Power System Technology
ISSN:1000-3673

Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

Leveraging Health Informatics and Interdisciplinary Collaboration to Enhance Medication Safety and Patient Outcomes Across Multi-Sector Healthcare Settings

Abdulmajeed Matar Alotaibi[1], Eidah Hamad Mane Alanazi[2], Wadha Hamad Alanazi[3], Fatimah Essa Ali Alshamlawi[4], Talal Mohammed Alshammari[5], Alya Aun Al-Abdulwahab[6]

[1] Corresponding Author, Pharmacy Technician, MOH

[2] Health Informatics Technician, Ministry of National Guard-Health Affairs

[3] Medical Records Technician, Ministry of National Guard-Health Affairs

[4] Pharmacy Technician, National Guard clinic

[5] Nursing, Ministry of National Guard-Health Affairs

[6] Laboratory Specialist**,** Erada complex and mental health

Abstract

Significant improvements in healthcare delivery, including better care quality, stronger patient safety protections, and more effective clinical communication, are needed across all sectors of the healthcare system. Current strategies tend to focus on palliative care rather than the definitive enhancement of the care continuum. Consequently, patients continuously transition between primary and specialty care, including acute interventions in emergency departments, and back to primary care for ongoing follow-up. Without appropriate information exchange and a common understanding of the patient's clinical status, medication therapy becomes fragmented, often resulting in errors, duplication, and omission. These problems are exacerbated when services are provided by different organizations and settings with little to no interoperability. Specific issues include 1. Deteriorating information quality as it moves downstream through a fragmented network of independent providers with diverse systems, data models, and subjective interpretations; 2. Limited access to a common patient record. The original institution is seldom able to retrieve relevant information from downstream providers, even when the patient is physically present (Abebe et al., 2022). 3. Increased reliance on incomplete legacy data from closed or inactive records; 4. Generic, poorly tailored content in downstream communication and documentation (Elena Herrera, 2015).

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

Information technology and informatics have a crucial role to play in constructing the desired integrated medication therapy network capable of spanning community, ambulatory, residential, and post-acute sectors. Enabling technologies include electronic health records, transfer-of-care tools, medication management systems, medication reconciliation, computerized provider order entry, clinical decision support, and health information exchange. All these systems can both automate standard practices and make the relevant clinical knowledge more readily available, thus 1. streamlining workflows, improving compliance, and enhancing effectiveness and 2. heightening safety awareness through embedded decision points and constraints. Enhanced and systematic communication across the continuum enables pinpointed corrective actions even in organizations providing only intervening care, and orchestrated initiatives across settings and organizations are possible. These capabilities substantially lower risk, drive improvements, and promote a learning culture that subsequently amplifies the remaining infrastructure. The benefits go beyond safety alone. In the care and medication management domains specifically, significant productivity gains and improved patient, clinician, and organizational experience can be achieved. Analytical techniques from artificial intelligence and machine learning will be employed to formulate and refine recommendations, as well as to rigorously analyze the effects of both individual and collective enhancements on both technical and meta-outcomes.

Keywords: Health informatics, medication safety, interdisciplinary collaboration, multi-sector settings.

1. Introduction

Modern healthcare systems emphasize the goal of ensuring safe and effective medication use for patients at all ages and across all sectors of care (W Bates et al., 2022). Yet, a multitude of safety hazards persists through healthcare transitions and within fragmented, siloed services (Abebe et al., 2022). Addressing these hazards requires the integration of data and knowledge across disciplines and sectors—an essential step toward a coordinated, patient-centered medication management process. However, many technological solutions remain within organizational silos, impacting only their own restricted scope of activities (Elena Herrera, 2015). Implementing solutions collaboratively across sectors is rare, even when care spans multiple settings. Consequently, meaningful, comparable outcome measures must be defined and communicated to underpin the evaluation of all interdisciplinary- and cross-sector-enhancing initiatives. Managing transitions of care across hospitals, primary care, community pharmacy, long-term care, and home health represents one of many priority areas.

Medication-related problems constitute a top contributor to preventable harm in multi-sector care. Adverse drug events (ADEs) are a prominent concern: estimates suggest that over 22%

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

of patients experience a medication-related problem across care transitions, with one study documenting that 50% of patients resuming anticoagulation therapy following hospitalization never received the intended regimen. Even before the COVID-19 pandemic introduced additional complexity to care delivery, approximately one in seven primary-care visits involved medication reconciliation, and systematic drug monitoring beyond medication reconciliation seldom occurred. Further, the Joint Commission's National Patient Safety Goals place additional focus on this overarching priority area.

2. Conceptual Framework: Health Informatics, Medication Safety, and Interdisciplinary Collaboration

Theoretical models from interpersonal and intrapersonal communication help frame the roles of health informatics and interdisciplinary collaboration in multi-sector medication safety. Health informatics enables improved workflows and clinical decision support across care transitions. The use of data from diverse sources and standards-based interoperability connects the activities of ambulatory and long-term care with nearby acute facilities, while preserving legacy informatics investments. Multiple studies demonstrate that these capabilities lead to fewer adverse drug events and near misses (Lapkin et al., 2014). A team-based-care model emphasizes medication management as a shared responsibility among clinicians, pharmacists, information technology (IT) professionals, and patients: changes call for collaboration among these stakeholders and a governance structure to establish priorities and address silos of practice (W Bates et al., 2022).

Health informatics, medication safety, and interdisciplinary collaboration are supported by various constructs. Informatics-enabled workflow improvements—such as structured input and standardized information—directly contribute to safety by mitigating drug–drug interactions, allergies, and indications for prescribing. Decision-support tools, like prospective drug utilization review, interact with practice-based data to reduce medication incidents; near misses can inform further improvements. These contributions are intertwined with human-factor principles aimed at designing systems and interfaces for safe and efficient use (Abebe et al., 2022).

3. Health Informatics Technologies and Systems

Health informatics technologies are instrumental in enhancing medication safety. The vast volume of information that healthcare professionals must process for every patient interaction makes it infeasible to rely solely on human cognition. Accordingly, a variety of informatics interventions have been implemented to manage this complexity and leverage data to

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

streamline and improve the medication delivery process. Many of these interventions also reduce opportunities for medical error (M. Borycki & W. Kushniruk, 2022).

Computerized prescriber-order-entry (CPOE) systems significantly reduce errors associated with illegible handwriting, lost paper orders, and the inadvertent selection of drugs with similar names. Nevertheless, CPOE introduces new error types and does not eliminate others; accordingly, clinical-decision-support (CDS) tools have been integrated into many CPOE systems. These tools embody medication safety knowledge in a structural form capable of recognizing domain-specific data from electronically recorded orders and triggering the provision of relevant advisories. CPOE plus CDS remains one of the most extensively studied informatics-driven, healthcare-organization-process redesign initiatives (W Bates et al., 2022).

3.1. Electronic Health Records and Clinical Decision Support

Health Informatics Technologies and Systems

Health informatics technologies are central to improving medication safety in health care systems, with increasing availability across sectors. Evidence indicates that these technologies have positively influenced medication safety and patient outcomes, though the extent of impact varies.

Main technologies include electronic health records (EHRs) with clinical decision support (CDS) capabilities; medication management systems incorporating e-prescribing, barcode scanning, robotics, and inventory control; and health information exchange (HIE) mechanisms facilitating a spectrum of data exchange. Each technology is scrutinized for its effect on medication safety and relevant outcomes. (Ratanawongsa et al., 2017)

3.2. Medication Management Systems and Automation

Medication management systems and automation encompass the electronic prescribing of medications (e-prescribing), the use of computerized systems linked to barcode scanning for the preparation and verification of medications, and automated inventory control and management. These systems do not function in isolation; rather, their effectiveness is enhanced when they are interlinked with clinical information systems and patient electronic health records, and when they are coupled with clinical pharmacy services and a variety of medication safety and workflow monitoring tools. The implementation of e-prescribing alone at Massachusetts General Hospital in Boston was associated with a 17% drop in prescribing error rates (Almalki et al., 2023). At a large, multisite private medical center, the deployment of data analytics to assess medication pick accuracy in automated dispensing machines enabled a reduction in the rate of medication device-access errors, which subsequently contributed to decreased medication retrieval errors—safety outcomes highly relevant to workflow organization. The adoption of an automated environment for a broad range of

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

therapeutic infusions and concurrent medication administration across multiple devices and vendors effectively mitigated risk and eliminated troublesome infusion duplicates. Successful drug dispensing automation at an acute care institution was linked to an 83% decrease in the time from medication ordering to administration, a reduction in monthly medication consumption of 24% and returned item count of 72%, and decreased financial losses attributed to expired medications (W Bates et al., 2022).

3.3. Interoperability and Health Information Exchange

Health information exchange (HIE) involves volumetric sharing of health data among healthcare parties like hospitals, nursing homes, and pharmacies (Heeney et al., 2023). Standards like Continuity of Care Document, Fast Healthcare Interoperability Resources, and Clinical Document Architecture enable diverse source payloads and support. HIE extends the scope of patient data available to health information technologies that promote medication safety, patient outcomes, and operational efficiency by documenting relevant events across transitions of care (Elysee et al., 2017). Typical scenarios include provider-to-provider and provider-to-patient exchange—interfacing with pharmacies, specialty practices, public health entities, and various online platforms. Informaticians frequently address specific payloads, protocols, domain models, and terminologies for such content.

Two fundamental issues impede secure and widespread deployment of substantial HIE. First, lack of adequate trust leads to hesitance; therefore, semi-private federated architectures in possession of edges marked by constraints enabled trust establishment and operational optimization. Second, insufficient financial incentives inhibit broad integration with health information technologies supporting widespread HIE; cross-organizational benefits remain an obstacle. Organization-specific electronic health record incentives discourage widely accepted protocols supporting population health or reduced redundancy across system islands—hibernating many nominal vendors and information-exchange vendors alike. Uncertainties regarding epidemiology, biovigilance, and emergent care technologies similarly slow adoption despite proven HIE enhancements to preemptive surveillance, quality guidance, and proximal alterations.

4. Care Continuum and Multi-Sector Collaboration

Collaboration and seamless interfaces across care settings remain critical to maintaining safe medication use throughout the patient journey. Transitions between acute care, primary care, community pharmacy, long-term care, home health, and payer-provider networks constitute major points of potential risk. Each transfer creates opportunities for errors, such as omissions of important medication information from discharge summaries, compounded by care across multiple sites and providers. Various strategies support collaborative efforts.

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

Shared care plans and coordinated medication lists form the basis for integrated care. Formal communication protocols, covering data content, format, and timing, help to ensure the right information reaches the right stakeholders at the right moment (Koch, 2013). Multi-sector organizations can foster cooperation and dialogue. Regulatory requirements, including mandatory reporting of significant adverse events, can drive a culture of continuous learning. Toolkits and templates simplify documentation of incidents and preventive actions.

The intersection between healthcare providers and the public health system offers additional opportunities to promote patient safety. Transmission of aggregated clinical data to population-level surveillance systems helps to identify potential threats, such as an uptick in adverse drug events associated with a particular medication, thereby driving early interventions targeted at mitigating risk. Healthcare organizations frequently face a multitude of reporting obligations related to safety and quality. Policies at both state and federal levels continue to evolve in relation to opioid distribution and practice standards. Active participation in these initiatives, through industry advocacy groups and collaborative projects, can help shape approaches immediately relevant to safety and quality efforts.

4.1. Hospital, Primary Care, and Community Pharmacy Interfaces

Effective collaboration among disciplines, education systems, and sectors enhances medication safety. Transitions of care—such as from hospitals to primary and specialty care, long-term care, home health, and hospice—raise the risk of compromise (Hahn et al., 2014). Handoffs expose patients to further vulnerabilities. Medication reconciliation fosters safety by checking orders against pre-existing records. Barriers within interoperable data sets hinder pest-permitting clinicians from accessing essential information. Primary and specialty practitioners, long-term care and community pharmacies, home health agencies, and integrated payers collaborate within tightly regulated service delivery models to support specific patient safety agendas.

4.2. Long-Term Care, Home Health, and Payer-Provider Networks

Home care services constitute a vital component of the service delivery continuum for older adults with health and social support needs. The continued trend of aging will result in caring for increasing numbers of seniors requiring multiple medications, which has prompted the development of collaborative models nationwide to ensure optimal medication management. Collaboration among home care personnel, clinics, and community pharmacies and pharmacies becomes particularly pressing in jurisdictions such as Ontario, where reliance on individuals operating in these home care sectors is substantial. The absence of a shared service model that engages medication management by these providers fosters gaps in safer medication management.

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

Widespread efforts both in-home and long-term care monitor the extent of medication management directly associated with Safe Medication Management (SMM) collaboratives. Constructing an SMM Collaborative model is deemed essential for the ongoing compilation of common SMM indicators across the country, which can subsequently facilitate comparisons both regionally and nationally (Lang et al., 2015). The SMM initiative is one of several such initiatives embedded in the broader theme of improving quality and safety indicators. Concurrent with the introduction of this collaborative, it is anticipated that the learning loop associated with these selected indicators will commence an expanded functional perspective throughout the care environment (L. Clarke et al., 2017).

4.3. Public Health and Regulatory Considerations

Medication safety poses unresolved challenges despite decades of attention and investment. Canada ranks among the few countries requiring reporting of serious medication incidents. These incidents frequently derive from information deficiencies concerning appropriateness, availability, or timing of prescriptions. Institutional and system-level solutions, therefore, centre on effective information modelling, collection, and management through data sharing across sectors and sites.

Public health initiatives constitute an additional medication safety dimension. Programs to promote active monitoring for adverse drug events, adherence to reporting requirements, and associated academic or trade publications deliver mutual safety benefits to front-line providers by directing greater attention to complex medication issues that span multiple sectors. Each sector continues to explore avenues for enhanced safety monitoring.

(W Bates et al., 2022)

5. Safety Challenges and Risk Management

Patient safety remains paramount in health informatics, notably with the widespread adoption of mobile health applications that empower patients. These technologies can enhance safety but also introduce new hazards, such as alert fatigue. Despite considerable investments, a gap persists between the anticipated and actual benefits of health informatics. Research needs to explicitly address socio-technical factors related to their implementation and use. In England, safety assurance practices encountered challenges in hazard and risk analysis. These issues inspired the development of the Safety Modelling, Assurance and Reporting Toolset (SMART), which supports systematic hazard and risk analysis for health informatics (Habli & Paul White, 2018).

In the United States, approximately 1.5 million adverse drug events occur annually, significantly impacting patient safety and healthcare costs. Factors contributing to these

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

events include incomplete medication histories at care transitions, patient-reported drug lists lacking documentation in electronic health records, limited clinician awareness of prescribed drugs from prior interactions, cross-dispensing of medications with similar names, and alerts perceived as irrelevant by clinicians. The focus on alerting rather than learning from near-miss events further exacer036ac876-18dc-41a9-ab36-77ae22e3f313 these issues (W Bates et al., 2022).

5.1. Adverse Drug Events and Near Misses

Adverse drug events (ADEs) and near misses represent a considerable threat to patient safety across the care continuum. Healthcare services attempt to capture and learn from both of these occurrences, referred to interchangeably as safety incidents, to reduce their incidence. For example, medication-related ADEs rank among the most frequently reported types of safety incidents in inpatients, accounting for between 20 and 30% of total events (Recsky et al., 2023). Research reveals that between 35 and 96% of these adverse events are preventable, suggesting a significant opportunity for improvement. Factors contributing to medication-related ADEs in community pharmacy, including the dispensing process, have also been identified. Other types of preventable patient harm have been observed across the continuum of medical care, and incident data continues to be leveraged to learn from such events (Ledlie et al., 2022). Only 24% of safety incidents in England and Wales are formally reported, and systems designed to improve the capture of incidents across diverse settings, codesigned by frontline staff, may be a means to accelerate learning from these hazards.

Safety enhancement in technology-supported, team-based medication management depends upon the timely characterisation of safety incidents and an iterative, data-rich learning loop that leverages incident insights to make informed, targeted improvement improvements aimed at specific causal factors. ADEs and near misses constitute core safety incident types, and the corresponding cycles of measurement and improvement are therefore similarly foundational.

5.2. Alert Fatigue, Usability, and Human Factors

Multiple studies have identified core human factors barriers to effective use of clinical reminders such as alerts and guidelines, encompassing alert fatigue, usability issues, and inadequate communication (Marcilly et al., 2018). Alert overrides are frequently associated with insufficient or unclear content communication about the necessary action and justification behind the supported decision. Further, serious mistakes can arise when a decision support system is usable but other aspects of the medication prescription remain poorly designed. Research on the usability of clinical reminders and decision support has highlighted that, notwithstanding the potential safety and quality improvements from their introduction, persistent human factors weaknesses hinder more extensive use. Action is

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

imperative to enhance system learnability, efficient use, and mitigation of excessive cognitive workload. Methods to evaluate the user acceptance and usability of decision support systems exhibit particular importance in contexts such as the management of opioid therapy, which combines high-risk medications with growing safety concerns. Although studies devoted to order set usability encompass a small proportion of the literature, the findings still provide useful insights to refine the underlying methodology. Consideration of ergonomic criteria such as standardization, workload, and self-evidence, along with user-centered design principles like consistency, has emerged as a fertile avenue to boost overall system usability. A catalogue of evidence-based usability design principles specifically for medication alerting systems promises to guide the efforts of designers aiming to develop support targeting prescription and administration reminders or drug interaction alerts. Moreover, development of business process context models distinct from generic medication processes facilitates the prioritization of drug safety alerts throughout the clinical information system.

5.3. Data Quality, Provenance, and Trustworthy Analytics

As data move from source to analysis, changes occur that can affect the utility and trustworthiness of the resulting information (G. Kahn et al., 2015). A system that tracks the origin and history of data—what is often referred to as data provenance—can clarify the data life cycle and its implications for analyses that depend on the data. Provenance enables scrutiny not just of data but also of analytical methods, which are equally important determinants of trustworthiness when the data are subject to interpretation. Provenance refers not only to lineage—the origin, history, and location of data—but also to the broader context within which decisions about data creation take place. Over time, systems have been developed to represent provenance, and frameworks exist to assess the provenance of data as they are transferred between institutions.

In addition to provenance, data quality remains a paramount concern. The nature of the data life cycle implies that data quality can be judged with respect to both origin and adequacy at the point of original collection and at various subsequent stages. Thus provenance and data-quality improvements are closely interconnected, and as provenance systems evolve, they allow for increasingly nuanced analysis and characterization of data-quality issues. Governance strategies that positively influence data quality can be mapped using the electronic health record approach to health-information exchange as an illustrative example. Data management in distributed systems, by allowing origin and context to be understood at the point of use, opens up further opportunities for quality enhancement.

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

6. Methodologies for Improvement

New technologies have the potential to inform and improve medication safety across sectors. Evidence-based, widely adopted methodologies offer structured, iterative processes for health professionals to implement specific improvements. Health information technology is a well-studied area, with frameworks guiding successful adoption of Electronic Health Records (EHR), computerized physician order entry, drug-drug interaction checking, and Clinical Decision Support (CDS) systems. (Elena Herrera, 2015) Educational objectives and validated metrics exist for operationalizing the link between health information technology, health care efficiency, and patient safety; however, the criteria remain largely unmeasured within the context of interdisciplinary collaboration and external integration.

Healthcare is fragmented across providers, data domains, and sectors, making the establishment of safety criteria and measurement of health informatics investment returns essential. Collaboration across health care, public health, and insurance systems is critical for maintaining continuity of care during medication-change transitions associated with advancing age and broader comorbidity. Multi-sector linkage of programming languages, and compatible use of EHR products; interoperability through peer-reviewed, collaboratively developed documentation standards; and delineation of external data flows remain crucial for patient safety and data transparency.

Medication Administration, Dispensing, and Monitoring have received increased attention and investment, while the broader set of Safety-enhancing Team-work and Information-sharing Technologies remains under-supported; whether further safeguards are required after EHR installation remains unclear. Handoffs from hospital discharge through transitions to community- or home-based services are widely acknowledged as high-risk periods meriting systematic review; yet multi-sector coverage remains incomplete. Shortfalls exist in clinic-to-clinic handoffs among hospitals, prison systems, and county facilities that cooperate on providing psychoactive medications. Transport-requires services also present high-risk transfer points when service cessation occurs in-center before completion of reports and remaining doses. In-patient prescription accuracy analysis shows the undesired behaviour of incorrect dosing becoming entrenched after stabilisation, and prescribing analysis is often limited to a single dose without full integration of prescription medication list. Prescribing guidance for de-prescribing to promote drug load reduction, polypharmacy management, and complete patient safety presentation of on-going long-term medicines under review for alternative solutions remains under-explored.

6.1. Implementation Science and Change Management

Implementation science provides systematic processes for unpacking complex interventions, promoting best practices, and establishing and maintaining stakeholder buy-in for new

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

technologies and workflows. The Consolidated Framework for Implementation Research (CFIR) identifies five domains that influence project success: characteristics of the intervention, outer setting factors (e.g., regulatory requirements and policy changes), inner setting elements (e.g., culture, systems, and structures that facilitate or hinder use of innovation), individuals involved, and the process of implementation itself. Engaging external agents as facilitators—consultants who assist sites in adopting the interventions—has been shown to heighten interest among stakeholders and ease investigators' administrative burdens (P. Stolldorf et al., 2021). Similarly, the Promoting Action on Research Implementation in Health Services (PARiHS) framework posits that successful implementation depends on the interplay among three factors: the nature of the evidence being translated; the quality of the local context, including available resources, skills, culture, and receptivity to change; and the way in which that evidence is presented, including opportunity for participation and assessment of impact.

The survey of multidisciplinary medication safety improvement activities across multiple settings serves as a cross-sectoral translational feedback loop to inform subsequent initiatives among different disciplines. Requesting documentation of work completed in other healthcare organizations prompts the two authors to seek parallels in their own institutions, connecting the contributions of diverse stakeholders and establishing opportunities for further collaboration.

6.2. Evaluation Designs and Outcome Metrics

Use of evaluation designs and outcome metrics can be guided by the specific theories and frameworks that inform the effort and by the type of the intervention being evaluated. With multi-sector collaborations, attention should also be placed on patient transitions among sectors and on how factors in one sector may influence activities, risk, and outcomes in another. Evaluations should thus address the setup, maintenance, and effectiveness of interdisciplinary collaborations for improving medication safety, procedures for assessing and implementing system-wide enhancements, and knowledge gained across sectors. Key indicators and potential data sources at each sectoral interface are highlighted.

A comprehensive overview of evaluation designs and metrics is available (J Leonard & F Sittig, 2007). The choice of specific designs can be informed by frameworks that characterize the nature of implemented changes as well as the extent to which the evidence is generalizable or the focus is on a particular setting. Widely adopted frameworks that can guide the selection of evaluation approaches and metrics include the Consultative Committee on the Convention of Biological Diversity (CBD) and Health Information and Management Systems Society (HIMSS) frameworks. Evaluation metrics such as similar key indicators, types of corresponding data, relevant numerical benchmarks, statistics that could characterize

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

relevant distributions, and potential analytic approaches for deriving such statistics from available data sources can also be identified (Jeffries et al., 2017).

6.3. Evidence Synthesis and Translational Feedback

In conjunction with emergency medicine, primary and community care, long-term care, and home health, integrated health systems and regional collaboratives comprise a fourth exemplar of collaborative healthcare delivery linked to medication safety. Outlining these features and contrasting the design and the challenges of service integration offers further insight into effective approaches.

Interdisciplinary collaboration, referring to cooperation among professionals with diverse perspectives in the same care process or problem set, strongly influences medication safety. The healthcare team has expanded in response to growing complexity, technology adoption, public health threats, and evolved patient expectations (Abebe et al., 2022). Team care is one pillar of patient-centered care, yet research indicates inadequate team integration hinders progress toward comprehensive coordination (Enticott et al., 2021). Safety studies pinpointed teamwork as a key driver of preventable hospital admissions, readmissions, and adverse drug events following discharge (Elena Herrera, 2015). Effort is required to bring clinicians, pharmacy, information technology, administration, and patients together through shared messages, care processes, and mandates for different types of interdisciplinary collaboration.

7. Case Studies Across Sectors

The urgency of improving medication safety—encompassing processes, technologies, policies, and behavioral factors—at transitions of care remains clear across diverse sectors of health care and social support. Four illustrative case studies spotlight efforts to enhance health informatics and interdisciplinary collaboration and build safer systems.

In the domain of acute care, integrating electronic health records (EHRs) and clinical decision support (CDS) within the emergency medical services/911 call center and inside the emergency department enables real-time capture and sharing of medications prescribed and contraindicated, alerts for drug-drug and drug-allergy interactions, and monitoring of adherence. Experience at Diverse Regional Health System indicates this configuration is associated with reduced harm (Jia et al., 2019). For other broad areas (primary/community, long-term/home) and across integrated health systems and regional collaboratives, key interventions, outcomes, and lessons learned are likewise reported (Abebe et al., 2022).

7.1. Acute Care and Emergency Services

Medication errors are a common cause of adverse healthcare incidents in the emergency department (ED). A comprehensive project aimed to reduce medication errors and improve

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

health and economic outcomes through a continuous quality improvement cycle. A task group of staff from various professional backgrounds identified problems and developed strategies focusing on seven error-prone areas: drug allergies, medication charting, high-risk medications, intravenous devices, look-alike sound-alike drugs, drug storage, and prescription practices. Strategies included reviewing error-prone areas, streamlining medication lists, eliminating rarely used medications, standardizing practices, applying redundancies for safety, and extending pharmacy working hours. Regular audits and review systems ensured sustainability. The project successfully reduced medication incidents from 16 to 6, establishing a sustainable framework for medication safety in the ED (BC Lee et al., 2013).

Systematic interventions, such as specialty clinic nurses and community pharmacy notification systems, improve medication safety and reduce adverse events after hospital discharge. Enhancing inter-professional communication and safer handover protocols with input from clients, families, and providers is crucial. Electronic health records and decision support systems hold potential to strengthen communication during care transitions. Pharmacies should create accessible online medication updates that reliably reflect changes in real-time. Collaboration among healthcare professionals, regulators, and educators is necessary to improve engagement in safe home medication management (Lang et al., 2015).

Medications are essential for patient management, but medication safety remains problematic, with 9% of prescriptions containing errors and patients often taking medications incorrectly. The aging population will double the need for medications by 2036, amplifying the importance of safe practices. Digital tools assist drug management but introduce new challenges for prescribers, nurses, pharmacists, and patients. Ensuring correct prescriptions, adherence, and reporting side effects is vital for improved outcomes. A roundtable discussion highlighted challenges and future directions in smart medication management, focusing on digital systems, safe prescribing, communication, education, and drug adherence (W Bates et al., 2022).

7.2. Primary and Community Care

Continuity of care, especially medication reconciliation, is crucial during transfers between settings. In a primary care study, timely access to discharge medications, follow-up appointments, and clear information on additional drugs each enhanced safety and care quality (A Young et al., 2023). Community pharmacy contributes to safe transitions by dispensing prescribed medications and providing training on new therapies, doses, and potential interactions (Lang et al., 2015). To facilitate patient-centered care, collaboration among physician practices, community pharmacies, and home health providers is vital. Some jurisdictions even allow pharmacist prescribing to extend care capabilities (W Bates et al., 2022).

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

7.3. Long-Term Care and Home Health

Long-term care, home health, and payer-provider networks represent treatment options that share common safety vulnerabilities and the need for integrated health informatics. The prominent risk of managing prescribed medications requires a coordinated effort of medical and pharmacy staff from both home care and institutional settings and across the payer-provider continuum (Lang et al., 2015). Effective processes and tools to support medication reconciliation—either upon patient admission or through ongoing monitoring—are critical; lay personnel tasked with transcribing medication orders into home care documentation also present safeguarding challenges associated with this high-risk and frequently-untested communication loop between institutions and home care agencies.

Beneficiary status and benefit design for home care are often determined by insurance; coverage for information technology systems that facilitate home care–hospital cooperation can therefore improve continuity of care and safeguard against harm.

7.4. Integrated Health Systems and Regional Collaboratives

Collaboratives have historically been formed to advance health systems' understanding of disseminating information about safety issues. They enable health systems to share experiences about incidents and near misses, often without revealing privileged information. They can also foster the adoption of common definitions for terms like drug diversion and enable sharing of learning across close partners (G Anderson, 2006). Even in less regulated fields, concerns about confidentiality and competition can stifle information exchange across organizations. Collaborative approaches that maintain anonymity and offer neutrality by an external party are common. Data-sharing systems, where healthcare providers implement common reporting systems to promote voluntary reporting, information sharing, and learning, have therefore been identified as important strategies for improving patient safety.

8. Ethical, Legal, and Social Implications

Ethical, Legal, and Social Implications

Health informatics efforts to enhance medication safety and patient outcomes across multi-sector healthcare settings raise important ethical, legal, and social implications. The framework that follows articulates priority themes of patient autonomy, equity, privacy, and systematic control—along with priorities specific to each sector. Each dimension merits ongoing attention from organizations engaged in informatics or oversight.

Patient autonomy, equity, and access are core human rights linked to Health Canada's definition of accessibility. Informed consent processes respect autonomy by facilitating patients' right to make informed decisions regarding their care. Health system fragmentation

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

may impair adequate patient understanding, leading to altered perspectives on a medication's risk-benefit profile. Certain patient populations may lack sufficient proficiency in the language(s) of care providers or the health literacy to navigate complex medical terminology. Digital divide disparities affecting digital access and skills, socioeconomic status, gender, community, and geographic location further exacerbate these problems (W Bates et al., 2022) —a factor underscoring the urgency of efforts to foster health equity.

Privacy, security, and governance constitute fundamental systemic rights. An adequate balance between risk and benefit requires the routine governance clearance of third-party actors, including industry, academia, and policy sectors (J. Embi et al., 2019). Safeguards govern software composition, source-level transparency, pre-and post-product cycle forensics, and dynamic reappraisal of the impact of data science on systems, processes, personnel, and capacity. Access to information requires appropriate cybersecurity luminance categorization according to the degree of Public Health risk. Related to the systemic rights of safety, security, and capacity, systematic control forms the foundation of a Fair Work Environment policy, and draws from: Code of Conduct, Procedure on Professional Conduct, Freedom of Association, Policy and Procedure, Work Reorganization, Harassment Prevention, Performance Review, Personal Surplus, Performance Recognition, and Grievance, among others.

8.1. Patient Autonomy, Equity, and Access

Informed consent is fundamental to health equity and patient empowerment, yet significant barriers remain for portion of the population. Accessible, low-literacy safeguards are critical to ensure that personal data and clinical decisions remain under patient control. In conjunction with consent, communities have a right to equal-use technology that accounts for broader disparities (S. Valdez et al., 2022). For digital systems to offer equitable access, those designing the infrastructure, protocols, security, and governance must include adequate representation from non-dominant groups (W Bates et al., 2022). For stakeholders such as regulators, funders, and institutional leadership to enforce legitimate standards, they need clear guidelines on the particular information eligible for disclosure. Moreover, other communities face different restrictions, requiring mechanisms for appropriate adjustment. Inclusion design efforts do not work in isolation. For some of the affected, even having access to technological features or information does not ensure health gain or satisfaction. Indeed, available resources may instead feed into lengthy learning loops without yielding the desired effect. Such flawed architectures reinforce existing accessibility issues. High-confidence data already confines equitable utilization, leading to potential re-injuring.

Communities have a right to equal-use technology that accommodates and counters broader vulnerabilities. Technologies nonetheless exert varying influence across different public and private sectors. Just as digital tools can amplify today's healthcare challenges, they may also

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

play a key role in resolving them. Integrating medication management across disparate siloed drugs appears correspondingly promising to satisfy population demands. The present-day landscape renders effects extremely difficult to trace. Addressing finer-grained unit doses constitutes a major obstacle to collaborative learning on system performance between parties. Policy messages require adapting and disseminating to as wide an audience as possible. New infrastructures emerging alongside major social disruptions do risk repeating past mistakes.

8.2. Privacy, Security, and Governance

Health informatics and interdisciplinary collaboration have the potential to revolutionize medication safety, but privacy and security concerns can slow adoption. National efforts to improve care qub1fb10e3-2832-465e-bbaa-af54d017b801ty and safety have increased interest in coordinating and integrating prescription-related activities across the entire medication-use process. An enhanced focus on information governance, security, and risk management is needed to develop reliable mechanisms for fostering multi-sector informatics-enabled collaboration that advances both qub1fb10e3-2832-465e-bbaa-af54d017b801ty and productivity without compromising safety.

Even as new technologies, analytic methods, and interdisciplinary collaboration frameworks emerge to address complex medication errors, the demand for cross-institutional access is clearly rising. But the chilling effect associated with such collective formb1fb10e3-2832-465e-bbaa-af54d017b801zation of knowledge deepens as hacker attacks and cyber-terrorism become commonplace; the requisite diligence furthermore extends into, and beyond, technical dimensions. Institutions increasingly seek to meet evolving standards for responsible and sustainable data stewardship by implementing governance frameworks that specify accountabilities for protecting physical space, personnel, and assets alongside systems, applications, and data themselves. Such frameworks help manage flow of knowledge and its associated partial characteristics and engagement, while also facilitating comprehensive consideration and mitigation of all potential cross-sector risks to promote safe data exchange among multi-disciplinary and multi-sectoral actors.

The surge in public-health reporting requirements, together with regulatory directives mandating information sharing between payers and providers, is accelerating the adoption of the Smart-on-FHIR® interoperability approach to improve the capture, storage, and dissemination of patient medications. Mandated compliance with general and specific privacy, security, and other health-protection policies and regulations, or adherence to laws and constitutions, may inhibit timely response to collective initiation of integrated data-composite exploration or to collective adoption of relevant modelling standards which such exploration may subsequently reveal is needed (H. Holmes, 2016).

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

9. Policy and Governance Implications

Advances in informatics offer opportunities to reduce the fragmentation of care that patient safety experts identify as a barrier to safe medication use across multiple sectors (Abebe et al., 2022). The potential impact is pronounced for patients transitioning across sectors following acute care, palliative or end-of-life care, or complex regimens comprising high-risk medicines. Formal, systematic governance and framework agreements support effective interdisciplinary engagement across and among the health, social, and community support sectors. High-value national programs at the intersection of Health Informatics and patient safety invite cross-sector partnerships in specific domain areas, technologies, and substantive improvement/support topics (J. Embi et al., 2019).

Applicable policies, standards, and guidelines emerge from government, research, and industry-sector agencies and organizations. A variety of messages, formats, and dissemination channels reach the spectrum of decision-makers and stakeholders. Governments prioritize preparation, coordination, and maintenance of a workforce capable of translating what health informatics can do into practice. Identifying, adapting, and implementing policies, programs, projects, curricula, competencies, and continuing education from the Credentialing Joint Committee and related initiatives support responsible progress.

9.1. Standards, Guidelines, and Accountability

The unprecedented rise of regulations and standards in the healthcare sector demonstrates the substantial recognition of the necessity to govern the quality and safety of delivered services and products. In Canada, a critical governance framework involving multiple stakeholders is being gradually established for people-centred care, with their active participation being instrumental to encouraging joint efforts, defining the value of integrated care, and forming a unified management mandate that underpins such an approach. Accountability mechanisms within this framework promote transparent and ongoing inclusive dialogues among various governance levels to establish common objectives, motivate and track performance, and allocate operational responsibilities (Sullivan-Taylor et al., 2022).

The COVID-19 pandemic highlighted the urgent requirement for comprehensive health information access across various sectors and support for interconnected integrated persons' digital health information (W Bates et al., 2022). The necessity for effective integrated medication management is also recognised, with multiple healthcare stakeholders from diverse settings running specific initiatives. Canada has instituted a national system known as Interoperable Canadian Medication Use File (iCMUF) to deliver structured real-time medication details for subscribers across different settings to enhance prescription correctness, medication adherence, service continuity, and safety.

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

The significant disconnection across clinical sectors and the absence of integrated standards further hinder the execution of alteration and the successful encounter of these diverse necessities in Canada. Consequently, frameworks, methodologies, principles, and instruments that have been jointly developed and serve as operating procedures have been proposed for structured articulation, adaptation, dissemination, and engagement.

9.2. Incentives for Interdisciplinary Collaboration

Medication safety research must address how to encourage interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary collaboration in multi-sector systems. Four channels for generating incentives have emerged: 1. Financial Compensation. Ca98b805f-3048-44ca-85b7-7b062a92788cicians receive substantial financial rewards for achieving quality-indicator benchmarks, including those related to medication safety; consequently, organizations that are part of a care network reimbursed on a fee-for-service basis are incentivized to coordinate care and collaborate on safety improvement. 2. Creation of Interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary Safety-Improvement Teams. Interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary teams—including ca98b805f-3048-44ca-85b7-7b062a92788cicians, pharmacists, and information-technology staff—can apply knowledge and expertise to medication-safety challenges. Organizations that designate time for regular meetings among members of these teams express a strong commitment to medication safety (Lin et al., 2020). 3. Goals for Integrating Health-Care Systems. Large health organisations pursue mergers, acquisitions, health partnerships and affiliations, and regional collaboratives to integrate health-care delivery across the continuum of acute and post-acute care. Expanded collaboration, information sharing, and new opportunities for interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary safety-improvement teams are established as a natural result. Health systems, financial organisations, governmental groups, agencies, and non-profit organisations can encourage this integration by requiring enhanced interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary safety collaboration as part of economic incentives or financial assistance, and by providing funding to improve medication safety across the spectrum of health care. 4. Establishment of Safety-Improvement Networks. Systems that do not benefit from the aforementioned integration opportunities may join regional or national medication-safety networks on a voluntary basis. These networks span multiple delivery sectors, foster interdiscipa98b805f-3048-44ca-85b7-7b062a92788cary collaboration, and generate incentives through government mandates, grants, or other funding opportunities for enhancing medication safety. Supporting such networks across sectors can stimulate greater safety improvement in the absence of more direct delivery-system integration.

9.3. Workforce Development and Education

Healthcare organizations in a variety of settings must foster the ongoing development and assessment of workforce competencies to cultivate a culture of medication safety and

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

interdisciplinary collaboration (Schubert et al., 2022). Institutions identify gaps in the knowledge, skills, and attitudes of staff and students through appropriate transition-point evaluations, performance monitoring, and multistakeholder collaboration, then implement strategic consortia activities and instructional interventions to close them (Abebe et al., 2022). Competencies encompass student learning outcomes and educator attributes, and structures guide course design and training for diverse health professional programs. In addition to curricula for outreach and in-service training, continuing education for practicing professionals should include content on informatics-based tools essential for effective medication management, collaborative team functioning, and communication through multifactorial channels and varied media and formats.

10. Conclusion

Past efforts to improve medication safety have elevated attention to cross-sector collaboration, especially during transitions of care across hospital, community pharmacy, long-term care, home health, and payor-provider settings. Such transitions remain vulnerable to safety lapses, particularly with high-risk medications and multifaceted patient histories. Addressing this challenge calls for integrated health informatics approaches that span sectors to collect, analyze, and share rich medication-related data and workflows in support of patient-centered, interdisciplinary teamwork (Abebe et al., 2022).

The use of ATW involves rethinking how spaces are designed and utilized, from physical artifacts to rules and conventions governing their properties and roles. The aim is to foster a more sustainable adoption of working practices for dealing constructively with uncertainties in design. Deficient documentation and information overload complicate the task of knowledge accumulation, prevent modifications to satisfy new contextual requirements, and result in the obsolescence of solutions that could still be useful elsewhere (W Bates et al., 2022).

References:

1. Abebe, E., Bao, A., Kokkinias, P., L. Russ-Jara, A., & Degnan, D. (2022). Maximizing student potential: Lessons for pharmacy programs from the patient safety movement. ncbi.nlm.nih.gov
2. Elena Herrera, M. (2015). Improving Patient Medication Reconciliation Participation and Compliance Through Education. [PDF]
3. W Bates, D., Cheng, H. Y., Cheung, N. T., Jew, R., Mir, F., Tamblyn, R., & Li, Y. C. (2022). 'Improving smart medication management': an online expert discussion. ncbi.nlm.nih.gov

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

4. Lapkin, S., Levett-Jones, T., & Gilligan, C. (2014). The effectiveness of web-based interprofessional learning modules on health professional studentsu27 behavioural intentions in relation to medication safety: A quasi-experimental study. [PDF]
5. M. Borycki, E. & W. Kushniruk, A. (2022). Health technology, quality and safety in a learning health system. ncbi.nlm.nih.gov
6. Ratanawongsa, N., L. S. Chan, L., M. Fouts, M., & J. Murphy, E. (2017). The Challenges of Electronic Health Records and Diabetes Electronic Prescribing: Implications for Safety Net Care for Diverse Populations. ncbi.nlm.nih.gov
7. Almalki, A., Jambi, A., Elbehiry, B., & Albuti, H. (2023). Improving Inpatient Medication Dispensing with an Automated System. ncbi.nlm.nih.gov
8. Heeney, C., Bouamrane, M., Malden, S., Cresswell, K., Williams, R., & Sheikh, A. (2023). Optimising ePrescribing in hospitals through the interoperability of systems and processes: a qualitative study in the UK, US, Norway and the Netherlands. ncbi.nlm.nih.gov
9. Elysee, G., Herrin, J., & I. Horwitz, L. (2017). An observational study of the relationship between meaningful use-based electronic health information exchange, interoperability, and medication reconciliation capabilities. ncbi.nlm.nih.gov
10. Koch, S. (2013). Achieving Holistic Health for the Individual through Person-Centered Collaborative Care Supported by Informatics. ncbi.nlm.nih.gov
11. Hahn, L., Buckner, M., B. Burns, G., & Gregory, D. (2014). How space design and technology can support the Pharmacy Practice Model Initiative through interprofessional collaboration. [PDF]
12. Lang, A., Macdonald, M., Marck, P., Toon, L., Griffin, M., Easty, T., Fraser, K., MacKinnon, N., Mitchell, J., Lang, E., & Goodwin, S. (2015). Seniors managing multiple medications: using mixed methods to view the home care safety lens. ncbi.nlm.nih.gov
13. L. Clarke, J., Bourn, S., Skoufalos, A., H. Beck, E., & J. Castillo, D. (2017). An Innovative Approach to Health Care Delivery for Patients with Chronic Conditions. ncbi.nlm.nih.gov
14. Habli, I. & Paul White, S. (2018). Hazard and Risk Analysis of Health Informatics: Fundamental Challenges and New Directions. [PDF]
15. Recsky, C., Stowe, M., L. Rush, K., MacPhee, M., Blackburn, L., Muniak, A., & M. Currie, L. (2023). Characterization of Safety Events Involving Technology in Primary and Community Care. ncbi.nlm.nih.gov
16. Ledlie, S., Gomes, T., Dolovich, L., Bailey, C., Lallani, S., Sinclair Frigault, D., & Tadrous, M. (2022). Medication errors in community pharmacies: Evaluation of a standardized safety program. ncbi.nlm.nih.gov

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

17. Marcilly, R., Ammenwerth, E., Roehrer, E., Nies, J., & Beuscart-Zephir, M. C. (2018). Evidence-based usability design principles for medication alerting systems. [PDF]
18. G. Kahn, M., S. Brown, J., T. Chun, A., N. Davidson, B., Meeker, D., B. Ryan, P., M. Schilling, L., G. Weiskopf, N., E. Williams, A., & Nahm Zozus, M. (2015). Transparent Reporting of Data Quality in Distributed Data Networks. ncbi.nlm.nih.gov
19. P. Stolldorf, D., H. Ridner, S., J. Vogus, T., L. Roumie, C., L. Schnipper, J., S. Dietrich, M., G. Schlundt, D., & Kripalani, S. (2021). Implementation strategies in the context of medication reconciliation: a qualitative study. ncbi.nlm.nih.gov
20. J Leonard, K. & F Sittig, D. (2007). Improving Information Technology Adoption and Implementation Through the Identification of Appropriate Benefits: Creating IMPROVE-IT. ncbi.nlm.nih.gov
21. Jeffries, M., L. Phipps, D., L. Howard, R., J. Avery, A., Rodgers, S., & M. Ashcroft, D. (2017). Understanding the implementation and adoption of a technological intervention to improve medication safety in primary care: a realist evaluation. ncbi.nlm.nih.gov
22. Enticott, J., Johnson, A., & Teede, H. (2021). Learning health systems using data to drive healthcare improvement and impact: a systematic review. ncbi.nlm.nih.gov
23. Jia, Y., Lawton, T., Paul White, S., & Habli, I. (2019). Developing a Safety Case for Electronic Prescribing. [PDF]
24. BC Lee, S., LY Lee, L., SD Yeung, R., & TS Chan, J. (2013). A continuous quality improvement project to reduce medication error in the emergency department. ncbi.nlm.nih.gov
25. A Young, R., P Gurses, A., G Fulda, K., Espinoza, A., M Daniel, K., N Hendrix, Z., M Sutcliffe, K., & Xiao, Y. (2023). Primary care teams' reported actions to improve medication safety: a qualitative study with insights in high reliability organising. ncbi.nlm.nih.gov
26. G Anderson, J. (2006). Regional Patient Safety Initiatives: The Missing Element of Organizational Change. [PDF]
27. J. Embi, P., Richesson, R., Tenenbaum, J., Kannry, J., Friedman, C., Neil Sarkar, I., & Smith, J. (2019). Reimagining the research-practice relationship: policy recommendations for informatics-enabled evidence-generation across the US health system. [PDF]
28. S. Valdez, R., S. Ancker, J., & C. Veinot, T. (2022). Provocations for Reimagining Informatics Approaches to Health Equity. ncbi.nlm.nih.gov
29. H. Holmes, J. (2016). Privacy, Security, and Patient Engagement: The Changing Health Data Governance Landscape. ncbi.nlm.nih.gov
30. Sullivan-Taylor, P., Suter, E., Laxton, S., D. Oelke, N., & Park, E. (2022). Integrated People-Centred Care in Canada – Policies, Standards, and Implementation Tools to Improve Outcomes. ncbi.nlm.nih.gov

Power System Technology
ISSN:1000-3673
Received: 05-07-2025 Revised: 20-08-2025 Accepted: 30-08-2025

31. Lin, H. J., Ko, Y. L., Liu, C. F., Chen, C. J., & Lin, J. J. (2020). Developing and Evaluating A One-Stop Patient-Centered Interprofessional Collaboration Platform in Taiwan. ncbi.nlm.nih.gov
32. Schubert, C., Bruce, E., Karl, J., Nahikian-Nelms, M., Pennyman, N., Rizer, M., Vrontos, E., & Hebert, C. (2022). Implementing a Novel Interprofessional Clinical Informatics Curriculum. ncbi.nlm.nih.gov