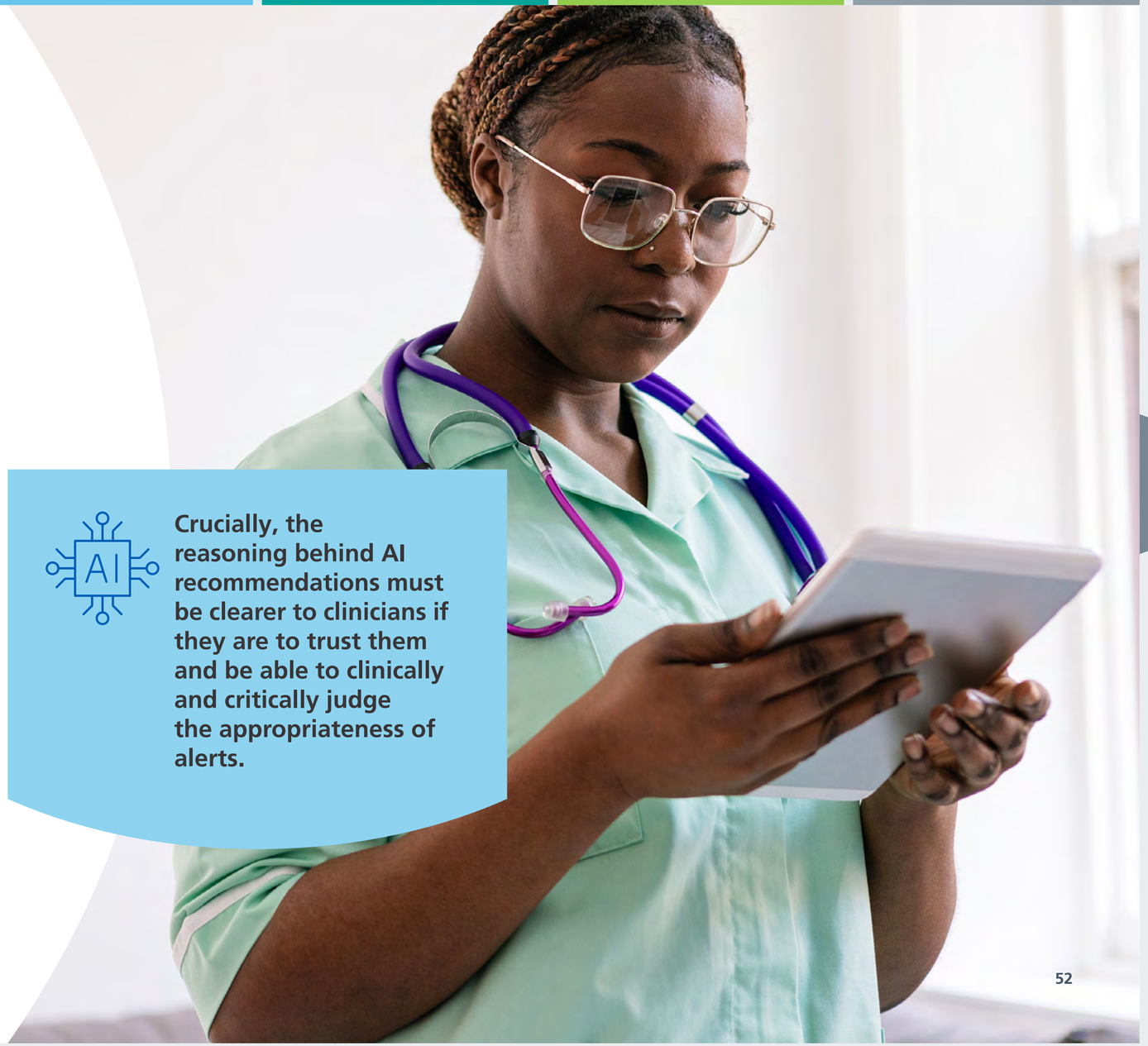
- Identifying and preventing prescription errors
- Improving alert relevance by predicting prescriber responses or prioritising prescription checks
- Enhancing the detection of medication problems, such as adverse drug events requiring clinical intervention
- Supporting ‘pharmacovigilance’ by identifying previously unknown DDIs or predicting hazardous drug combinations
- Optimising drug dosing and predicting therapeutic response.

Continues on next page.

Despite this promising potential, several challenges hinder the widespread adoption and successful implementation of AI-based CDS. There is a noted lack of real-world evaluation and generalisability in existing studies. Sociotechnical factors are crucial, with barriers including a lack of perceived usefulness, relevance, ease of use, and efficiency. Concerns also arise regarding data quality and availability, trust, and transparency, particularly due to the 'black box' nature of many AI algorithms (meaning their decision-making processes are not clear to users). Regulatory and ethical issues, along with system maintenance, also present significant hurdles.

Future evaluations must thoroughly consider contextual factors such as clinical specialty, patient-specific information, and user expertise. They must also clearly report on the characteristics of training data to allow healthcare teams to judge its relevance to their own populations. Crucially, the reasoning behind AI recommendations must be clearer to clinicians if they are to trust them and be able to clinically and critically judge the appropriateness of alerts.

AI has transformative potential to enhance medication-related CDS by providing accurate and relevant recommendations and managing data effectively. However, successful implementation and scalability require comprehensive evaluation that considers not only the accuracy and validity of these tools – but also the critical sociotechnical factors influencing their adoption in clinical practice.



Crucially, the reasoning behind AI recommendations must be clearer to clinicians if they are to trust them and be able to clinically and critically judge the appropriateness of alerts.

Key principles

The following ‘golden thread’ learning points are derived from the most prevalent insights featuring consistently throughout the literature and across each of the themes identified.

Alert fatigue

Alert fatigue is a major threat to patient safety in electronic prescribing, arising when clinicians are overwhelmed by excessive, irrelevant, or poorly timed alerts, which may not only relate to medicines.

Alerts that are generic, too inclusive (for example, broad drug class cross-reactivity), or presented without sufficient context are prime contributors to this problem. This leads to high override rates – often exceeding 90% – and increases the risk of missing critical warnings.

Alerts must be patient-specific, accurate, and relevant to the immediate clinical situation, and should use consistent terminology and visual cues (such as colour-coding) to cultivate trust and ensure they are heeded. This requires integrating a wider variety of information sources (such as laboratory and pharmacy data) into decision rules. The ability to customise alerts based on institutional policies, user roles (for example, pharmacists or clinicians), and patient characteristics can also reduce alert fatigue. Alerts should be presented at the appropriate time and location in the workflow, avoiding early or late interruptions that lead to annoyance and overriding. The display should be concise, unambiguous, graphically strong, and should group related information in a clear way.

The consensus among experts is to introduce alerts highly selectively, focusing on important clinical challenges and high-risk medications or patient populations. Systems need sophisticated mechanisms to manage and filter knowledge bases effectively. Customisation of alerts, context-awareness, and clear, actionable recommendations improve usability. Another approach is to provide justification and alternatives – alerts should not merely stop the workflow but offer explanations for the warning, suggest alternative actions, and provide direct links to carry them out. This promotes informed decision-making rather than simple compliance.

Regular analysis of performance logs, override rates, and user feedback is essential to identify frequently overridden alerts, refine trigger rules, and suppress ‘false positives’. Refinement of alert rules focusing on high-value alerts can reduce unnecessary interruptions – the guiding principle is the fewer alerts, the better.

Alerts should be presented at the appropriate time and location in the workflow, avoiding early or late interruptions that lead to annoyance and overriding.

Focusing on high-value alerts can reduce unnecessary interruptions – the guiding principle is the fewer alerts, the better.

User-centred design and usability

User-centred design is crucial for successful system integration in clinical settings – focusing on ease of use, efficiency, and seamless workflow integration.

Poor usability – resulting from problems such as confusing interfaces, excessive navigation, and inconsistent terminology – can hinder adoption, increase errors, and lead to unsafe workarounds.

Clinicians value systems that are intuitive, reduce cognitive burden, present information clearly, and streamline workflows. Investment in effective user interface design and thoughtful alert presentation enhances system acceptance, safety, and efficiency.

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Stakeholder engagement and multidisciplinary approach

Effective EP system implementation and ongoing optimisation rely on early and continuous involvement of multidisciplinary stakeholders – including clinicians, IT specialists, administrative leaders, and patients.

Collaborative governance structures and clear leadership ensure systems align with optimal clinical workflows and address user needs, fostering ownership and reducing resistance.

User-centred, iterative design and feedback – from conceptualisation through to refinement – are crucial for ongoing system adoption and safety. Ultimately, **strong communication and collaboration among all stakeholders is essential** for successful and sustainable EP utilisation.

Training

Effective system adoption relies on comprehensive and ongoing user training, continuous education on updates, and role-specific sessions.

All training material developed must be readily accessible for end-users to maximise engagement. ‘At the elbow’ support during implementation is essential, enabling immediate problem-solving and adaptation.

Without sustained training, user discomfort and errors increase, and bad habits and unhelpful workarounds can creep in. Additionally, providing personalised, credible, and timely feedback – especially through in-person discussions – is more effective than generic communication.

Continuous evaluation and optimisation

Effective implementation of EP is an ongoing process that extends well beyond initial deployment. Continuous optimisation, monitoring, and adaptation to clinical needs are essential.

There should be robust mechanisms for technical support, user training, gathering feedback, and iterative refinement to address usability issues and evolving requirements. Local configuration plays a critical role, with success hinging on careful tailoring and regular evaluation of system performance and alert strategies.

To identify problems such as unintended consequences, promote or ensure patient safety and optimise the clinical environment, there is a need for ongoing audit.

Ultimately, the value of EP depends as much on sustained, responsive improvement as on the initial technology itself.

Data quality and standardisation

A fragmented digital health landscape with poor data standardisation and limited interoperability restricts effective data use for audit, research, and population health management.

High-quality, standardised, and structured clinical data – enabled by consistent terminology and reduced free-text entry – is essential for reliable clinical decision support, safety, accurate reporting, information sharing and robust secondary uses.

Seamless integration and information exchange across healthcare systems are critical to avoid errors, ensure continuity of care, and fully realise the value of digital health technologies.

Workflow transformation and optimisation

EP systems should enhance clinical workflows rather than hinder them. Poorly designed systems can lead to inefficiencies, extra work, and workarounds that may compromise patient safety and documentation.

Effective EP solutions can transform and optimise clinical workflows, deliver decision support at the right time and place, and are tailored to local needs while balancing customisation and standardisation. Clinicians' involvement in and ownership of system design is critical to ensure usability and clear presentation of information, and to minimise disruption and enhance overall acceptance.

Not all decision support needs to be interruptive – passive alerts and pre-written order sets can guide prescribing without causing alert fatigue. For example, the most successful antimicrobial stewardship interventions combine technology with education and feedback – optimising both clinical behaviour and workflow.

Case studies

The impact of an electronic prescribing system on anticoagulation management

Read more about key topics linked to this case study:

- Anticoagulants CDS
- Implementing EP systems

Background

In 2023, a new electronic prescribing system was installed at Maidstone and Tunbridge Wells NHS Trust – enabling the switch from paper to digital processes.

It was envisaged that the EP system would improve risk management post-implementation, but instead an increase in safety incidents were experienced – particularly relating to the treatment of venous thromboembolism (VTE).

Prior to the switch, the VTE risk assessment (RA) and anticoagulant thromboprophylaxis prescriptions were integrated. The new digital system separated these components, and access to the separate risk assessment documents was obscured by numerous other documents within the system. This separation led to an increase in incidents including failure to complete the VTE RA, missed doses, and duplicate anticoagulant prescriptions.

Action

It was recognised that planning to support a change in behaviours and processes could have been improved. The team implemented several key strategies to address these issues:

- **Collaborative approach:** Developed a steering group involving senior medical staff, patient safety leads, nurses, pharmacists and digital analysts to ensure a multiprofessional approach to system optimisation.
- **Risk assessment integration:** Ensured that risk assessments were completed in a timely manner by blocking prescribers from placing new medication orders without completing the risk assessment within 12 hours. A prompt was added after 24 hours to ensure the risk assessment was repeated.
- **Streamlined prescribing process:** Reduced the number of clicks required to prescribe VTE prophylaxis from 11 to 4, which made the process more efficient and user-friendly.
- **System configuration:** Configured the system to include a dedicated ‘omission’ information order for when VTE prophylaxis is NOT required. Developed a summary page to reconnect the VTE RA with the anticoagulant prescription so that all relevant information was in one place – improving clinical oversight.

Impact

The implementation of these strategies had a significant impact:

- **Improved compliance:** The completion rate of VTE RA on admission increased to 96%, ensuring timely and accurate assessments.
- **Enhanced efficiency:** The streamlined prescribing process reduced the number of clicks required, making it easier for prescribers to complete their tasks and reducing the likelihood of errors.
- **Collaborative success:** The multiprofessional approach ensured that all relevant stakeholders were involved in the process, leading to better outcomes and increased buy-in from staff.
- **Comprehensive oversight:** The summary page provided a single view of all relevant information, improving clinical oversight and reducing the need to search through multiple documents.

The project began with the mandatory VTE RA rollout in November 2024, with the improved summary view developed for go-live in May 2025. Further developments will include alignment with updated anticoagulant guidelines.

Overall, the transition to the EP, coupled with the strategic actions described above has significantly improved the safety and efficiency of the prescribing process. It has also addressed the initial challenges and lead to better patient outcomes.

Perceived benefits of EP	Lived experience of EP, including opportunities for optimisation
Real-time access	• Enables remote review and monitoring • No 'lost' drug charts • Worklist manager can be viewed by multiple people
Clinical decision support	• Although limited, too many alerts • Clinicians experience alert fatigue
Legibility	• Eliminates handwriting errors (for example: poor handwriting, missing frequency)
Audit trail	• Enhances traceability and accountability
Improved prescribing	• Drug catalogue • Order sets (for example: anticipatory meds Rx, cost-saving switch prompt) • Standardised prescriptions (for example: phosphate polyfuser)
Medicines administration	• Takes longer to complete a drug round • Missed doses • Harder to view
Integration	• Expensive / data not yet standardized
Business intelligence / data	• Requires highly-skilled personnel to create reports (rate limiting)

Leads: Katy Allen, Principal Pharmacist: Electronic Prescribing and Medicines Administration (ePMA) Clinical Safety Officer and Johanna Kelly, Chief Nursing Information Officer – both at Maidstone and Tunbridge Wells NHS Trust.

Improving insulin prescribing

Read more about key topics linked to this case study:

- Insulin CDS
- Networks and vendor relationships

Background

In 2020, the Pharmacy directorate and the Diabetes and Endocrinology directorate at Gateshead Health NHS Foundation Trust initiated efforts to improve insulin prescribing.

This was in response to general concerns highlighted in the NHS Get It Right First Time for Diabetes report (2020) and the National Diabetes Inpatient Audit (2019) which revealed that insulin prescribing was suboptimal nationwide, with two-fifths of inpatient drug charts for insulin-treated patients containing errors.

The complexity of insulin prescribing poses significant challenges for electronic prescribing systems. Systems/configuration may lack the functionality to support adjustable insulin doses, the prescribing of insulin pumps, and the ability to undertake asymmetric prescribing of insulin (such as different AM and PM doses), leading to a potential increased risk of errors.

Action

The team implemented several internal changes to enhance consistency and safety in insulin prescribing, including:

- Conducting a comprehensive review of the insulin build on the EP system.
- Establishing a standard naming system that matched drug storage cabinets, to rearrange the selection list on the prescribing system and including adjusted defaults to remove ‘1 unit’ as the default dose.
- Introducing a standardised process for insulin prescribing on admission and medication reconciliation.
- De-prioritising insulins not frequently used in the drug files.
- Removing alerts for all insulins and replacing them with tailored alerts for high-strength and bovine and porcine insulins at the point of prescribing (but only for the initial prescription and not for amendments).

Despite these improvements, further enhancement was needed. The team collaborated with multiple trusts using the same EP system – to share ideas, protocols, and workarounds.

A national working group was formed in collaboration with the EP system supplier with an aim to improve essential insulin prescribing through improving ‘off the shelf’ EP system functionality.

Through this forum, specific improvements to functionality were discussed which supported the development of a new module for insulin prescribing, designed to overcome some of the issues identified.

Impact

- Benefits were realised from both the in-house developments completed at trust level and following collaborative supplier developments.
- Meeting with suppliers and trusts helped develop a shared understanding of clinical need.
- The collaborative approach with trusts and suppliers has enabled a similar approach for other high-risk medications.

Lead: Claire Davies, Diabetes and Endocrinology Specialist Pharmacist, Gateshead Health NHS Foundation Trust.

Using ePRaSE to support EP system optimisation

Read more about key topics linked to this case study:

- Evaluation tools
- Leadership and support

Background

In October 2022, United Lincolnshire Teaching Hospitals NHS Trust initiated the transition from paper-based prescribing to an electronic prescribing system for adult inpatient services.

Through ongoing and comprehensive, multidisciplinary stakeholder engagement, the Trust demonstrated a strong commitment to digital transformation and EP system optimisation.

Recognising its relatively low level of digital maturity initially, they adopted the ePRaSE tool to assess the impact of implementing new processes. This tool was instrumental in facilitating learning, identifying areas for improvement, and highlighting aspects that were working well. It also consolidated informal networks with other organisations undertaking similar changes and using the same EP system.

This collaborative approach helped to foster shared learning and build confidence among staff as the system was embedded.

Action

The rollout of the EP system at ULHT began within the cardiology department and was subsequently expanded across all clinical areas.

The Trust's Pharmacy team really helped with **system implementation and ongoing optimisation** by supporting with 'at the elbow' training of staff and consistently raising configuration queries where they arise.

The use of the ePRaSE tool served as a catalyst for valuable **internal discussions and conversations with other trusts.** Benchmarking data has helped facilitate these discussions.

Under the leadership of the Trust's Chief Clinical Information Officer, there was a strong push to ensure widespread and consistent adoption of EP throughout the organisation. There is **ongoing and proactive identification of issues** and delivery of improvements through Digital Transformation team input at various groups (safety, medicines optimisation, quality) and collaboration with the multidisciplinary team.

Examples of successful system improvements include warfarin prescribing and monitoring, variable rate insulin prescribing, and antimicrobial indication-based prescribing. To **support process standardisation**, a suite of templates was developed and, where identified, workarounds leading to unintended consequences (for example: during IV to oral switching) were actively investigated and resolved.

The team have also successfully implemented EP in the Emergency Department – one main benefit being the **seamless transfer of information** across departments.

Impact

Completing the ePRaSE tool and analysis of the results has opened up productive and valuable conversations internally and externally, both within existing and new networks. This learning has helped shape ULHT's EP system optimisation strategy.

The Digital Transformation team has strengthened the Trust's medicines safety agenda and identified and replaced outdated processes, contributing to more robust clinical workflows. Senior leadership support has been vital to this progress, as have inter-trust networks that continue to drive shared learning and improvement.

With improved digital maturity, ULHT is preparing to launch a combined EP and EPR system in September 2025. The Trust is now much better positioned to maintain safety and minimise risk.

Leads: Kyle Savage and Emily Marr – both Specialist Pharmacy Practitioners: Digital Transformation, Lincolnshire Community and Hospitals NHS Group.

Enhancing T2 and T3 prescribing with electronic prescribing

Read more about key topics linked to this case study:

- Workflow optimisation
- Vendor collaboration

Background

At Oxford Health NHS Foundation Trust, a project was completed to enhance the use of digital systems and support adherence to prescribing requirements for patients treated within mental health services.

Under the Mental Health Act (MHA) 1983, treatment for mental disorders must be formally authorised after three months of a patient's initial prescription, for individuals detained under section. This ensures that ongoing treatment is legally reviewed and appropriately consented to, in line with statutory requirements.

- If the patient is competent, has capacity, and consents to treatment – the responsible clinician completes statutory Form T2.
- If the patient lacks capacity, is not competent, or refuses treatment – a second opinion doctor is required to assess and authorise treatment via Form T3.
- Some exceptions apply, but compliance with this process is critical.

Historically there was a paper-based system for T2/T3 completion, but this was very onerous and had many associated risks such as forms going missing, or paperwork not checked and completed correctly. Additionally, issues were identified following the Care Quality Commission's Mental Health Reviews relating to drugs prescribed on drug charts not aligned with T2 and T3 forms, and the legal implications when treatment is given that is not included on the required forms.

Following the implementation of electronic prescribing in 2021, a project was developed to identify digital methods to enable the completion and update of T2 and T3 forms, plus the ability to update forms with any additional information to ensure compliance with legal requirements. There was also a focus to support prescribing clinicians to be able to readily access required information, streamline processes and work within the MHA requirements.

A pilot was launched in 2024 to test the new process and system developments.

Action

The team worked closely with the EP system supplier to develop a process to digitalise T2 and T3 forms. Different options were explored, with the final solution devising **a form that links into the clinical system and adds a flag to medications** to highlight if they are included on T2 and/or T3 documentation. This enables the nurses, doctors and pharmacists to easily identify any gaps, omissions or amendments that are required before prescribing or administering medications. There is a plan to set up the same system for Section 62 medications.

The flags enable a visual notification at the point of prescribing, highlighting that the drug prescribed is not included or varies from the patient's consent form. There are messages to advise the prescriber to reissue the T2 form, to complete a Section 62 form, or to refer the patient for further review. The prescriber must also confirm the legal reasons relating to care, this **encourages prescribers to stop and think before issuing prescriptions** and ensures legal compliance within the Mental Health Act.

The process has since been rolled out across the whole Trust following the success of the pilot.

Impact

- **Increased confidence:** Prescribing of medicines in this patient cohort is done correctly and in line with legislation.
- **Improved efficiency:** There is no need for repeated checking and searching for paper forms as the system clearly demonstrates status.
- **Streamlined processes:** Cancellation of prescriptions not included on the MHA assessments and automatic recording of this action.
- **Reduced errors:** Alerts highlight any potential errors before prescribing or dose changes to medicines.
- **Improved understanding:** The system supplier had a better understanding of UK legal and clinical implications and how their EP system design can effectively support these elements – particularly as this is their first installation in a mental health setting.
- **Improved results:** Testing on a pilot ward demonstrated 100% achievement in all measures audited apart from one standard which achieved 98% compliance. These results demonstrated significant improvements realised. Measures included availability of documentation on the ward and uploading of documentation onto the electronic health record.
- **Increased clinician awareness of legal requirements:** Clinicians were supported to understand which assessment form (T2 or T3) is required, there are checks to ensure patient consent, and if any further amendments to medication is required that needs approval from the consultant. Teams were equipped for digital success through e-learning, bite-size videos, and the option of face-to-face support.

Lead: Lex Moon, Digital Medicines Clinical Lead, Oxford Health NHS Foundation Trust.

Safer paediatric prescribing

Read more about key topics linked to this case study:

- Paediatric CDS
- Order-set optimisation
- 'Soft' CDS

Background

The medicines safety leads at Queen's Hospital Burton, University Hospitals of Derby and Burton NHS Foundation Trust, have provided ongoing support for electronic prescribing system optimisation since the local development of the medicines safety officer role.

One area of focus was configuring system set up to support with safer prescribing of paediatric medication regimes. The aim was to develop dosing sets for use in paediatric prescribing – enabling a proactive approach to minimise risks associated with certain high-risk drugs and support safe prescribing. The goal was to proactively reduce medication errors, especially with high-risk IV antibiotics and chronic condition treatments for asthma and diabetes.

Action

Working together with clinicians and specialists, actions were determined to develop rules-based processes to enable prescribing guidance via dosing sets, order sets, and safety alerts. This would help minimise prescribing errors, ensure safer use of medicines, and generally make the task of prescribing as easy as possible.

1. **Developing paediatric dosing sets**
   - **Drug selection and dose calculation:** Prescribers select the paediatric drug option line, and a dose based on age, and indication. The system uses the patient's recorded weight to automatically calculate the dose.
   - **Dose rounding and safety caps:** Doses are rounded to practical values (for example: 253mg becomes 250mg) to assist with administration of medication. As the majority of dosing sets are for IV medications, the rounding is based on measurable doses using the concentration recommendations from Medusa (Injectable Medicines Guide). Caps are applied to prevent exceeding limits recommended by the British National Formulary – with system alerts for overdosing risks.
   - **Override options:** For drugs such as clindamycin and cefuroxime – where the British National Formulary for Children offers dose ranges or alternative dose or frequency for more severe infection – clinicians agreed on optimal dosing points within those ranges. Override functionality was enabled to provide clinical flexibility.

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2. **Creating paediatric order sets**
   - **Asthma protocols:** Default inhalers are pre-ticked, with options for oral prednisolone and intravenous hydrocortisone (with capped doses), aminophylline (loading/maintenance), salbutamol (loading/maintenance) and magnesium infusions. Preparation instructions and infusion rates are auto populated using a combination of standard strength infusions with additional instructions on screen regarding rate (the prescriber inputs the rate) and dosing sets (dose calculated by system, preparation instructions included on screen).
   - **Diabetes management:** Order sets for newly diagnosed patients include insulin dosing pathways, pump initiation protocols, guidance-aligned calculations and the 'discharge take home kit' to simplify prescribing.

3. **System safeguards and alerts**
   - **Medicines and Healthcare products Regulatory Agency (MHRA) guidance integration:** For females aged 9–55, the system flags prescriptions requiring justification for prescribing of sodium valproate – if outside MHRA guidance. For children under the age of 12, the system blocks the prescription of codeine.
   - **Critical medicines flagging:** As part of a system-wide project, all medications considered to be 'critical' (has a risk of patient harm if a single dose is omitted or significantly delayed) have the prefix '! CRITICAL'. This is visible to prescribers when ordering medication, on the medication administration record chart, and on the pharmacy screens. It provides a passive prompt to highlight the importance of timely prescription, communication of active prescription, and administration of such medications. Should staff mark the medication as 'NOT GIVEN', there is a further reminder to remind them to inform the medical team. The flagging helps to promote incident reporting relating to critical medicines. While audits are pending, reports are actively used to monitor themes or concerns relating to critical medicines.

4. **Collaborative configuration and review**

   EP system configuration improvements were developed in close collaboration with clinicians and pharmacy teams. Feedback loops were established with stakeholders to refine the system.

Impact

- This system optimisation demonstrated improved safety and usability – prompting consideration for wider use of dosing sets.
- The Medicines Safety team actively encourage clinical teams and specialist safety groups to suggest changes or request new EP initiatives to support safe prescribing.
- A similar scale of improvement work was undertaken working in collaboration with the then QHB Diabetes Safety Group to move all inpatient insulin prescribing onto the EP system. This was successfully achieved. It also included a 'hard stop' preventing insulin doses of 100 units or more being prescribed as a single EP order due to the misinterpretation by prescribers of the 100 units/ml strength found on information sources such as repeat prescriptions and GP records.

This system optimisation demonstrated improved safety and usability – prompting consideration for wider use of dosing sets.

Lead: Julie Vanes, Senior Pharmacist Medicines Safety / Paediatrics, Queen's Hospital Burton sites.

Patient prioritisation through a locally developed acuity dashboard

Read more about key topics linked to this case study:

- Effective governance
- Seamless integration

Background

Managing medications across emergency departments, inpatient wards, discharges, and outpatient clinics is a complex and often fragmented process.

Although the electronic prescribing system originally used by Liverpool University Hospitals NHS Foundation Trust facilitated prescribing, it lacked seamless integration with dispensing and other clinical platforms. As a result, pharmacists were required to access multiple platforms and systems to gather essential information, leading to inefficiencies and potential safety risks.

Recognising these challenges, a pharmacy-led team identified the need for a centralised local solution that would streamline data access and enhance patient safety. Over the last 15 years, they have iteratively developed the ‘Pharmacy Portal’ - an innovative, bespoke, in-house solution to manage workflow prioritisation.

Action

The team spearheaded the development of a locally-built portal – a comprehensive acuity dashboard. This digital solution was designed to collate and consolidate critical data from disparate sources – including EP, clinical documentation including venous thromboembolism assessments, laboratory results, and additional hospital systems and workflows such as inpatient ordering and night-store access logs – into a single, user-friendly interface.

Key features were developed through an iterative, user-centred approach, with rotational pharmacists embedded in the design process to provide real-world feedback. The portal introduced visual indicators to highlight patient review status including fall reviews, prioritisation flags for high-risk medications, therapeutic drug monitoring, supporting with automated safety alerts for issues such as dual anticoagulant prescribing, insulin dose anomalies, and antimicrobial and oxygen prescribing.

Governance for the project is managed by a Digital Medicines Steering Group, which prioritises developments effectively based on medication safety, impact, and available resources.

Objectives included:

- Providing a holistic view of patients with risk factors and medication needs
- Reducing time accessing different systems
- Embedding safety alerts
- Supporting clinical decision making
- Enhancing governance processes by iterative development through user feedback.

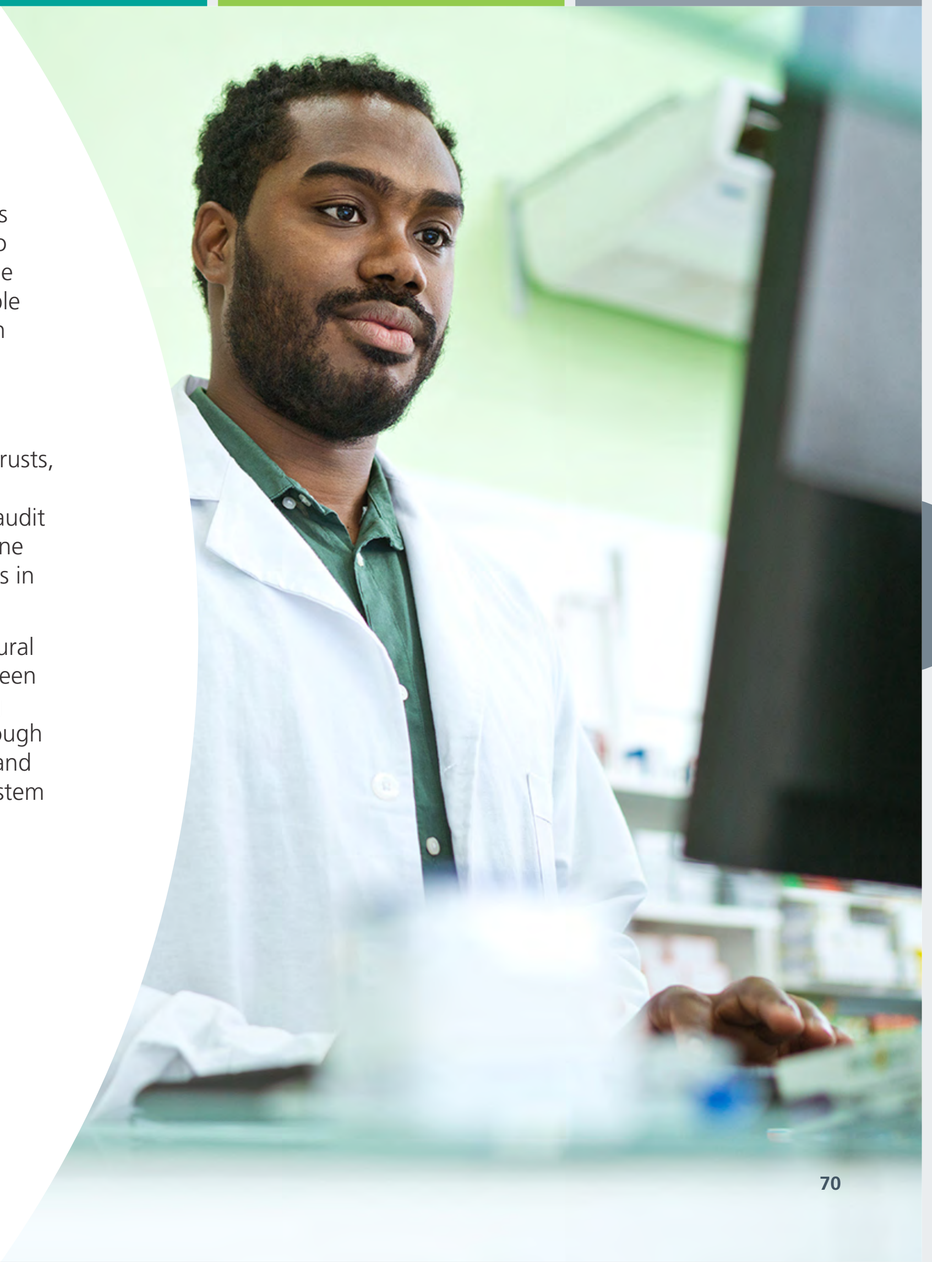
Impact

Since implementation of this new portal, workflow efficiency for pharmacy teams has significantly improved. They are now able to access all relevant patient information in one place and spend less time navigating multiple systems. Automated alerts and prioritisation logic have enhanced patient safety by preventing missed reviews and highlighting high-risk scenarios.

The system is now widely used across two trusts, supporting both pharmacy workflows and inpatient supply processes. While a formal audit is pending, anecdotal feedback from frontline pharmacists indicates marked improvements in both prioritisation and medication safety.

Additionally, the project has fostered a cultural shift, promoting greater collaboration between pharmacy and digital teams and supporting ongoing innovation in clinical practice. Through regular workshops and the steering group and based on the feedback of end users, the system is being continually developed.

Leads: Sarah Thompson, Chief Clinical Information Officer and Ben Logan, Electronic Prescribing and Medicines Administration Lead Pharmacist – both at Liverpool University Hospitals NHS Foundation Trust.



Appendices

Glossary

Term	Definition
ADE	Adverse drug events
AI	Artificial intelligence
AMS	Antimicrobial stewardship
CDS	Clinical decision support
Corollary orders	Orders triggered as a consequence of another order [1]. For example, requesting glucose levels after ordering a prescription of insulin within an EP system, or ordering laboratory tests (such as serum drug levels), radiographic tests, or physiological tests (e.g. ECG, lung function).
DDI	Drug-drug interaction
EHR	Electronic health record
EP	Electronic prescribing This is defined as the use of digital platforms that replace traditional paper-based methods – enabling healthcare professionals to prescribe and record administration of medicines electronically. EP systems support informed decision-making regarding medication selection, administration, and supply – enhancing safety and convenience for both patients and staff. It also offers a comprehensive audit trail throughout the entire medication management process, helping to reduce waste and improve care efficiency.
ePMA	Electronic prescribing and medicines administration
ePRaSE	Electronic Prescribing Risk and Safety Evaluation

Term	Definition
Integration	Integration typically involves hospital-wide, multi-modular systems, aiming for a unified patient record and cohesive user experience.
Interoperability	A focus on linking diverse standalone systems from different suppliers to facilitate information exchange, often through agreed standards.
Juxtaposition errors	At the point of selection, a medication listed before or after the desired medication is erroneously chosen
SME	Subject matter expert
Socio-technical system	A system combined of interconnected social (people, culture, work practices) and technical (technology, infrastructure, processes) subsystems, where both must be optimised together for effective performance and wellbeing. The core idea is that optimising one aspect without considering the other leads to suboptimal outcomes. For example, simply introducing new technology without addressing its impact on people and work practices will often result in failure to derive the full benefits from that technology.
Secondary use of data	The reuse of clinical and/or operational data for purposes other than direct patient care or the original purpose for which the data were initially collected.
UI	User interface

How this resource was developed

The Learning Lab is informed by academic work, reported incidents, lived experiences and user needs. It also draws on findings and themes from the ePRaSE assessment tool. Early and ongoing engagement with stakeholders provided feedback on potential ideas for useful content to include, and identified examples of EP system optimisation activity to showcase.

Forums such as the NHS e-prescribing Masterclass and the Regional Medicines Safety Officer Network guided the development of the Learning Lab. This was further supported by a focus group where participants offered feedback based on their experiences of EP systems.

The project team wishes to sincerely thank all who reached out and contributed their valuable insights, time and enthusiasm for the Learning Lab.

Identification of EP system optimisation learning

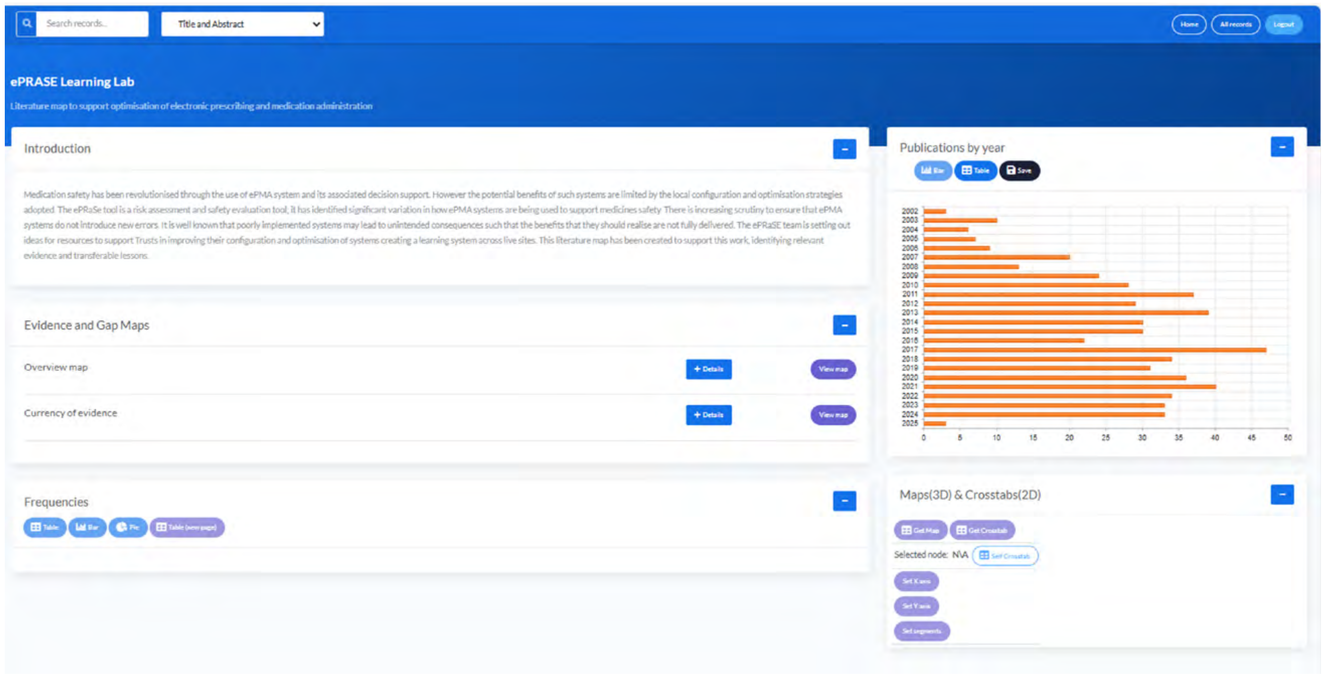
Three main methods were used to gather insights from the literature:

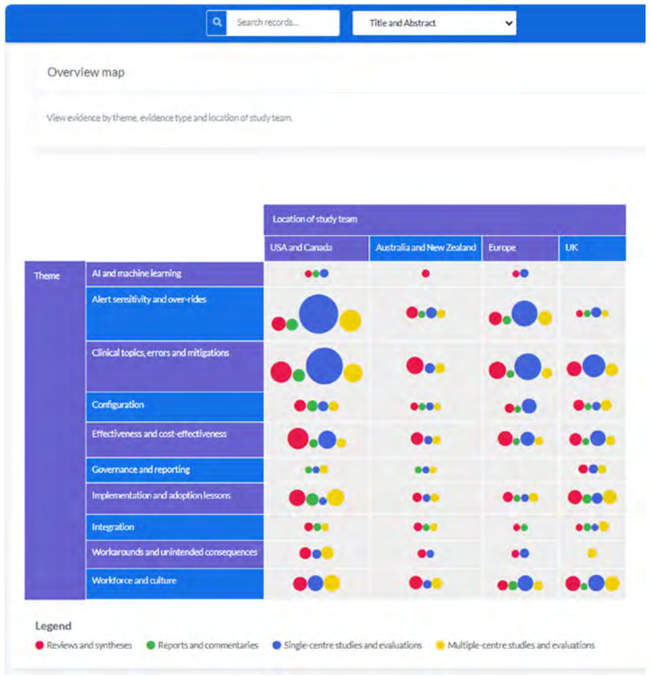
1. Optimisation themes were identified using artificial intelligence technology with SME input. These were further analysed to identify key learning points.
2. 'Key principles' was developed following a review and synthesis of the key learning points.
3. ePRaSE tool results were used to identify learning relating to high risk medications and the optimisation of clinical decision support systems.

Literature evaluation and creation of literature map

The foundation of the Lab is a comprehensive literature review, undertaken to identify relevant evidence and transferable lessons relating to EP system optimisation. The search scope included international research undertaken over the past 25 years up to and including March 2025. The initial searches revealed just under 20,000 articles, which were then screened for relevance and grouped into pre-defined themes – identified by the subject matter expert (SME) team.

After this screening process, approximately 650 articles remained, from which the Lab was created. Relevant studies were arranged into an 'evidence map' – a visual overview of the evidence, which could be filtered by different characteristics such as type of evidence, study team location, theme, author and year of publication.





Images taken from the EP Learning Lab EPPI-Vis® webdatabase (evidence map)

The EP Learning Lab evidence map

A map was created to visually summarise relevant evidence identified from the literature review.

This method is based on work by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre), Institute of Education, London. The map serves as an interactive tabular display, allowing users to examine available evidence by category and filter by characteristics such as evidence type or study design.

We used four stages to develop the Learning Lab based on the scoping review method developed by Arksey and O'Malley.

1. Scope – agree protocol

The scope was agreed with the subject matter expert (SME) team, identifying inclusion and exclusion criteria. For example: date range, relevant geographies, evidence types, recommended grey literature sources, and specific authors).

2. Search and screen – database and grey literature searches

This involved searching a range of sources, including MEDLINE and EMBASE, as well as selected grey literature sources. The results were screened using the agreed criteria.

3. Map – organise results

The evidence map was created by categorising the literature into a thematic framework which also identified evidence type, location of study team, and year of publication.

4. Summarise key learning – create EP Learning Lab

The identification and analysis of key learning from the evidence map literature was undertaken using AI with SME input. ePRaSE tool results were also used to inform best practice around high risk medications and clinical decision support systems.

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Many thanks to all the individuals who provided valuable feedback and assistance throughout the development of this document.

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Bibliography

Access the bibliography for the Electronic Prescribing Learning Lab here: ePRaSE