Why is measuring the effects of information technology on medication errors so difficult?

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See Articles page e403

"Boeing had underestimated the effect that a malfunction of new automated software in the aircraft could have on the environment in the cockpit" reported *The New York Times* on Sept 26, 2019. In October, 2018, and March, 2019, two Boeing 737 MAX airplanes crashed, killing everyone on board. Worldwide, all MAX airplanes have been grounded while investigations continue on what caused the crashes.[1] The US National Transport Safety Board, highlighted the effects that a large number of concurrent alerts firing in response to the system malfunction had on pilots' response, and opined that "[...] the company had not considered the chaos that ensued inside the cockpit".

Identifying how a technology contributes to errors is a complex endeavour. It is easy to establish the role of the system when the fault can be isolated to single components, such as an improperly manufactured part or a faulty software update. It is much more difficult when the problem lies in the interaction between humans and technology or in the wider sociotechnical system. This difficulty is perhaps a reason why Google has removed human intervention in its autonomous cars.

Automation and information technology (IT) have been integrated in health care to improve patient safety. Technology targeted to the problem of medication errors in hospitals is potentially transformative in reducing adverse drug events, increasing appropriate and effective prescribing and administration of medications, and reducing health-care costs.[2,3] Electronic prescribing systems (also known as computerised provider order entry systems) have been associated with substantial reductions in medication errors, but important questions remain regarding their effects and the mechanisms that contribute to these effects over time. These are adaptive sociotechnical implementations, often involving numerous people. In health care, not only technology but also sociotechnical systems need to be optimised.

Establishing the outcomes of an IT implementation and its role in causing these outcomes presents serious challenges. Does the introduction of an electronic prescribing systems in a hospital reduce medication errors? Which errors are facilitated by the system? What are the mechanisms for these effects? As hospitals continue to refine these systems, add electronic decision support, and improve interfaces, the effects on safety are expected to increase. Yet, to date, long-term evaluations of this optimisation process are rare.

Sarah Slight and colleagues[4] present a longitudinal investigation in a UK hospital to examine the association between an electronic prescribing system and the rate and type of medication errors over 22 months as serial changes were made to the system. The electronic prescribing system had been in place for several years and the researchers examined changes in error rates at four time points, across four wards. System changes included the introduction of new decision support, links to allow pharmacists and medical staff access to summary general-practice information, an enhanced interface, insulin prescribing, and access to outpatient information. Overall, no significant change in the primary medication error rates over the four periods was found, although certain types of errors appeared to reduce over time. The study illustrates the complexity of studying technology longitudinally, considering a range of contextual and work system-related changes, and trying to assess their relative effects.

The methodological challenges of assessing the effect of electronic prescribing systems on errors are considerable. Challenges lie both in the definition of the IT intervention that is being evaluated (since the technology evolves over time) and in the research design and tools used for evaluation. A rigorous foundational research infrastructure—involving, for example, validated definitions of errors and harm associated with errors[5]—and an established audit processes to accurately and consistently identify and assess errors, including system-related errors, are needed.[3] Assessing when an error ends and the next begins is also an important question, in the effort to better understand the dynamics of clusters of errors in the medication process during a patient's hospitalisation.[6] Slight and colleague's study contributes new information about clusters of errors and hypotheses about how these might be associated with specific IT design features.

Studies need a baseline against which to assess change. To have confidence in attributing causation, there must

For the **The New York Times' report** see https://www.nytimes.com/2019/09/26/business/boeing-737-max-ntsb-mcas.html

For **an example of a faulty software update** see https://www.brisbanetimes.com.au/national/queensland/more-trouble-for-queensland-hospital-software-after-statewide-issues-20190911-p52q46.html

For more on the **removal of human intervention in autonomous cars** see https://www.nytimes.com/2017/11/07/technology/waymo-autonomous-cars.html

be sufficient sample size and appropriate controls—which are difficult in natural settings. To account for the development (and perhaps optimisation) of the IT system over time and to account for users' adjustments to workflows and workarounds,[7] these studies must also be longitudinal and multisite. Ultimately, the aim is to inform improvement and system redesign. At a local level, studies must be able to generate a high level of detail about the effects of electronic prescribing systems on different error types and identify potential contributing factors to allow action to be taken. At the policy level, comparative evaluations between systems[8] and information about how contextual factors affect system effectiveness and safety are needed.[9] A strength of Slight and colleagues' study[4] was their attempt to investigate the longitudinal effects of the electronic prescribing system on medication error rates, which is rarely undertaken. However, the changes in their IT system varied considerably in their potential scope to affect decision making and overall error rates in each of the four periods examined. Substantial system and work-practice changes occurred in some periods, whereas such changes were minimal in other periods. Attributing resultant error rates to specific optimisation strategies adopted or—as the authors point out—to "the cumulative effect of system optimisation"[4] is thus difficult, which limits the lessons that can be drawn from the findings for other settings. Linking specific optimisation strategies with their target outcome (eg, whether strategies targeting the prescription of clozapine or oxycodone affected error rates associated with these medications) would have been beneficial in understanding their effect. Future studies should first clearly identify the mechanisms by which optimisation strategies are expected to produce changes in prescribing behaviours and errors and then measure these outcomes.

2017 saw the launch of the WHO's Global Safety Challenge, Medication Without Harm, in recognition of the personal and financial costs of preventable harm and death as a result of medication errors, consuming over US$42 billions annually worldwide.[10] Policy makers, researchers, and clinicians have shared responsibility to establish improved evidence of the effects of clinical information technologies on safety and how and where to intervene to make their use more effective in reducing errors and harm.

Johanna I Westbrook, Valentina Lichtner
Centre for Health Systems and Safety Research, Australian Institute of Health Innovation, Macquarie University, Sydney, NSW 2109, Australia
johanna.westbrook@mq.edu.au

We declare no competing interests.

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