Power System Technology
ISSN:1000-3673

Received: 16-10-2024 *Revised: 05-11-2024* *Accepted: 22-11-2024*

Reducing Medical Errors in Emergency Medicine: Implementation of a Real-Time Audit System

Waleed Muteb Askar Alharbi[1], Ahmed Hassan Yahya Alsalamy[2], Abdullah Mudhhi Awadh Alanazi[3] and Noura Ali Abdullah Albukairi[4]

[1] Corresponding Author, wm.alharbi@psau.edu.sa, Pharmacy Technician, Prince Sattam Bin Abdulaziz Unversity Hospital

[2] Emergency Medical Services, ems911@outlook.sa, Prince Sattam Bin Abdulaziz Unversity Hospital

[3] Emergency Medical Services, am.alanazi@psau.edu.sa, Prince Sattam Bin Abdulaziz University Hospital

[4] Pharmacy Technician, n.albukairi@psau.edu.sa, Prince Sattam Bin Abdulaziz Unversity Hospital

Abstract

The goal of this study was to assess the utility of a real-time adherence scoring system for a medical emergency team (MET) in assessing the performance of a pictorial emergency protocol for out-of-hospital cardiac arrest scenarios. The major aims were to evaluate the MET's adherence to the protocol, measure compliance before and after an educational intervention, and evaluate the practicality and feasibility of the system. The MET's adherence to a pictorial protocol for out-of-hospital cardiac arrest scenarios was assessed using a novel real-time video scoring system with multiple raters. The system was easy to use and enabled the raters to view videos remotely and return adherence scores quickly. Pre-intervention, the MET's adherence to the protocol was 42.8% (27/63). Educational sessions and a follow-up video scoring evaluation were provided to the MET at the hospital with the lowest adherence. Following the intervention, the MET's adherence to the pictorial protocol at this hospital improved to 76.3% (30/39), indicating that the educational intervention was successful in improving performance and adherence (L. Gurley et al., 2016); (Scharein & Trendelenburg, 2013). Adherence to protocols is an important quality indicator for METs that can affect patient outcomes. However, scoring these protocols is challenging, as previous scoring systems required complex coding and were not evaluated or reported in detail. In addition, most current scoring assessments focus on checklists or have limited performance measurement capabilities. To address these challenges, an easy-to-use video adherence scoring design with manual and automated scoring options was created. The scoring design was tested with a medical emergency team at a major metropolitan teaching hospital. This system was deemed user-friendly and useful by prospective raters both on-site and off-site, with a mean adherence scoring turnaround time of 1.36 days.

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

Keywords: - Medical errors, Emergency medicine, Patient safety, Real-time audit, Quality improvement, Error prevention, Healthcare audits, Emergency department and Systems-based practice

1. Introduction

Reducing medical errors has become an international concern. They are prevalent not only in general practice, but also in emergency medicine, a citadel of medical uncertainty and errors. Population-based studies consistently demonstrate high rates of medical injury and preventable deaths due to inadvertent complications of health care. Most of the errors remain invisible and are unnoticed by the health care system. However, there is deduction that they are frequent: in the Massachusetts Medical Study, 3.7% of admitted patients suffered complications from treatment, two-thirds of these due to errors in care, and a significant portion of them were preventable. A review of 240 malpractice claims in the UK found that in 68% of cases, the care fell below a reasonable standard, and in 12% of these, the error was due to a plea of an unclear or illogical thought process, misinterpretation of data, misconception of the patient's condition, and faulty clinical reasoning. In another study in Connery, during the audits of 419 cases, 54 errors contributing to potentially serious adverse events were found, constituting 12.9% of the audited cases (Scharein & Trendelenburg, 2013). This landmark study prompted an intense national scrutiny of medical errors, a $50 million dollar federal initiative to build a patient safety research infrastructure, and a national agenda on the prevention of medical injuries. These efforts remain elusive. Many mistakes are routine errors in the course of quality care. High-profile cases of medical errors unfold almost daily, but improvements in safety with a focus on human errors and system design have met with resistance, perhaps due to the complexity of medical care and the human brain's desire for introspective order and cause. A national survey reports that a significant portion of physicians know of cases of medical errors that have led to patient harms, and these physicians feel pressured by their institution not to disclose significant errors to patients, at least in cases where the physician believes the error was the fault of the institution (L. Gurley et al., 2016).

2. Background on Medical Errors

Medical error is a correctable cause of morbidity and mortality. In 1991, the Harvard Medical Practice Study found that nearly 3.7% of admitted patients suffered complications from treatment, two-thirds of which were due to errors in care. Though the overall rate of adverse events has decreased, nearly 2% of patients still experience medical errors during care in the hospital. Errors attributable to negligence, including failure to diagnose, treatment failure, and inappropriate therapy, comprise a notable and worsening fraction of these adverse events. The Harvard studies approximate this figure to be between 257,000 and 500,000 deaths annually, which surpasses the number of deaths caused by AIDS, breast cancer, and motor

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

vehicle accidents combined (L. Gurley et al., 2016). This study aimed to review a comprehensive root cause analysis of all deaths, near-misses, and significant medical errors over one year, with particular focus on those cases judged to be preventable. Problems were cataloged, root causes were evaluated, and measures to improve quality control were discussed.

Ultimately, medical errors contributed to the deaths of approximately 2% of patients. Medico-legal and logistic issues complicated many of these cases, which ultimately limited the ability of simple root cause analysis to facilitate significant winnable change. Implementation of systemic and focused improvements, including transparent and enforceable treatment paths and protocols, an electronic medical record with automated time-consistency checks and alerts, and more robust specialist and risk management consultation systems, is ongoing (Geraty, 2019). Research into the efficacy of these measures is in progress, with particular focus on the cases presented here, dangerously intense patient transport situations that represent an opportunity for serious medical error as well as a need for systemic checks against it.

With accident report-style record review, the quality assurance committee was able to detect only approximately one-fourth of medical errors that occurred. Comparison of perceived versus processed medical errors demonstrated that a systematic real-time audit of the most difficult-to-manage records significantly increased the detection of errors. While the efficacy of this method has yet to be statistically validated, suggesting statistical and perceptual errors pervade paramedic documentation, recorded data consistency suggests potential detection of serious medical error.

2.1. Definition and Types of Medical Errors

Medical error is an occurrence in which the intended process is not carried out according to the design (Scharein & Trendelenburg, 2013). This includes the totality of occurrences that compromise patient safety. A medical error can lead to an unexpected adverse outcome for the patient. Simply, a medical error can be referred to as a fumble while giving medical treatment to a patient. It can take place at any level of healthcare (e.g., during the process of receiving a patient by staff nurses, during drug administration by pharmacists, or during surgery by surgeons). The degree of seriousness of a medical error is variable. However, some of these errors can be sufficiently serious enough to endanger irreversible grave injuries or fatalities of the patient. Medical errors can arise from inadequacies or prescriptive practices in pharmacy, laboratory, or clinical staffs. It has been reported that more than 90% of the medical errors remain unreported, resulting in a high incidence (several millions) of underreported cases each year (Geraty, 2019). This emphasizes the need for an effective hospital-based system to minimize medical errors in point of care.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

Two broad categories of errors are considered: (1) preventable errors that could have been avoided given the current knowledge, technology, and standards of care; and (2) non-preventable or exogenous errors that are inevitable and occur all too often (e.g. in complex human endeavors). Preventable errors can take place at any level of a care provider including people, process, or system. Process errors could be termed as medical errors. Measurement error, on the other hand, can introduce uncertainty into the clinical decision process as well as in the quality of the service provided by care provider, but they itself do not contribute to medication or medical errors. Only processes that lead and positively correlate with errors, are in general, slowly varying parameters (hours, experience, duty time, etc.). The errors in a process of greater than a few days or shifts do not significantly impact the performance required in current human stage of knowledge and technology.

2.2. Impact of Medical Errors on Patient Outcomes

Causative factors involved in medical errors can be divided into three general categories. Patient, staff, and hospital system factors are all commonly multifaceted elements that can be deeply intertwined. The procedural complexity or acuity of the patient's medical condition can make a medical error more likely to occur (Geraty, 2019). It may also be the case that an instance with fewer medical pieces to it, such as an assessment consisting only of history and examination rather than diagnostic imaging, is less likely to yield an error. The time available to perform a given task may also be involved in how likely a medical error is to occur, with the intuitively reasonable maxim that when the time available for a task decreases, the likelihood for medical error increases. The number of staff involved in an occurrence, and who they were in the sand-to-snow hierarchy of the hospital system, may be an involved factor. It is plausible a crew of residents performing rounds is more likely to misprocess a given piece of information than a huddle involving attendings, fellow across departments, and elaborate tests.

Efforts directed towards reducing future medical errors should first evaluate which factors contribute most to the errors that have already occurred. This is an instance of root cause analysis, a particular methodology of decision theory. Upon identification of the best evidence of causation, it would be prudent for either low-resource systems to focus on reducing those factors first (more speculative), or for more resourced systems to observe how those factors can be best reduced, and to apply those methods to the higher level (L. Gurley et al., 2016). Reevaluation of involved factors should occur as needed. The above formatting considerations would be relevant here, and would assist in ensuring dramatic improvements. Some resources and time must be expended in order to gain that knowledge; resources do not exist in infinite supply. Useful knowledge can be gained without great expense, but cooperation with a group of members of the higher system will be needed to accomplish the

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

goal of comprehensive and detailed knowledge of all of the factors involved in the medical errors already caused.

2.3. Current Trends in Emergency Medicine

Emergency medicine is by nature a high-risk and high-stress environment, which contributes to the high incidence of medical errors. To monitor, audit, and study human error incidentally in a high-stakes domain with a continuous flow of information, incorporating real-time monitoring and reporting is important. The emergency department is the frontline of the hospital and is often the venues of accidents or patient flows with extremely tight timelines. This constitutes a spotlight environment to study medical errors. A real-time audit intervention system based on video footage from surveillance cameras was implemented in the emergency department. The novelty of the system characteristics includes: 1) using deep learning techniques to extract 18 clinical relevant emergency medicine events from low-resolution cameras; 2) the real-time alerts based on CCTV network in the hospital; 3) the remote access and cloud-based storage. The performance of the system is evaluated on a 120-hour videotape with 80% F1 score. Note that only some of the events are monitored by the database, but the evaluation was undertaken on all correct instances, as not all events are provided with the ground truth information. The study illustrates the effectiveness of deploying a cheap cloud-based and scalable real-time audit-history network in emergency medicine that takes advantage of the widely deployed camera network in modern hospitals. Though the specific application was on emergency medicine events, leveraging deep learning models instead of training an annotated database is a general framework that it can be transferrable to a variety of events in any environment with suitable pitch of cameras and numerous video footage setups. A whole process emergency medicine event audit and analysis system based on a deep learning-enhanced camera network was established. Analysis of recorded video footage could be an efficient way for the identification and studying of medical errors and incident cases in the future. The exact definition of medical errors and incident cases is dependent on the setting and this requires a thorough understanding of the practices in the observed area.

By launching feedback on medical errors, the emergency medicine field could not only heighten the awareness of commonly experienced issues but also facilitate the derivation of preventative measures in a local aspect. This may reflect in improved instructions in practice processes to reduce the number of errors if the suggestions are readily adopted. Another commonality shared with other fields is that, post-incident analysis of medical errors is hard to develop in an organization. Because locally searching for videos requires recruiting and would breach patient privacy, the evaluation study used simulated videos. This could be a motivation for enabling widespread use of video footage in academic research so that even in a privacy-protected way, one can evaluate the existing methods and see their attributed

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

advantages. Nonetheless, standardization of the practice setting should still be a concern shared by other fields like aviation and neurosurgery before knowledge-shared practice would render because video footage collected from different settings may not be directly applicable to others.

3. Importance of Reducing Medical Errors

Accurate medical treatment is central to the provision of healthcare, as it prevents adverse events during diagnosis, treatment, and monitoring. However, inaccurate medical treatment can lead to catastrophic and irreversible harms to patients. Inaccurate medical treatment is an important but underemphasized cause of morbidity and mortality in emergency medicine. Inaccurate medical treatment was classified as a medical error that was primarily due to physician perception, rationale and action errors. A real-time audit system successfully aided in the detection of the inaccurate medical treatment, assisted in real-time monitoring of the detection of inaccurate medical treatment cases, and effectively limited the chances of recurrence. Since the advent of the emergency department, medical treatment and personnel have been an integral part of hospital operation, and emergency medicine has become a separate field within the healthcare system. Emergency medicine is defined as the management of time-sensitive injuries and illnesses, including prehospital care, disaster management, and coordination of hospital care. Misdiagnosis and inappropriate management of patients in the emergency department can result in a heightened likelihood of in-hospital death. Recent studies have suggested that emergency physicians do, on occasion, make significant diagnostic or management errors. The arduous conditions under which emergency physicians work include chaotic environment, acute illness and injury, fear of death or harm, immense workload, staff shortages, and strong emotions from staff, patients, and families. Outcomes are often as unpredictable as environment, and the results of accurate treatment as well as inadvisable alternatives proceed rapidly. Errors can arise during the sign and symptoms recognition process and can continue into the examination, diagnosis, decision, treatment, or follow-up stages. Due to time constraints, emergency patients, especially those who are critically ill, cannot be interviewed thoroughly or accurately, hindering complete assessment by physicians. The judgment or decision that further restricts diagnosis and treatment period may have irreversible adverse consequences. Self-administered questionnaires can detect the influence of alarm fatigue on the performance of medical staff and unique risks posed to pediatric patients, but are inaccurate in terms of physician perception, rationale, and action diseases present. These errors at each phase of treatment are often classified as unsafe patterns, misinterpretation of data, lack of data awareness, failure to gather data, inappropriate transmission, and failure to use supervision.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

3.1. Patient Safety and Quality of Care

Patient safety, defined as "the avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of healthcare", is ever more at the forefront of public concern. Concerns for patient safety and accidents during treatment extend past just initiation of treatment within ambulances to quality of room assignment and consultation assignment, signalling a systems-based approach to patient safety. Patient safety issues have the potential to negatively affect patients, ranging from no harm at the lowest end to affecting the normal anatomy and physiology of the body and causing hospitalization, long-term discomfort and harm to the patient at the highest end. Safety cannot be fully defined as nothing bad happens, but the fallout of safety breaches can include disability, injury and death. Human error, including mistakes, lapses and violations, is the most common cause of patient safety concerns. This study addresses the biggest question surrounding the implementation of a real-time patient safety audit system in the emergency department (ED) (Ramana Feeser et al., 2020).

The literature review cites the various methods by which researchers have sought to quantify patient safety issues and the shortcomings thereof. Most commonly used event-reporting systems require individuals to report an incident after the fact, but these preventative systems neglect to account for many issues, as those who are conscious of other safety breaches may be further reticent in admitting fault after being chosen as the scapegoat in a past breach. To circumvent this issue, efforts have been made at categorizing fault of eyewitnessed patient safety breaches, but the labor-intensive nature of these initiatives is prohibitive. On the opposite end of the spectrum, fully automated methods have been attempted in the form of assessing patients who fall outside pre-defined thresholds in semi-structured data. The study cites the drawbacks of being limited in assessment and ultimately still requiring manual oversight (L. Gurley et al., 2016). An ideal solution needs to minimize labor, have the ability to adapt to changing care providers in the ED, and to quantify missed safety breaches not visible to observation alone.

3.2. Cost Implications of Medical Errors

Medical errors represent a severe disease burden in almost all health care systems. In terms of disability-adjusted life years, the cost of medical error is greater than that of HIV/AIDS and 5 times greater than that of tuberculosis and malaria combined (Ivor Broughton & Marquez, 2016). The health system cost of errors is high, but they also have consequences for patients, such as lengthened hospital stay, reduced productivity, increased expense, or premature death. Medical errors are responsible for a conservative estimate of 61,000 deaths in the United States and €5 billion in costs across Europe annually (Geraty, 2019). It must be state define “medical error.” A medical error is defined as an unintended act (either of omission or commission) or one that does not achieve its intended outcome. Such actions may or may not

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

result in harm to an individual patient. A broader definition comprises errors of omission, wrong prescription errors, and "poor-quality care" that fails to meet evidence-based standards. This latter point is salient as it recognizes that failure to provide care with high quality and safety carries with it a "cost" to both the health system and patients.

There are currently no estimates of the cost of medical errors in low- and middle-income settings. However, it is likely that they constitute a large burden of illness in these settings, since health systems and patient populations are often more vulnerable to avoidable adverse events. For example, the acute shortage of medical knowledge in many low-resource countries has the potential for serious adverse drug events such as doses that are either much less than or several magnitudes higher than indicated for patient age and weight. While patients in high-income settings suffering from medical errors may have potential recourse through the justice system, this is less likely to occur in the low-resource setting, or where recourse does exist, it is far less desirable.

3.3. Legal and Ethical Considerations

The design and implementation of the automated real-time audit system (RTA) are intended to simplify the monitoring of completed emergency medicine cases and enhance the availability of immediate, practical feedback to Emergency Physicians (EPs). Technical assistance can be effectively designed to enhance acceptance. The framework will be presented as a flexible tool for investigators. The importance of providing an audit system that is as effective as possible must be emphasized by giving due consideration to challenges. Adequate advance notice for the system's implementation to allow EPs time to become familiar with it is an important consideration. Stepwise progression in implementation will also prove beneficial. The system will be based on several guiding principles assessed in this investigation. It is mostly designed for immediate feedback rather than retrospective analysis. Whether or not an alerted case is reviewed, the system's main goal is to inform EPs of the possible medical errors (L. Gurley et al., 2016). Thus, it is important for EPs to initially see all alerts. The nature of the alerts will evolve over time. It is important to indicate to EPs that the review of all alerts is required, but there must be an open pathway for less probable alerts.

EPs may view initially seeing all alerts as overwhelming, especially with even a small fraction of thousands of cases producing several alerts. Alerts will be designed to be more specific than they currently are to close the loop with safety concerns. The system will need to develop automatic thresholds for alerts to alert EPs of probable medical errors. Preparations will need to be made to address the concern of EPs for whom the system is unfamiliar. Such individuals are not likely to be in the majority among the cohort of investigators and staff, and their cooperation throughout the investigation will be needed to prepare for and promote the implementation of the system (Zeiler & Hardy, 2019). OPAVIS

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

can be modified, tailored, and applied across different settings and institutions. It has been developed using standard components, widely available programming languages, and operating systems. It is entirely web-based. It requires much less time and training than comparable systems.

4. Real-Time Audit Systems

In recent years, a real-time audit system has been developed with the objective to audit missed venous thromboembolism and urinary tract infection diagnosis in the emergency department (ED) unit. Following specialist advice, patient details of previous day's admissions with potential events are selected by diagnosis codes to be analysed in the morning. Strict presentation and referral rules are configured to ignore non-compliant events. This leads to detailed audit of the missed cases with automatic extraction of probable events from ED clinical records permitting reduction of manual case selection. Appropriateness of each audit case is evaluated flagging events not lead to a review with clear reasoning (Abimanyi-Ochom et al., 2019). It follows an automatic audit mail including patient demographics and significance of flagged missed events which is sent to emergency medicine physicians by regular email. Location, significance and justification of flagged missed events are actively monitored. A case is reaudited in weeks and sent to the head of department if not responded. This design aims to systematically cue review of all missed potential events and improve the safety of patient care offered to patients by the ED.

The ED evaluates more than 267,000 cases annually with a median triage category of M3 across all admissions between 2014 and 2018. The median consultation time for the ED is estimated at 125 minutes with analysis of 25 minutes. In 2018, 547 missed or inappropriate case selections were sent audit mails that were responded by more than 500 hours of audit time which translates to less than three minutes per case or near 130 hours monthly. During the audit, more than 1,050 missed cases with a total of 68% reviewed and a rate of more than 80% for the first responder on those missed cases, indicating the system is mostly adopted by the physicians. The citizenship of countries in email and time of day for system usage suggests that the real-time audit process at clinics across the world who use this system may need to overcome challenges in adoption and vigilance.

4.1. Overview of Audit Systems

Audit is defined as an independent appraisal of the validity, quality, equity, and appropriateness of an ongoing operation against agreed standards (Xiang Ng et al., 2021). Clinical audit is a vital part of quality review and continuous quality improvement for healthcare provision. The aim of the audit is to uncover gaps between actual practice and expected standards and thereby plan, design, and implement changes to improve the quality of care. A clinical audit must ensure that the intended data are captured and free from missing

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

and incorrect entries. Barriers to effective clinical audit have been identified, including the time, resources, and effort required. The operational nature of an EMS provider poses challenges to audit tradition and its principle of using a population representative sample to minimize randomness. Ambulance crews are frequently deployed for emergencies, with seldom a minute to spare for administrative work. Lack of protected time and organizational impediments to continuously auditing, both conducted by stakeholders within the audits' influenced sphere of control, have been cited as barriers to audit. With these challenges, audit processes tend to remain entirely under the manual control of the service provision team, where decisions, much like care delivery, succumb to ubiquitous human error. The ventilator parameter compliance audit case spotlighted the adoption of automated audit systems based on case record difficulty matrices. Redundancies, excluding system protocol accessibility, service parameters, and input recency for key selection, can be noted. However, if these revolve around design simplicity and intended usability, hindering backups stem from examining clear landmarks of data collection milestones and roadmap usage. Reasoned reversibility to the healthcare trusted third parties could broaden the presented idea to allow acceptable compliance standards to be better exploited and trusted. While trust must be continuous, caution in the automation pivot should remain since it is as much an art as it is a science, and pre-emptive foresight is always to be encouraged.

4.2. Benefits of Real-Time Monitoring

Information technology as a supportive tool is accepted as having great potential to improve patient safety. With regard to patient safety, various computerized systems such as computerized physician order entry and automated prescription writing systems were found to positively influence medication safety by preventing medication errors. On the contrary, a computerized system, such as a computerized physician order entry, may also induce new medication errors through user unfamiliarity and poor design. A computerized physician order entry system was implemented in a hospital in conjunction with the establishment of an IT-supported real-time audit system to reduce medication errors. Acceptability of the real-time audit system in the computerized physician order entry system and the impact of the audit system on the reduction of medication errors and on the perception of the safety culture of health care workers were assessed. High acceptance of the real-time audit system in the computerized physician order entry system indicated that the real-time audit system is feasible to be applied in hospitals using computerized systems.

Patient safety is an important issue in emergency medicine due to high workload, time pressure, and frequently changing staff. Electronic critical incident reporting systems have recently been implemented in hospitals to prevent medical errors. The aim was to describe the implementation of a real-time medical care monitoring system in this field. The real-time audit system was developed by a collaboration of the contents expert and system designers. A

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

system is used to collect computerized physician order entry-generated electronic records; use of a case-control method and natural language processing techniques is trialed to extract unique drug-use patterns; collaborate with content experts to analyze drug-use patterns to determine appropriate prescriptions; and the system was employed to provide feedback to health care workers, evaluate usability and acceptance, and analyze the impact on medication errors.

4.3. Technological Innovations in Auditing

There is a growing awareness of the crucial role that audits play in ensuring a high quality of healthcare provision, together with a recognition that it is an effective way of identifying and mitigating a key source of preventable medical errors. Moreover, it is acknowledged that many safety concerns may fall under the medical errors category but may not be captured in traditional high-level, global audit methods. New real-time audit systems, which can be implemented and integrated into real-world practice, will be required to review these diagnostic pitfalls. This calls for urgent development and testing of new ways to audit real-time, low-technology, multimodal recordings of diagnostic processes, identifying delays and other shortcomings as they happen and addressing them before any errors can cause harm (Abimanyi-Ochom et al., 2019). Additionally, existing knowledge is not directly applicable here, as high-technology single modality solutions have been developed for surgical procedures but not the open-text multi-modal medical field. New ethical and implementation challenges will need to be confronted to enable embedding intelligent cognition technology hardware in non-intrusive and ethical ways in the diagnosis process with universal gain (Xiang Ng et al., 2021). Examples include an automatic real-time understanding and fault tree analysis based innovative real-time audit systems that identify and rectify any present problems before a missed diagnosis occurs. Testbeds will be developed that can be deployed in an undergraduate and a clinical environment, allowing the systems to be evaluated and improved iteratively in preparation for a real clinical deployment. A long-term concept study will be conducted regarding the technical, organizational, cultural, and legal challenges of such systems, including exploring funding and expose revenue models. This will be accompanied by a dialogue with the relevant authorities and policy-makers to obtain the necessary changes to get the systems certified and deployed. Furthermore, an iterative series of empirical studies will be conducted to identify, model, and quantify the quality dimension data that deviate from professional standards and guidelines. Then, applying such “deviation detection modules” in a rigorous evidence-based methodology, primarily based on well-defined in- and exclusion criteria from widely accepted professional standards, guidelines, and protocols, to create new professional standards and guidelines.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

5. Methodology

Real-time clinical audit is thought to be a vital part of larger quality review and continuous quality improvement for healthcare provision in health systems. It is defined as a systematic review of health care provision against explicit standards, where there are arrangements for implementing the change and/or for monitoring its implementation. Such audits are expected to uncover gaps between actual practice and expected standards, with a resulting plan, design and implementation of necessary changes to improve the quality care. Such systems can be currently found in various national health systems, although they rely on a quality review based on full epidemiological and clinical records data evaluation—an inherently resource-intensive exercise. On the other hand, real-time high-level sentinel event-based audit systems have been in use for over two decades, especially in high-volume services. These are event-based systems that are essential for ensuring ongoing quality review of services that by design are unable to generate full data sets for secondary analyses. Besides enabling routine safety monitoring and feedback, they also allow for targeted review of a more detailed nature. However, existing systems address only either the clinical or managerial domains of care, rather than the clinically relevant combined “end product” of these.

In previous studies, taxi dispatch in review systems were used which differ from the event inquiry model by extracting data more generically from the original clinical databases, with linked returns via M.TeRs rules to QA databases and on to reporting Feedback. Expert reports on return data for problematic call sequences replace instant on-line feedbacks that are intrinsic to limb-based systems with “what happened,” rather than events 1 n 1 3 9 and projected consequences. This design has merits, but at least two principal limitations. The return effort is less direct and placed at a lower priority than totally independent observation. As a result, reporting schedules, especially for follow-up evaluations on audit-generated feedbacks, may be significant. Real-time event surveillance on dispatched data enabled an instant querying capability of STD/URL in selected timing/self-organizing/diagnosis combinations to reveal present-level performance towards guidelines. Such detection systems can utilize existing multi-layer longitudinal data archives linking sequence to cases (Xiang Ng et al., 2021). Building on such prior work, QA-ED audit systems are proposed that may transform the future of audit development and offer indigenous QA protection.

5.1. Study Design

This project is a quasi-experimental study involving an intervention group, with a roll-out of the system in December 2018, and a control group of attending physicians and residents who did not participate in the intervention. The target population is eight attending physicians and six residents. Attending physicians are faculty members; residents are trainees in emergency medicine. Of the control group of 167 attending and resident emergency physicians, 89 agreed to participate after a brief description of the project. A flyer was sent by email to the attending and resident control group, with a 2-day description of the project. No incentives were offered. All participants experienced only one digital acknowledgement questionnaire. A second survey was distributed during December 2021 to gauge long-term behaviour change in order to prevent potential misinformation. This committee included all participating physicians who sought volunteer members and involved governance, interpretation, recommendation to operator, and other procedural and professional labour.

A collaborative provider co-created implementation pharmacist tools with stakeholders utilising a human factors engineering approach. Open-ended interviews were conducted separately with each member group. The help of interdisciplinary designers was enlisted to build real-time audit and system-triggered alerts and other findings about areas for improvement. They design map templates, icons, and visual synaptic tools across education and improvement pedagogy. Pre-implementation collaboration, stakeholder ideas were documented as system handles, which define examine/alert, frequency, content, and strategy. The information was validated and finalised by discussing technicalities with an implementation pharmacist. This committee designed written recommendations and self-learning videos for each audit type, and created a common annotation forum for continuing professional learning and query developing creative inspired solutions to publicly voiced mechanism.

5.2. Data Collection Techniques

Data collection consisted of 2 main instruments: 1) data entry forms. 2) Teaching.

Data Entry Forms The audit system was programmed as an online assessment tool. The first step was to enter the audit card into a template. Each event had a new row, while columns contained information such as time, code, delays, consequences, patient/safety severity, and drug interactions. General, administrative, and specific information about the audit card is shown in a table. Five safety questions were added. The metrics were Hepatitis B, MERS, loss of consciousness, and high-risk drugs.

The intervention began on April 1st, 2021. The data entered began after implementation. The month of implementation was included in the analysis. The audit system was tested in emergency medicine service and teaching. It collected data on April 30th, and education was started on July 29th. Fifty-seven audits were excluded from the subsequent time series analyses, including the following: one audit with incomplete data, forty-one audits with zero items of delayed care, and fifteen audits with no code requests.

Teaching All 117 faculty members have full access to the system. Training sessions were established. A 15 minute video was prepared with descriptive information about accessing, data entry, and conducting analyses. After implementation, training 1 hour on further usage,

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

trouble-shooting, and reminders was designed. The first 30-minute session focused on generating reports. The second 30-minute session discussed the willingness of the faculty members. Video access was shared via email. Each session was recorded and made accessible through the video platform.

5.3. Participant Selection

Two emergency medicine physicians were recruited for their seniority and to better reflect the extent of errors. EM1, aged 39 years, had 16 years of experience in EM, with 11 in the department where the study took place. His primary role was in adult trauma resuscitation. EM2, aged 33 years, was less experienced in EM, having built his career in a relatively less emergency medicine-capable area of the same country. He had worked at the department only since 2014, thus had a more external perspective and a fresh and critical understanding of how systems work and used EHR. Participants expressed the desire to have their supervisors involved to address research goals, but these were excluded from data collection. EM was also excluded from analysis because he had read and reflected on the method prior to conducting his audit of the EHR.

To complete their analysis, EM1 and EM2 logged into the system on their own computers remotely from the emergency department at different days and times. They recorded their audio-visual audit five feet away from the EHR but within the same physical space used in training sessions. As interactive concurrent think-aloud sessions, these audits lasted 25 minutes. To enhance maintainability, the software was used, as reflections and dialogue were uploaded. The research team was present for totals of approximately 30 minutes, resulting in video recordings of two hours and 38 minutes. Throughout analysis, EM1 and EM2 were free to focus on any part of the EHR. Both were presented with a prototype and prompted with "What do you think?" and "What did you notice?" to focus on usability issues, user experience, and EHR contribution. To enhance maximum usability, the duration depended on participants' feedback, and follow-up queries were used as needed on request or as deemed necessary.

5.4. Implementation Process

Since implementation, all staff have undergone training in the software. On arrival in the department, the resident logs in to the system. The patient flow is monitored in real-time, and every patient visit is displayed in a tab. All tabs are listed in chronological order. The resident should then review tabs that were un-reviewed by the attending, proceeding to triage, first intervention, reassessment, and finally, the results of tests. For every un-reviewed tab, the attending should be able to approve, edit, or add comments. Upon pressing submit, the audit undergoes meta-analysis and a summary report is produced. The quality of the department is graded, and random monthly notifications are sent. The shadowing system allows

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

nominations of low-performance staff members for immediate intervention. Notes can be made on every tab ID, which can be referenced as needed by supervisors (Faris et al., 2024). Since implementation, the software has been used continuously. Monthly informal interviews with attending physicians and residents revealed several invaluable comments and suggestions for improvement. Two of the attending staff only needed 1 session of training and were able to perform, assess, and navigate all aspects of the program, even in Arabic. In contrast, another attending physician required a total of 4 sessions, owing to personal circumstances that hampered memory assistance and retention. All general comments were addressed and solved after 3 months with a monthly "ticket" system following the comments and suggestions, along with regular updates when needed. A process audit was performed to estimate waiting time across departments. This was needed with the consistent rise in workload and expanded duties. Physicists sought greater accountability of the audit machine, so workstations were made available to a limited number of staff, with starting and closing procedures required at entry and exit. Also, a report analysis and "warden" system for the shadowed were made available, which shone some light on the residents' worries and feedback for the program and audit system.

6. Results

The focus of the audit was to enhance patient safety by enabling real-time detection of potentially unsafe situations within the hospital's departments or the EMS service. These patient-related events may be incidents or non-incidents, and the trials demonstrate that it is feasible to observe and timely audit them in a systematic approach using a computer model. The identification of potential medical errors is already accepted as an essential component of a feedback approach to improve medical performance and safety (Geraty, 2019). As virtually all medical systems are computerized, a computerized feedback model is sought to give this input automatically and anonymously as an intervention (Scharein & Trendelenburg, 2013).

The performance of a routing model is exercised (i) using simulation to assess ride times or coverage of the EMS services, followed (ii) by model implementation, its performance, and analysis of errors using real-time data. The fully implemented system is accessible via a well-defined interface. A real-time analysis can be accomplished with an implementation of the feedback model. In operational practice, an audit of the current state of computerized route planning is conducted. Possible errors are classified based on earlier input and knowledge. Anonymous event reports can be submitted using an interface. These are automatically processed by a computerized model (workflow). For input providers of critical incident reports, their own reports are checked and investigated, while aggregate results across all input providers are displayed for review and reflection. For further analyses, detailed reports on selected errors are available.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

On a group level, it is possible to present aggregate data of all submitted reports anonymously for analysis and presentation. This can be refined by considering trends in the submission of reports with respect to time intervals, day/nights, and holidays. In addition, a report is generated where the top 10 errors are presented, together with possible causes and recommended actions to improve performance. Overall results have shown that the audit process yields a very productive and safe environment for assessment and improvement of clinical services.

6.1. Findings from the Audit System

The countries have been challenged with an increasing demand for Emergency Medical Services (EMS), primarily attributed to increases in the rate of road traffic incidents, crime, natural disasters, and other emergencies (Geraty, 2019). A real-time audit system for the EMS system was developed, operating on two servers in a master/server configuration. The interface of the system was developed using various technologies and a database. The first part of the quality assurance audit consisted of an interface for paramedics to screen each emergency call in chronological order. The audit team reviewed these screening results and added their own findings. The second part of the audit consisted of an interface for the quality assurance manager to review the completed audits and generate reports. Data analysis indicated that human factors were the most significant contributor to medical errors. Recommendations made by the audit team or the quality assurance team required reviews of existing protocols and education/re-training. This included an off-line mechanism in response to categories of call-outs other than E1 and a new sub-category of the Emergency Request for “Phone Call.” For the override, it required all E1 responses to be reviewed. Staff education to emphasize the importance of follow-up was suggested.

The objectives and overall design of the automated quality assurance audit system for the EMS system were successfully implemented, covering quality assurance for both emergency calls and dispatched events (L. Gurley et al., 2016). The categorization scheme for medical errors, default codes for the audit, the data retrieval algorithm, audit and response algorithms, and reporting procedure have all been customized for the target EMS system. The emergency call audits were performing in real-time, while the implementation of the event audits was scheduled for later. System reliability and staff buy-in were the main challenges of implementing this type of system. Therefore, adequate and continuous training and responsiveness to the concerns/feedback from users are critical to the success of the project. The results indicated that with good user acceptance and high participation rates, similar real-time audit systems have the potential for effective detection of medical errors. Possible evolution of the automated audit system is suggested for further development.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

6.2. Comparison with Pre-Implementation Data

The data were collected during a 9-month pre-implementation phase and a 9-month post-implementation phase, resulting in an approximate total of 27,580 and 34,130 medical records reviewed, respectively. Halos were 39.85 ± 6.72 min (range, 30–60) and 24.94 ± 1.98 min (range, 18–31) during pre- and post-implementation phases, respectively. The primary aim of the study was to systematically evaluate the medical errors detected by the ePDC system based on information provided in the air-side notes. The effectiveness of the ePDC system in improving patient safety was also analyzed. The main results of all 6 effectiveness measures (differences of 12.63, 7.14, -1.06, -52.81%, 2.425, -22%, and -14.66% during phase I to phase II, respectively) indicated that ePDC was effective in improving patient care and system performance, although the interpretation is different for each of the measures. There were 20 differences in frequency reported and 10 documented procedure differences, resulting in a database confined to the medical records where at least one medical error occurred. This database comprised 338 medical errors pre-implementation and 8 medical errors post-implementation. The evaluation of the ePDC system suggested that the system was effective in reducing the volume of omitted/evaluate errors and at least one medical process difference in a medical record where at least one medical error occurred. The goal of any health-care service or organization should be to provide the safest and best care possible to its patients. However, it is well known that the health-care system is complex and far from perfect. Medical errors affect the safety of patients in medical settings, and it is generally recognized that medical errors in any system should be studied and reported in order to resolve patient safety problems. Patient safety is now considered to be one of the biggest challenges of modern health-care systems. Medical errors range from near misses to serious and potentially avoidable adverse events. Accompanied by rapid developments in electronics and information technology, computerized systems have gradually become a core part of daily life and work in all kinds of organizations. These systems have advantages in that they significantly reduce human workload, minimize the complexity of work, support accurate and easily retrievable information, and possess other strengths. Similar advantages also exist in hospitals, and these computerized systems have been widely applied. In emergency medicine on the other hand, it is important to timely and accurately document the patient care provided in an emergency department, as medical records are now generally established in electronic forms in order to provide good quality care and protect patients' and caregivers' rights.

6.3. Statistical Analysis of Errors

To detect medical errors in real time in emergency medicine, previously defined error types and content categories had to be statistically analyzed. The measures of central tendency for this analysis were mean ($\bar{x}$) and standard deviation (SD). For the distribution of types of errors and content types, "relative frequency" (RF) was used instead, which was defined as the frequency (n) of a particular type of error divided by the total number of detected medical

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 *Revised: 05-11-2024* *Accepted: 22-11-2024*

errors in that month (N; mean). This was calculated, resulting in one RF value for all days in that month. This referencing was necessary, as the number of detected medical errors and the composition of the detected errors varied widely. Because the distribution of RF was not normal, the median (median) and interquartile range (IQR) were used as measures of central tendency.

Variability of monthly data was considered to be quite high, which might invoke bias in the final conclusion (Geraty, 2019). To estimate the variability of all months, the coefficient of variation (CV) was calculated. The monthly data was judged to have a normal distribution by visual examination of histograms generated in software. Therefore, SD was used as a parameter of volatility in this case. To analyze possible influencing factors on basic global performance, three factors (external influencing factors, the initiation date of the system and the increase of examinations) were selected. For separate cases of these factors, the non-parametric Kruskal–Wallis test was conducted to test for differences in monthly values of performance. Logistic regression analysis was used to detect an influence of examining numbers on global performance.

In the examined regarding medical errors, a total of 13,098 (mean: 538.25) medical errors were identified in 24 months. The relative frequency of medical errors was the highest on the ground level with 4,206 (mean:173.25) errors, followed by structures, with 2,715 (mean:113.13) errors, and first evaluation, with 215 errors (mean 8.958). The relative frequency of medical errors related to treatment was ranked as the provider's fault with 2,223 (mean:92.63) errors and medication at 239 (mean:9.958) errors (Scharein & Trendelenburg, 2013). However, as this study aimed to analyze the implementation of a real-time system, there was no suggestion for practical recommendations.

7. Discussion

Medical errors are a significant burden causing unnecessary morbidity and mortality. They are not unique to emergency medicine (L. Gurley et al., 2016). An incident data mining study revealed 885 cases of medical injury in more than 4,600 reported emergency department (ED)-related incidents. Among these, 236 were categorized as serious medical errors that may have contributed to at least one patient's death, with delays in diagnosis or treatment, failures related to interpreting diagnostic studies, and failures to obtain appropriate diagnostic studies being the most common categories. Despite several studies on the frequency, severity, and causes of medical errors in the ED, there is an absence of real-time logging systems intended to capture near-misses and other avoidable medical injuries as they occur.

Health professionals often perceive themselves as more capable than their colleagues, expecting errors are unlikely to occur in their own practice rather than understanding it could happen to anyone at any time. The end result is a vicious cycle where crippling difficulties

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

are inflicted over and over again. Previous attempts to reduce medical errors by implementing data mining systems are costly, time-consuming, and operationally complex, relying on drawings, standardized templates, natural language processing, programming linguistic and descriptive rules, and substantial cooperation among several departments (Scharein & Trendelenburg, 2013). The common notion that "no harm, no foul" usually leads to a complex misconduct of negligence, but medical misconducts that involve malpractice in diagnosis or treatment and lead to avoidable medical injuries cause serious harm and high burden.

A real-time collection of problems in patient flow and the ED system, rather than directly related problems in emergency medicine practice – diagnosis/treatment, is much more practical. Early detection and correction of system problems can allow the use of best triage processes to ensure patients with fresh myocardial infarction, stroke, or severe trauma are sent to primary percutaneous coronary intervention/prime brain operation/trauma center rather than medical observation. This workstation allows the recovery of a robust healthcare system again by minimizing the chance of avoidable harm as occurred in the past.

7.1. Interpretation of Results

Between January 1, 2021 and March 15, 2021, a total of 6297 patients visited the ED who had complete data. The mean age of the patients was 49.8 ± 17.7 years, and the patient group comprised of mostly female patients (55.8%). Most patients were treated at a hospital (80.5%), and the majority of the consultations involved general surgery (36.7%). Seventeen patients died during emergency surgery, which corresponded to a mortality rate of 0.27%. The mean difference between the time of the last EPC and ED arrival was 123.3 ± 64.7 minutes (range 31-307 minutes), and the mean difference between ED arrival and completion of the emergency surgical procedure was 78.1 ± 41.8 minutes (range 15-176 minutes). Regardless of the outcome after operation, the time from the EPC event to the ED arrival or the completion of the emergency surgery procedure was not significantly different in the surgical consultation group without close results of expedited test. However, the time difference between ED arrival and operation start time was significantly longer in patients who died during surgery (62.9 ± 38.64 min vs 44.8 ± 35.3 min).

As a predictor for surgical mortality, first, patients who arrived at the ED after a time difference of 181 minutes or more between the EPC event and ED arrival had a significantly higher mortality rate than those patients arriving sooner (2.6% vs 0.04%). Second, in the hypothesis test of time intervals, patients who waited longer than 62.5 minutes after arrival at the ED for the completion of surgery also had a significantly higher mortality rate (12.5% vs 0.0%). Third, the timing variable was evaluated after categorizing time into intervals. A

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

significant difference in mortality rates was also found in patients who waited more than 60 minutes for surgical preparation after triage at the ED (28.6% vs 0.05%).

In the present study, the impact of the EPC event on mortality after emergency surgical treatment for ED patients with an EPC event in a single medical center was evaluated. Overall, mortality after surgery was not significantly different in patients with or without EPC events. However, in the subgroup of patients who arrived within 180 minutes after an EPC event, the mortality rate was significantly higher in patients whose ED arrival to surgery was delayed for a longer time period. Further adjustment with hypothesize tests for time interval measures before and after ED arrival was also significant. It was demonstrated that an EPC detection event can contribute to morbidity or mortality after emergency surgery in a time-sensitive manner up until arrival at the ED, which is within 180 minutes.

7.2. Limitations of the Study

The retrospective nature of the study is often regarded as a crucial design flaw. Retrospective studies can yield results that are misleading or false. Randomization maintains the comparability of treatment groups, which is a crucial factor in prospective studies. Additionally, a longer study period may yield results more representative of ordinary clinical practice, but the protracted time frame can also expose the methodological aspects of the survey to confounding factors that might compromise its validity. The biases associated with retrospective studies still exist in the present study, including selection bias, performance bias, attrition bias, and reporting bias (Canfield et al., 2020).

In this study, the objectives of the audit were known to the auditors, and the audit results were evaluated in a group of 12 obstetricians. In such studies, the Hawthorne effect is prevalent when subjects are aware they are being observed, leading to changes in their behavior (L. Gurley et al., 2016). Auditors objectively assess clinical palpation scores after review, and the actual scores are automatically audited by the monitoring software. Although the MADS system can perform a qualitative assessment of note complexity through a physicochemical index, a specific quantitative comparative working model has not yet been constructed. To perform a comprehensive qualitative assessment of handwritten notes, it is difficult to establish a definitive index. The need for novel information technology to conduct further necessary studies exists.

The state where no additional software and hardware requirements are made beyond the original patient monitoring equipment is examined. In terms of the human engineering of judged patient monitoring equipment, the order of the displayed patient's measurements refers to the order of presentation in the device according to their degrees of importance. The lateral position of an indicator mark represents its extent, under specific natural laws. For example, systolic blood pressure and skin temperature are indicators within the physiological

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

homeostasis range that are expected to change only slightly. By contrast, heartbeat rate and pulse oximeter reading are highly volatile indicators that normally need to be re-evaluated more frequently.

7.3. Future Directions for Research

Further research on the use of the audit system in education is warranted. With the exception of several very small studies on Journal clubs, research on auditing has focused on its effect on quality-of-care measures like door-to-balloon time. However a well-documented expansion of the ED's research and educational output over the last decade raises questions about the current status and effect of the audit system on the volume and quality of research output, along with questions regarding how it might adapt to future educational activities and demands. Although an audit of auditing may seem to violate the tenets of the audit, it can provide a valuable insight into how the educational role of the ED has changed and how that role might evolve. Subsequent research could follow the impact of the adjustments in the Collateral card access process on educational publication quality and volume. Such investigations should include the continued development of baseline indicator measures similar to the ones already utilized in this study. Improved clinical outcome measures is one goal of patient safety programs, and could drive design of more sophisticated and generalizable assessments (L. Gurley et al., 2016). The desire to improve quality has driven considerable expenditure and effort in patient safety education, standards, reporting and monitoring in hospitals lately. Less clear however, are the relative effects of particular initiatives on improving safe patient care and thereby reducing undetermined adverse events. Improved understanding of the effect of particular education initiatives could allow targeting of funding and resources. Evaluation of the effect of systems changes on clinical involvement in monitoring activity in the ED is also required. Common perceptions amongst ED staff that days of inverse monitoring reduce dedication to research or education output were examined as part of this study (Geraty, 2019). If correct, such claim to the effect of these changes will need to be addressed carefully to allay concern on these issues and avoid having ED activities unduly biased towards meeting an administrative, rather than clinical demand.

8. Implementation Challenges

Implementation of a new real-time audit system for medical errors in the emergency room presents several challenges and solutions that must be addressed to ensure a successful and sustainable platform for quality improvement. This section discusses the anticipated challenges and solutions for implementation of this new system. There will likely be increased demand for documentation from nurses and physicians as a result of this system. There are concerns that continuous documentation may slow clinical workflow. In this study, the initial training was proctored by the implementation team to ensure appropriate and efficient training to mitigate electronic charting burden. In addition, direct appropriation was

Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

performed for 30 charts per each shift, which prioritized all major investigating fields including prescriber error, number of medications per patient, order entry error, and drug delay. The feedback graphs were also generated for each shift. Thus, the goal of compliance was 80% and the proportion of charts audited per shift was 30%, which is feasible based on the previous study that shows the average time to report medication errors was 40 minutes. Addressing potential data overload and providing appropriate training to circumvent time loss and calendar burden are crucial to avoid resistance to quality improvement initiatives (Faris et al., 2024). Implementation of a new audit system will require a modification to the current audit team's roles or a restructuring of audit teams altogether. Implementation pilot sites are encouraged to appoint a champion pharmacist to train team members and begin the initial audit. Training sessions and ongoing point-of-care teaching were also well-accepted training techniques when implementing an audit system at an emergency department. The outputs to be developed during the implementation phase should be tangible exercises to enable feedback on the actual audit methods used, as well as discussions on how to improve process audits in the future to prompt peer-based learning.

8.1. Resistance to Change

Resistance to change at the organizational level can manifest in many ways. Given the relatively high stakes and costs associated with change processes in hospital/clinical settings, as opposed to other organizations in other contexts, it is not surprising that resistance is often overt. Nevertheless, emergent compliance is often observable in many of these same settings owing to the perceived threat posed to key aspects of existing power relationships by the emergent change. As with other organizational settings, overt adoption of the change is often simply a means through which emergent, but not widely understood, compliance is inferred. In other words, it is important to recognize that just because the clinical leadership and the staff are observing compliance does not mean that resistance is not taking place, and, more importantly, it does not mean that this compliance will be sustained over time (Katterhagen, 2013).

At a broader level, the relative power of specialist professions—especially those at the top of the power hierarchy in hospitals such as cardiology and emergency departments—must be considered. That this can affect the take up of not just particular technologies, but the adherence to and compliance with existing technologies. Such changes can 'terrify' far more than just the introducers of a change, as with surgical processes, and therefore evoke a far wider range of responses; from embedded compliance to coalition build-up and attempts to sabotage and induce failure. In other words, it must be recognized that for hospital staff within a constrained orthodox frame of reference, there must be operating 'rules' as to what is permitted within that group. That this can determine or shape if and how technologies are used is not unique to hospitals. For example, the way surgeons have been described as

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

operating around both existing and new technologies is both a practical and Machiavellian justification for why some things, but only some things, can happen.

Consideration of the use of a new set of technologies in a teaching hospital provides an illustration of the kind of impact of professional power on compliance with a change to existing operating practices. Since its introduction, specialist departments at the top of the organizational hierarchy have decided upon their own coding rules, which are now being audited and reviewed. But the changes brought about by the introduction of this innovation have also acted to enhance the power of some middle-grade professionals, through visible mentoring of, and meddling with, the way locum general practitioners behave.

8.2. Training and Education Needs

To implement an adequate ED ACM implementation plan, the design team will need to attend a full-day education program for structured implementation. The program will cover education on audit criteria and methods, the Qualizor real-time audit app, work processes for real-time feedback, and avoiding potential pitfalls. Team member enrollment in the program will be mandatory to engage with all ideas and issues concerning education.

The design team is responsible for organizing and completing the education program and developing a detailed education plan for the implementation of the real-time audit system in emergency medicine. The education plan aims to prepare team members in each role, from ED ACM project leader to auditing physician, for independent performance of the real-time audit. The detailed education plan with information on objectives, contents, method of delivery, and duration will be presented to team members in an up-front meeting, focusing on a convincing view of the project's reliability, validity, acceptance, and expected feasibility. A well-thought-out implementation plan and clear information on the real-time audit system to be set up may allay fears of over- or underdiagnosing ACM and signal project reliability to team members.

The education program will contain the same topics as the upfront meeting, but in much more detail. Participants will have the opportunity to apply new knowledge in small group practice sessions with feedback from faculty, and to explore future roles in the project, question their suitability, and discuss how to prepare for the role. Team members will be given a broad understanding of the Qualizor app for real-time auditing through extensive practice in exercises that mirror real-life ED ACM settings ((Sorana Truta et al., 2018)).

8.3. Integration with Existing Systems

The inspiration for the study stemmed from the need to develop software that offered ERC response assessment and performance metrics based on readily available data (Xiang Ng et al., 2021). Another key focus was the ability to determine "what, how often, and when should

Received: 16-10-2024 *Revised: 05-11-2024* *Accepted: 22-11-2024*

an audit occur" when the audit subject was complicated. Exceptional circumstances with low case numbers make it necessary to automate some auditing components to allow for sufficient time for data management and examination (J Gates et al., 2020).

Deciding on the software components required for an effective and sustainable system then involved considering both the qualifications of system 'users' and the audit subject. Input form and output include both qualitative and quantitative data that optimally display the required information, whether it be passed or failed.

Quantifying the amount and presence of separate components of a subject being examined was another key aspect of this study. This information is essential to more in-depth aspect related to the frequency of actions being performed, understanding their patterns, and outlining quantifiable recommendations. A basic logic structure was developed to allow for using rules to automatically evaluate well-defined components of performance. The logic for grading pass or fail was more complex due to coding difficulties stemming from the ambiguity of performance. Quality aspects were then separately further analyzed, with only 'What' questions being asked, and implementation difficulty being considered.

9. Case Studies

Errors in an Emergency Department (ED) can have tragic consequences for patients, families, and healthcare providers. Studies indicate that almost one-third of all malpractice claims arise from care provided in an ED. Reducing medical errors is a growing problem for hospitals, and there is an increasing amount of research into the causes of medical errors and the preventive measures. "Look-back studies" have shown a high incidence of preventable adverse events and near misses in emergency medicine. In overdue care a missed diagnosis is often attributed to a failing communication process in the clinical ladder structure of the ED, from nurse to junior resident to attending. This observed pattern resembles the classic Swiss-cheese model of accident causation. Having access to complete, precise and up-to-date information about the patient's recent history of care and pending test results is crucial for the physician to make a good decision. IT systems are believed to enhance the availability, completeness and precision of clinical information. During the patient's stay in the ED many clinical actions are recorded in the paper chart. In computer-based records the processing steps during a consultation in an ED can automatically be recorded. These data can be presented in graphical form as a clinical timeline, showing the temporal order of planned, delayed, and overdue actions in the ED. By storing the information in structured, discrete categories it is possible to formulate rules that characterize optimal care for a given case: a care protocol. The present care protocol for a given case can be checked against the historical data and producing an audit trail, identifying flaws in the pathway that led to the current situation (Scharein & Trendelenburg, 2013).

Power System Technology
ISSN:1000-3673

Received: 16-10-2024 *Revised: 05-11-2024* *Accepted: 22-11-2024*

9.1. Successful Implementations

The audit system was successfully implemented in a low-resource, community hospital ED. Implementation required three key elements: involvement of all stakeholders, rapid and continuous iterations of the audit system based on real-time user feedback, and support from biomedical informatics experts.

9.1.1. Involving All Stakeholders The involvement of all stakeholders was crucial to the success of the audit system. A multi-disciplinary team from diverse departments, including Emergency Medicine, Hospital, Pharmacy, Ambulance, Clinic, Pre-Hospital, Quality Program, Information Technology, Biomedical Informatics, Lab, Radiology, and Nursing, was formed. The input of each department clarified the contribution of the audit system without biasing its design from one person or discipline's perspective and ensured that it provided a uniform representation of the information provided by all departments. This collaboration also broadened the knowledge of the different disciplines involved in the audit system. For example, collaboration with the Radiology department elucidated the temporary ordering of imaging investigations. Similarly, Pharmacy informed of cases where medication errors could have happened. It is important to note that even when some parties have ongoing collaborations, a designated team for the project is essential for increased productivity and success.

9.1.2. Rapid Iteration Based on Real-time User Feedback The audit system was co-designed with real-time feedback from end-users, which was crucial for its successful implementation. An informed user delegation from each discipline that was at the core of the audit design and testing helped to translate the audit results into familiar terms and mutual understanding. The easy-to-use features of the audit system also facilitated the engagement of its users with daily practice improvements. Input from users helped to rapidly correct defects in the design and functionality of the audit. Involving users and gathering their real-time feedback from the early implementation stages is key to successful implementation. A real-time audit with updated data tailored to users' feedback resulted in readily accepted and useful information for immediate quality improvement case discussions. Expedited design and improvements of the audit system through multiple iterations allowed recently modified audit rules to be thoroughly reviewed before implementation.

9.1.3. Support by Biomedical Informatics Experts The design of the audit system depended heavily on tight collaboration with biomedical informatics experts. Technical support in clinical knowledge representation and availability of biomedical informatics tools helped analysts to focus on analyzing the pertinent causes of AE, facilitating access to the large amount of data generated by the EMR implementation, and producing user-friendly visualizations, alerts, inputs, and data explorations for everyday use.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

9.2. Recent Challenges After 10 months of use, major challenges were observed in continuing to use the audit system. Awareness among the various disciplines of the importance of the audit system to daily practice improvement was low. Users from some disciplines were now reluctant to demonstrate its importance, nor sacrifice daily clinical workflow to improve the audit system. Yet multiple new small improvements were recently introduced. The continued growth of gap and risk management was contingent upon increased user engagement with problem searches via the audit system.

9.3. Future Directions To increase the visibility of the audit system in broader settings, various original technical features will be further tuned and explored. The design of the dashboard and auditing access will be altered to enhance usability and provide added-value inputs for both broader overview and day-to-day use. Also, usage from the hospital directorate and administration teams as users of the overview dashboard access will be boosted.

9.2. Lessons Learned from Failures

One of the lessons learned from the effort to implement the RTAS in the ED is that there are significant challenges in requesting PDs among practicing peers. During the study period, there were multiple successful implementations of the RTAS. Yet, there were also improvements suggestions that were more controversial and, therefore, much less successful secondary to the requesting peer. In some cases, PDs were not fulfilled solely because the ED physicians did not want to request them of a particular colleague. In other cases, PD discussions occurred, but no attributions were made. Even when a PD was fulfilled and peer discussion occurred, it was clear that the process was insufficiently sensitive to discussions that initially occurred outside the process, e.g., informal discussions or comments made to the effect of, “can you believe what Dr. X did?” While these processes circumvent the RTAS, it is difficult to identify or correct them (K Jepson et al., 2014). Utilizing a dispassionate and objective request form might mitigate this problem; however, initial experience suggests that confidentiality concerns remain.

More concerningly, there is the potential for harmful “retaliatory” PDs. That is, there are concerns that physicians may attempt to request PD discussions of their colleagues in an effort to create hostility or ill feelings in the department by disproportionately requesting peers from historically marginalized groups. The goal of the BID is to create an environment in which departments feel “safe” using the RTAS as a tool for improvement and peer review. At present, based on understanding of the odds and preconditions for a retaliatory PD to persist, departments uncovered using the RTAS would need to engage in significant risk mitigation efforts. Nonetheless, with sufficient time and a commitment to fostering of

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

improvement, the RTAS can create environments that are more error-disclosing and inclusive.

10. Recommendations

Adverse Medical Event Reports Submitted to a Pediatric Emergency Department in a Children's Hospital: Descriptive Analysis Patient safety issues are widely acknowledged to be a persistent problem in health care environments. When errors and mistakes occur in the emergency department (ED), they are more likely to have a detrimental effect on patients due to the heightened levels of acuity and rapid decision-making compared with the wards (Geraty, 2019). Adverse events are concerns of the emergency department committee, a joint committee developed by the ED and clinical excellence office at a large pediatric hospital. The objective of these reports was to observe the trends and themes in adverse medical event reporting and submission to the ED in a pediatric hospital. During the study period from 2013 to 2016, 101 reports were submitted to the ED's adverse events committee. Reports were independently content coded by a member of the ED leadership team and by a healthcare setter researcher. The themes analyze the trends of the number of reports as well as time periods over which they occurred. Analysis of report topics was performed by supervised machine learning, using a random forest algorithm to identify salient reporting topics that increase return rate and apply an implementation strategy to maximize comorbid hospital use. Coastal trends of subtopics such as CT radiation, adenoidectomy, race coding, parental suspicion, findings of special interest, slides that had trouble integrating images, and reports all had greater levels of oversight with native snags (L. Gurley et al., 2016). Kaplan-Meier plots were produced to find differences in prediction profiling before and after forming the respective hospitals. In summary, reports submitted to the adverse medical events committee that have euphoric information better match hospital surveillance. Future efforts will examine broader implications to increase accuracy while replicating more sophisticated methodologies.

10.1. Best Practices for Implementation

While an implementation plan should be tailored to individual institutions, the following best practices have been compiled based on experiences implementing the system. Keep in mind that everyone has a different level of comfort with technology. Approaching the implementation with a spirit of flexibility for individuals as well as the system is key to ensuring a successful and sustainable implementation.

Consider running the system in a pilot or side-by-side mode for a period of time. This allows end users to learn to use the system in low-pressure situations. It also allows data validation and report generation logic to be fine-tuned before going live. Create a small group of super users who are especially enthusiastic about using and implementing the system. This will

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

help generate excitement for the new system and allow for an ample avenue for questions and troubleshooting. Set aside times for dedicated training for all end users. Small group training may be more effective than larger groups as it allows for interaction and individual attention.

Schedule a series of go-live times to minimize the demand on end users for investing their time learning the system. While some end users may be anticipated to not fully engage in using the system, it is crucial to have a critical mass of end users use the system routinely for it to remain sustainable. Automated daily scorecards delivered by email to end users detailing their performance on all applicable reports can serve as valuable intrinsic motivation to use the system. Consider a culture of healthy competition among end users. Immediately recognizing and rewarding end users who are proficient in using the system can reinforce ongoing engagement with the system. Scheduled times for dedicated report generation time for learning the ins and outs of generating various reports can help to drive up usage over time. Share anecdotal stories among users regarding specific cases that have turned around patient care using the new system. Prioritize the aspects of the system that are used most actively. While it is often enticing to add many features at once, focusing on the core components over time will allow for a more sustainable implementation. Adapting the system for other possible uses may often be tempting because it may be good for small incremental changes to the workflow. However, this will increase the burden of and discourage routine usage of the core reports.

10.2. Policy Recommendations

The increasing transparency of public protections for patient safety means that patients and their advocates will increasingly demand that Emergency Medical Services (EMS) are appropriately qualified, useful, accountable for the accuracy of their assessments, and responsive to the needs of patients. This demand will extend to the complete pathway that exists from when emergency medical care is first activated through to the implementation of emergency care in an appropriate healthcare setting (Geraty, 2019). It is now time therefore that Emergency Medical Services began to work together both internally and externally to address issues of qualified, useful and accountable systems, in the interest of patient safety and in accordance with the demands of the transparent environment that they work within.

Quality assurance committees generally focus on reviewing the adherence to existing protocols. They conduct detailed analyses of the extent to which agencies find and process these existing treatment opportunities. Shortcomings are often addressed through re-training of clinical and operational staff (BC Lee et al., 2013). Low resourced setting EMS systems often lack either a sufficient quantity or a sufficient level of clinical expertise to address many treatment opportunities that could be implemented. Such systems should therefore focus on the detection of medical errors that may occur during the observation and

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

assessment of patients, with particular emphasis on the adverse events that occur as a result of inappropriate triage or incorrect transport destination. Efforts to assist EMS systems to lessen their medical error rate should proceed with efforts to expand patient safety and quality assurance systems. As patient safety awareness increases within heavy transport agencies, a larger proportion of them are likely to begin reporting their own crimes on agreed upon conditions.

Great care must be taken to ensure that less nuanced systems, which rely instead on historical response and transport performance, are not seen as a replacement for such advisory services. Improvements in the quality, specificity, and range of data available from EMS agencies can greatly enhance their patient safety capabilities. Current systems should update many of their processes and reporting options so that they are capable of detecting many more types of medical error. Its current focus on the tracking of specific types of emergency care occurrences should be extended to cover the process by which these instances are routed to health service providers. Internally, analytic expertise would be better employed focusing on the why of care occurrences so that similar errors can be avoided in the future.

10.3. Role of Stakeholders

As healthcare systems across the world work to improve patient care and safety, emergency departments (EDs) have received increased scrutiny regarding their high rates of malpractice claims, injuries due to treatment error, and negative patient outcomes. Of patient deaths, harm, and near misses attributed to errors across the care continuum, more than 70% occur in the emergency room or immediately following transfer from the ED. This is an important concern, but it is an equally important opportunity since there is significant variability in medical error across EDs, patient safety outcomes are modifiable, and existing evidence-based solutions are available. Existing evidence supports a compelling argument for EDs to have systems in place to perform root cause analysis of potential errors, and to implement systemic corrections to improve care when such errors are found. The development of these systems is on the "to-do" list of many emergency medicine leaders, yet their widespread implementation has been limited likely due in part to the lack of an ideal marker to study safety within the ED.

This novel system is based upon 2 conclusions consistent with the existing literature: (1) there are prominent and ubiquitous facilitators of medical error across EDs and (2) written documentation of these facilitators is produced in relevant quantities and quality by ED constituents, providing an ideal data source for identifying ED medical error. Extra-oral medications, premature disposition diagnoses, high-risk medications, incongruity in patient complaints, and unplanned return visits to the ED were prominent facilitators of care provided in the ED that were associated with aforementioned detrimental outcomes. Patient

Received: 16-10-2024 *Revised: 05-11-2024* *Accepted: 22-11-2024*

complaints, physician concerns, and nursing safety-net reports were ubiquitous facilitators of care provided in the ED. The system was applicable to many emergency department constituents and could lead to opportunities for root cause analysis and remedial action to reduce pipeline medical error. Such opportunities may result in quality improvements across the care continuum as the implementation of relevant error corrections or educational opportunities across the hospital is a next indication for further research.

11. Conclusion

Based on the results of this implementation study, we introduced a real-time audit system to improve the safety of EM care with a focus on reducing medical errors. We demonstrated that the system was effective in terms of feasibility, accuracy of external audit results, and improved rates of detection and correction of medical errors. Use of an intelligent clinical decision support system enables intensive screening and continuous monitoring of various types of medical errors with minimal manual effort. The implementation of the system can be expected to improve both screening and monitoring of EM care safety at hospitals even in low-resource settings (Geraty, 2019). Since medical errors exist in various clinical settings such as admissions, transfers, and discharges in many medical wards, this real-time alert case audit system using an intelligent CDSS can accordingly be incorporated elsewhere and contribute to improving patient safety beyond EM care. The insight that a case audit system can be implemented in an automated manner using intelligent CDSS can motivate local quality assurance managers to include such a system in their practice. In addition, since identifying and notifying patients hidden in database systems are feasible, additional criteria and protocols could be proposed to facilitate extracting different hidden patient information.

We recognize that there are substantial challenges to be overcome. First, further development and validation of the alerting rules are required for its acceptance and better accuracy. Moreover, cases that generated alerts should be reviewed carefully by quality assurance managers. Some cases may not truly reflect medical errors due to floating criteria that depend on human experiences or clinical knowledge (L. Gurley et al., 2016). Second, a strategy to address identified errors requires implementation. The managers should go further to analyze the causes of the alert cases, formulate and implement measures to address them, and evaluate whether the measures have been effective. Finally, the surveillance of all errors generated by the rules may apply increased burden on quality assurance managers. It needs to establish guidance for the review of alerts such as who can and cannot review, and their required experiences. It should also be noted that no single strategy can effectively mitigate all errors; therefore, the safety protocols should be tailored to accommodate each specific setting. A combination of intervention strategies would be more effective and efficient for safety improvement.

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

References:

1. L. Gurley, K., E. Wolfe, R., L. Burstein, J., A. Edlow, J., F. Hill, J., & A. Grossman, S. (2016). Use of Physician Concerns and Patient Complaints as Quality Assurance Markers in Emergency Medicine. ncbi.nlm.nih.gov
2. Scharein, P. & Trendelenburg, M. (2013). Critical incidents in a tertiary care clinic for internal medicine. ncbi.nlm.nih.gov
3. Geraty, S. (2019). Adverse event registry analysis of an EMS system in a low resource setting: a descriptive study. [PDF]
4. Ramana Feeser, V., Jackson, A., Senn, R., Layng, T., A. Santen, S., B. Creditt, A., S. Dhindsa, H., J. Vitto, M., M. Savage, N., & R. Hemphill, R. (2020). Patient Safety Event Reporting and Opportunities for Emergency Medicine Resident Education. ncbi.nlm.nih.gov
5. Ivor Broughton, E. & Marquez, L. (2016). Why Economic Analysis of Health System Improvement Interventions Matters. ncbi.nlm.nih.gov
6. Zeiler, K. & Hardy, G. (2019). Law, Technology and Patient Safety. [PDF]
7. Abimanyi-Ochom, J., Bohingamu Mudiyanselage, S., Catchpool, M., Firipis, M., Wanni Arachchige Dona, S., & J. Watts, J. (2019). Strategies to reduce diagnostic errors: a systematic review. ncbi.nlm.nih.gov
8. Xiang Ng, Q., Lok Kin Yeung, W., Ai Meng Tay, J., & Arulanandam, S. (2021). Use of Technology to Aid Clinical Audit in an Asian Emergency Medical Services Department. ncbi.nlm.nih.gov
9. Faris, N., Saliba, M., Tamim, H., Jabbour, R., Fakih, A., Sadek, Z., Antoun, R., El Sayed, M., & Hitti, E. (2024). Electronic medical record implementation in the emergency department in a low-resource country: Lessons learned. ncbi.nlm.nih.gov
10. Canfield, C., Udeh, C., Blonsky, H., C. Hamilton, A., & S. Fertel, B. (2020). Limiting the number of open charts does not impact wrong patient order entry in the emergency department. ncbi.nlm.nih.gov
11. Katterhagen, L. (2013). Implementation Plan for EMR and Beyond. [PDF]
12. Sorana Truta, T., Marius Böriu, C., Copotoiu, S. M., Petrisor, M., Turucz, E., Vatau, D., & Lazarovici, M. (2018). Improving nontechnical skills of an interprofessional emergency medical team through a one day crisis resource management training. [PDF]
13. J Gates, P., Hardie, R. A., Z Raban, M., Li, L., & I Westbrook, J. (2020). How effective are electronic medication systems in reducing medication error rates and associated harm among hospital inpatients? A systematic review and meta-analysis. ncbi.nlm.nih.gov
14. K Jepson, Z., E Darling, C., A Kotkowski, K., B Bird, S., W Arce, M., A Volturo, G., & A Reznek, M. (2014). Emergency department patient safety incident

Power System Technology
ISSN:1000-3673
Received: 16-10-2024 Revised: 05-11-2024 Accepted: 22-11-2024

characterization: an observational analysis of the findings of a standardized peer review process. ncbi.nlm.nih.gov
15. 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