What is the role of technology in improving patient safety? A French, German and UK healthcare professional perspective

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Abstract
Patient safety in hospitals can be compromised by preventable adverse events (AE). Among the preventable AEs, hospital-acquired infections (HAIs) are one of the most burdensome, contributing to not only poorer patient outcomes but institutional burden through direct financial losses and increased patient length of stay.

Technological innovations can enhance patient safety by automating tasks, introducing medication alerts, clinical reminders, improved diagnostic and consultation reports, facilitating information sharing, improving clinical decision-making, intercepting potential errors, reducing variation in practice, and managing workforce shortages as well as making complete patient data available.

A multidisciplinary working group from three European countries was convened to discuss how to optimise the use of technology to reduce preventable AEs in acute care hospitals. The working group identified examples where they felt there were opportunities to streamline patient pathways, including antimicrobial stewardship, point of care testing, microbiology test reporting to streamline time from sample-taking to clinical decision and mobile automated dispensing systems, which can reduce the burden on overworked staff. The working group also discussed key factors that were critical to ensuring different stakeholders, both within and outside the hospital, could meaningfully contribute to improving patient safety. They agreed that technological approaches and advances would have limited impact without meaningful cultural changes at all levels of healthcare infrastructure to implement the benefits offered by current or future technologies.

Keywords
Patient safety, technology optimisation, hospital optimisation, prevention of hospital-acquired adverse events, medication and drug error, preventable infections

Introduction
Patient harm has been a part of healthcare for as long as healthcare has been practised; it seems counterintuitive that entering a hospital should place patients at risk of harm – yet most of the burden for patient harm is associated with preventable adverse events (AEs), which occur in 1 in 20 admitted patients.1,2 Among the preventable AEs, hospital-acquired infections (HAIs) are one of the most burdensome.1,3 The WHO reports that 3.5–12% of patients are affected by HAIs: the problem is worse among intensive care unit patients where up to 51% experience HAIs.3

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HAIs can lead to poor patient outcomes, significant mortality and financial issues.\(^1\),\(^3\) It is estimated that 15% of expenditure in hospitals in developed countries is attributable to treating safety failures.\(^1\) The economic impact of HAIs is estimated at an annual financial loss of €7 billion in Europe and US$6.5 billion in the USA,\(^4\) but it has been estimated that the aggregate cost of HAIs could be as high as trillions. On average, HAIs increase hospital length of stay by 12 days, but this varies by type of HAI from 3 days for a urinary tract infection to 12 days for a surgical site infection,\(^5\) contributing to an institutional burden on those that are already experiencing capacity pressures.

Raising awareness and providing staff training is critical to address these issues, but are not the only solutions. Technological advances can potentially prevent AEs by automating tasks, facilitating information sharing, improving clinical decision-making, intercepting potential errors, reducing variation in practice, and managing workforce shortages, yet healthcare systems have a reputation for being reluctant to take up innovative technologies.

The authors of this paper recognised the slow and varied uptake of technology in their own and other EU countries. Therefore, this paper aims to describe the opportunities offered by innovative technological solutions that could contribute to improved patient safety, and suggest some possible answers to the question: with all the new technology now available, why has patient safety not dramatically improved?

Methodology

A multidisciplinary working group was convened to discuss how to optimise the use of technology in acute care hospitals to reduce preventable AEs. Participants were recruited to the working group by an independent-third party, Cogora, who searched for a variety of leading advisors in relevant fields who would fit the advisory board objectives. To minimise bias, participants were recruited from all relevant fields. The working group included one nurse director, three chief pharmacists or directors, two microbiologists (one infectious disease physician and one hospital epidemiologist), one medical director and one C-suite executive, from France (2), Germany (3) and the UK (4). The working group met 4 times over a period of 18 months, and each meeting was 1-day long and moderated by Cogora. Two key topics were introduced by the moderator: (1) how innovation can address hospital unmet needs and improve patient safety, and (2) implementing healthcare strategies for combating preventable HAIs. All participants of the working group were encouraged to share their perspective and most other related themes emerged naturally. In addition, case study-led discussions allowed for ideas on how to manage HAIs from different perspectives.

Results

The working group identified opportunities for innovative technology to improve hospital patient safety as well as the barriers that prevent its optimal use. It also increased participants’ awareness of the different practices and the problems in their own and neighbouring countries; however, despite the wide variation in practices, it became evident that many of the same barriers to using innovative technological solutions to improve patient safety were common between countries.

The key themes that emerged across the working group are summarised below, although this is not an exhaustive list of every possible technological intervention.

There is still scope to use technology to streamline patient pathways

The working group identified four key examples where they felt there were opportunities to streamline patient pathways, but technological solutions in these areas were not yet commonplace:

- **Antimicrobial stewardship:** Up to 50% of antimicrobial therapy given in hospitals is inappropriate.\(^6\) The ability to use existing databases/artificial intelligence to recommend the most appropriate antibiotic, dose and duration for a given patient based on clinical parameters could minimise inappropriate prescribing. This may include tracking global and local antimicrobial resistance patterns, prior antimicrobial therapy, and previous hospitalisations that raise concern for nosocomial cross-transmission. There is also a need for more rapid and accurate diagnostics to increase the proportion of patients who receive a tailored antibiotic treatment as early as possible.

- **Point-of-care testing (POCT):** There is good evidence of POCT’s clinical benefit in some areas, such as influenza POCT in the emergency department.\(^7\),\(^8\) but there is scope for a greater range of available tests. For example, up to 90% of ‘penicillin-allergic’ patients are found to tolerate penicillin on skin-prick testing.\(^9\) A rapid, inexpensive way to validate allergies would enable more patients to be prescribed narrow spectrum antibiotics, decreasing antimicrobial selection pressure and cost, while avoiding harm.

- **Microbiology test reporting:** There is a need for technologies that improves the time from sample-taking to clinical decision, as opposed to sample processing.
to result reporting. Additionally, since some clinicians may lack a detailed knowledge of antimicrobials, selective reporting of antimicrobial susceptibility within test reports should be considered to assist clinicians in optimal antimicrobial prescribing.10

- **Mobile automated dispensing systems:** These systems could reduce the burden on overworked staff by automating basic administrative tasks such as stock management, preparation and dispensing. While this technology is available, its use is not widespread.

**Existing technology needs to be adapted to ensure clinical utility**

The group identified a number of areas where current digital offerings could be optimised to increase their relevance to practice:

- **End-to-end systems:** Some IT systems are in development that enable systems from different hospital departments, e.g. radiology, microbiology, clinical chemistry and pharmacy, to be connected, but these are not yet in widespread use.

- **Laboratory testing systems:** Adaptations to test order systems to flag, or even block, unnecessary repeat orders would be valuable.

- **Electronic prescribing:** Many healthcare services use some form of electronic prescribing system. However, adaptations should be considered to improve the use of ‘hard stops’, which theoretically prevent antibiotic prescriptions from being dispensed if the patient does not meet certain criteria or where there is a potential for a serious medication error (e.g. daily methotrexate instead of weekly).

Additionally, validation of prescriptions against set algorithms would prevent prescribers deviating from accepted protocols. This is clearly not appropriate in all areas of medicine, but for fields such as oncology, deviation from protocol is a key issue that impacts treatment efficacy and patient safety.

**Institutional culture can restrict the use and optimisation of current technologies**

No innovation or improvement to technology will be successful if its use is not accepted or embraced by healthcare services and workers. A culture change at all levels of healthcare infrastructure, from clinician to international organisation, is possibly the greatest change that can occur to improve the benefits offered by current or future technology.

- **Hospital leadership:** For staff who are motivated by data and performance, seeing their department or organisation’s position in benchmarked data regarding patient safety metrics may encourage change and allow identification of areas for improvement.11

- **National policy makers:** National policy can be used to accelerate the uptake of innovative technology. For example, the UK Global Digital Exemplar programme promotes investment in digital capability in targeted areas, which is then blueprinted and used to enhance the digital capacity of other regions.12 Meanwhile, the German Ministry of Health supports an e-health initiative that aims to accelerate digitalisation within the healthcare sector.13

- **Industry:** The medical technology industry could be well-placed to offer desired training on guidelines and best practice updates either through live or web-based channels. Indeed, some responsibility for technology deployment and optimisation must lie with the industry selling these technologies. Through engagement with many healthcare providers, manufacturers could see examples of how their product is used differently in various locations, permitting them to share examples of successful implementation, and also facilitate peer-to-peer learning between hospitals. Purchased technology solutions must be flexible enough to be customised to suit the structure and requirements of an institution. While practices must change with the introduction of new technologies, complete re-engineering of services will not support staff engagement

**Discussion**

The working group summarised that the application of technology to enhance patient safety should be considered with respect to current clinical processes, employed technologies and the environment of care;14 there is little doubt that innovative technology is an important tool for improving patient safety, but institutions may need to be selective in which technology to invest in as there is limited evidence that some technologies improve safety outcomes.15 For the optimisation of technology, existing processes and systems need not be abandoned: instead, revising current processes allows for an increase in the uptake of innovative technology to improve patient safety. It was agreed that new technology that requires a complete overhaul of current processes would not be implemented. Instead, healthcare technology must be designed sensitively, in a way that mirrors the cognitive processes of its users with real-world clinical benefit as the ultimate goal.16 It is believed that existing technology has the potential to be optimised through sharing of creative and innovative best-practice examples.
Direction of new technologies

The direction technology innovation in healthcare is moving can best be described as ‘closing the loop’: there is need for technological systems that connect multiple departments and services to ensure continuity of care. Effective clinical decision-making relies on access to up-to-date patient information, yet healthcare providers struggle with a basic need: access to complete patient records. Continuity of care was once the gold standard for treatment but healthcare in the 21st Century makes this concept quaint and unrealistic – it cannot be assumed that one physician will be the predominant provider of care. However, innovative technological solutions provide a way to offer continuity, at least of the patient record, if not the provider. Having access to basic, complete patient information, irrespective of the point of care, can only optimise patient care and reduce harm. For example, future systems could ensure that a prescribed antibiotic aligns with a patient’s blood culture results.

In recent years, there has been a move towards centralisation and consolidation of microbiology laboratories. A centralised laboratory can provide a single set of tests that can be ordered as well as cost savings. In a centralised setting, a healthcare system can allocate a single set of finances: one set of microbiologists, QC testing for assays, and the appropriate number of instruments to suit the laboratory’s volume. However, the disadvantages of a centralised system are the creation of a culture of disjointed care, and logistical issues that surround transporting samples (for processing), increasing the test reporting time and the likelihood of false-negative cultures. Centralisation, therefore, requires excellent communication between hospitals, couriers and clinicians to manage problems as they arise. Moving forward, total laboratory automation is likely to have increased efficiency, allowing for microbiologists to dismiss negative cultures and only examine those with significant growth. Furthermore, automation has the potential to enhance compliance with evidence-based protocols or guidelines, and thus address variations in practice. Automation is likely to eliminate the current disadvantages of courier delays and non-viable specimens while driving standardisation, speed and accuracy of results.

Optimising existing technology to enhance patient safety

Existing technology has the potential to improve patient safety by introducing medication alerts, clinical reminders, improved diagnostic and consultation reports, and the availability of complete patient data. Medical alerts can ensure adherence to guidelines and improve reporting can be designed to reduce variation in clinical practice, conduct quality assurances and optimise care for common conditions. Interoperability of technology would allow the exchange of patient information, yet achieving this goal remains elusive. Current interoperability of electronic systems is suboptimal since hospitals operate in functional, organisational and technical siloes that make sharing of patient data between departments in a single hospital, let alone between multiple services, a challenge. Data analysis tools should ideally integrate with existing IT systems across multiple settings. Some national tools are currently being developed with this aim, such as the Public Health England Fingertips service.

The group’s discussions identified opportunities for peer-to-peer learning and sharing of best practice between healthcare services. For example, some technologies allow for ‘hard stop alerts’, which prevent antibiotics from being dispensed if the patient does not meet certain prescribing criteria. In our experience, UK hospitals do not use ‘hard stop alerts’ owing to the potential risk if a necessary prescription is blocked. Nonetheless, French hospitals have successfully implemented ‘hard stop alerts’, so their use is not impossible; evidently, there are best-practice lessons to be learned from France that may be applicable to other countries.

Human factors

There is some evidence that suggests healthcare professionals are positive about the introduction of innovative technology, only to become disenchanted with the realisation that these technologies can be disruptive and inefficient. Overcoming this barrier is based on improved education and training, and a stepped approach to implementation to avoid disruption of current processes. Improved education and training are key in encouraging staff to embrace new technology processes not only before a new technology is implemented, but continuously as the technology is optimised based on user feedback and patient safety outcomes. The introduction of technology should reiterate how patient safety will be improved to encourage compliance.

Hospital leaders are responsible for promoting and embodying a culture in which employees feel safe reporting any barriers to patient and all reports (no matter how small) should be investigated to ensure patient safety. Virginia Mason in Seattle, USA, is a well-known example of this kind of leadership; their Patient Safety Alert System empowers any employee to raise an alert if they believe patient safety is being compromised at any time. The lessons from Virginia Mason’s Patient Safety Alert could help to form best practice among other healthcare organisations.
Workforce shortages in healthcare services can severely impact patient safety. In postoperative care, an additional patient on a nurse’s case load is associated with a 7% increase in the odds of a patient dying within 30 days of admission.24 Meanwhile, exposure to high workload/nurse ratios for a single day in an ICU can lower risk-adjusted odds of survival to hospital discharge.25 High workloads may encourage behaviours that compromise safety, in the pursuit of saving time. For example, many institutions require systematic monitoring and implementation of action plans if a HAI is reported. Although designed to protect patients, this requirement may result in time-starved clinicians avoiding reporting HAIs to avoid additional work. For protocols to be perceived as necessary, staff must be provided with – and helped to understand – the scientific rationale and the real-world benefit. Further, protocols must not exacerbate the problem they are intended to avoid.

Improving patient safety is a multidisciplinary effort, requiring all staff in an institution to consider safety their priority, and empowering patients to expect and demand improvement. Medical technology companies can support this by collaborating to create intuitive, practical and customisable offerings. However, no technological product will make a difference to patients if the hospital culture prevents its use; strong, supportive, change-positive organisational leadership is critical.

Limitations of this perspective

The group’s discussions centred around technology in hospitals, but technological solutions cannot be considered in isolation; for continuity of patient care and safety, digital strategies must connect primary and specialist care. Improved communication between hospitals, primary care practitioners and community pharmacists could reduce inequity of treatment and time-consuming admin. Primary care POCT may have the potential to guide treatment decisions and reduce inappropriate prescribing in the future, and critically prevent hospital admissions, but reimbursement (and, therefore, implementation) is poor. Similarly, technology to support decisions on when to refer or not to refer to hospital must be strengthened. Finally, medication reviews should be conducted in primary care, but systems are needed that automatically issue reminders without contributing to ‘alert overload’, and support healthcare professionals to undertake these reviews.26

Conclusion

‘Patient safety’ is a broad topic, and one that a single paper cannot hope to address all aspects of. However, the burden of ‘patient safety’ lies with preventable AEs, and among them, HAIs are one of the most burdensome.

To optimise technological innovation to enhance patient safety, it is suggested that sufficient training and support is provided, patient safety reporting is encouraged, technology is optimised based on user feedback, and patient outcomes and sharing of cross-country best practices to increase the uptake of technological solutions and their successful implementation. Technological advances can potentially prevent AEs by automating tasks, facilitating information sharing, improving clinical decision-making, intercepting potential errors, reducing variation in practice, and managing workforce shortages.

Acknowledgements

Funding for the working group meetings, report development and manuscript preparation was provided by Becton Dickinson, who have had no control over the content of this publication. Meeting facilitation and medical writing support was provided by Cogora.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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