

sired rates for BP control. The study by Green and colleagues<sup>8</sup> demonstrates that even early versions of Web and home BP monitoring technologies can facilitate better BP control if and when they are integrated with receptive clinical personnel. While certainly more work will be needed to refine these models, the future of BP management has taken a significant turn for the better. By finding new tools, ensuring appropriate use by patients and clinicians, and integrating these systems into clinical practice, it will be possible to achieve more effective and cost-effective BP control, and ultimately to save lives.

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## Taming the Technology Beast

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**T**HE MIRACLES WROUGHT BY BETTER HEALTH CARE technologies abound—like mended hearts, leukemias cured, noninvasive images, and organ system monitors. But with artificial heart valves came new risks from infections and anticoagulation; with the breakthrough of intrathecal methotrexate to cure leukemia came new deaths from intrathecal vincristine given by mistake; new monitors began sounding new false alarms that could drive nurses and patients crazy. Electronic medical records mitigate some problems<sup>1</sup> and introduce others.<sup>2</sup> Every new technology, like every new drug, brings good and bad news.

In this issue of *JAMA*, the report by van der Togt and colleagues<sup>3</sup> on electromagnetic interference (EMI) from radio-frequency identification (RFID) technologies affecting other medical equipment in intensive care units is of urgent significance. RFID devices are part of modern life, like the transponder on the car windshield that pays the toll automatically and the security card that permits access to an office building. These devices are also making their way quickly into health care including uses in remote monitoring equipment, as tiny chips that identify items in inventory, or even embedded in surgical sponges for tracking during an op-

eration. These tags that lie in whatever is tracked come in 2 forms: active tags, with a power source that can transmit continuously to a reader device; and passive tags, which are powered by the electromagnetic field of the reader.

In simulations not involving patients, the investigators<sup>3</sup> tested the effects of 2 RFID systems (1 active type and 1 passive) on 41 medical devices commonly used in critical care settings, such as infusion pumps, external pacemakers, and mechanical ventilators. In a total of 123 tests, the investigators found 34 EMI incidents. A panel of 5 intensivists rated each incident as hazardous (eg, a syringe pump's power switched off), significant (eg, an inaccurate blood pressure reading), or light (eg, a monitor error that would not require attention). Overall, 22 of the 34 EMI incidents were hazardous. The passive RFID device led to more incidents (26 incidents in 41 tests) than the active device (8 incidents in 41 tests).

The authors carefully disclaim that their results apply only to the RFID systems of 2 specific manufacturers and that “. . . testing one RFID system on EMI in a medical device does not imply immunity or vulnerability to other RFID systems.”<sup>3</sup> But frankly the 2 tested systems are not unlike many others in current use, and attention must be paid to these disturbing findings.

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See also p 2884.

The authors appropriately advise that their report should “. . . not initiate a frenetic ban on promising RFID health care applications.”<sup>3</sup> That would be overreacting; however, it seems that hospitals, regulators, and manufacturers certainly have some immediate work to do. Hospitals should consider internal surveillance, especially in critical care units, for EMI problems that staff have heretofore not noticed or reported. Regulatory agencies should determine if new and specific guidance on the safety of the relevant equipment is warranted. Manufacturers need to assess EMI interactions with equipment other than their own and seek mitigating designs, such as better shielding for both current and future products.

However, the central lessons of the article by van der Togt et al<sup>3</sup> are not just about EMI and RFID. This is a case study of the beast inevitably hidden in every technology: sometimes it purrs and sometimes it bites. This inevitability should not make physicians and other health care decision makers Luddites, but it should temper the immediate embrace of technology. The right enterprise is not to avoid technology but to tame it.

That is not easy. The study and improvement of safety in complex systems has the attention of some of the most capable engineers, designers, and operations researchers in the world today—talent invested because risk and its mitigation are of such deep concern to society. Nuclear power, military operations and weaponry, aviation, rail transport, space programs, and many more high-hazard endeavors have for decades enlisted the attention of scientists of safety, and most of those fields have a far better track record of taming the technology beast than health care yet does.

Useful analytic models exist for parsing the threats that come with technology. One example is the SHEL model, which is shorthand for 4 elements that interact in sociotechnical systems: software, hardware, environment, and *liveware* (people).<sup>4</sup> Systems scientists use this acronym as a simple mnemonic to guide orderly prediction and study of interactions and their effects. The RFID-EMI study by van der Togt et al<sup>3</sup> focuses on important hardware-to-hardware interactions, but other important interactions would be evident in applying the SHEL model to RFID in critical care. For instance, nurses would likely have much to say about what RFID brings to hardware-to-liveware interactions and their hazards.

One common analytic tool engineers and designers use to help anticipate and mitigate unwanted adverse effects of new technologies is failure mode and effects analysis (FMEA).<sup>5</sup> FMEA, which some health care organizations use,<sup>6,7</sup> exploits individuals' imaginations and experience to uncover possible hazards in complex systems before potential damage is done and to guide designs to become more robust.

Anticipation and imagination are especially important in what operations researchers call tightly coupled systems, that is, systems in which the effects of changes and breakdowns can propagate rapidly (and, even worse, unseen) into areas far from their origin in location, time, and type. For example, the disastrous opening of the much-anticipated Terminal 5 at London's Heathrow Airport, which snarled global traffic,

stranded passengers, and added huge costs for days, was in large part due to tight coupling between the main system that failed (baggage handling) and subsystems as apparently remote as airplane positioning, boarding queues, and online reservations. Health care is full of tightly coupled, hard-to-see systems, and the naive introduction of a change as apparently isolated as RFID tags on endoscope tubes might cause remote and dire consequences far away in space and time.

But even careful set-up is not enough. The best of today's safety scientists warn against viewing safety as a static property that can be ensured by proper prior design, even if tools like FMEA are applied. When it comes to safety, the complexity of systems precludes once-and-for-all solutions. Weick and Sutcliffe<sup>8</sup> call safety “a dynamic non-event” and emphasizes teamwork, social norms, the avoidance of complacency, and continual “sensemaking” as crucial sentinels. Some of the most exciting recent research on safe systems is identified under the rubric of *resilience engineering*, and its leaders reject the idea that proper designs can ever replace proper organizational cultures to keep us safe.<sup>9</sup>

From the particular case of RFID and EMI, therefore, emerge 2 important lessons. First, design in isolation is risky; even the most seductive technology will interact in the tightly coupled health care world in ways physicians and other members of the health care team had better understand, or they and their patients may pay a dear price. Second, no matter how good the design, in the end the battle for high safety and reliability in health care is never won. Safety is not a condition, it is a process. It can only emerge continually in a culture that is alert, cooperative, transparent, and resilient when the unexpected happens, as it always will.

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