THE DIGITAL DOCTOR

Hope, Hype, and Harm at the Dawn of Medicine's Computer Age

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Chapter 1

On Call

One must confess that whatever his mental and moral deficiencies, and they are certainly great, as a machine, man has no equal.

—Dr. Will Mayo, cofounder of the Mayo Clinic, in 1915

In late June 2003, 27-year-old Matthew Burton began a residency in general surgery in Buffalo, New York. The first year of residency, commonly referred to as the internship, is a rite of passage so colorful, ethically fraught, exhausting, and ennobling that it has served as the backdrop for countless books, television shows, and movies. Among physicians, a surgical internship is considered the most taxing of all, but Burton was ready for it—particularly since he was a "mature" student, having taken a few years between college and medical school to work as a systems analyst for Otis, the elevator company.

I'm sitting with Burton in a conference room on the third floor of Brackenridge, one of the dozen or so buildings scattered around the Mayo Clinic's main campus in Rochester, Minnesota. It is here that Burton now works as a human factors expert, helping Mayo translate its billion-dollar investment in information technology into better patient care. He is telling me the story of the horrific night that set him on the path to leaving his chosen field of surgery—in fact, to leaving the practice of medicine altogether—to devote his career to making healthcare's computer systems work.

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August 2, 2003, was a warm Saturday in Buffalo. Only six weeks after graduating from the University of Michigan's medical school, Burton was on call at Millard Fillmore Gates Hospital, one of several facilities affiliated with the surgical residency program of the State University of New York at Buffalo. In addition to seeing emergency room patients with potential surgical problems, such as appendicitis, and covering the post-op patients on the surgical floor, one of his duties was to carry the Code Blue beeper.

When somebody, usually a nurse, walks into a hospital room and finds a patient *in extremis* (a Latin term physicians use that means "at the point of death"), she pushes an emergency button on the wall or calls an internal 911-like phone number. This pages the Code Blue team, usually made up of doctors, specially trained nurses, a pharmacist, and a respiratory therapist. Calling a code is the hospital equivalent of summoning the cavalry.

You never know what you're going to discover when you rush to the scene of a code. In addition to finding patients in full cardiac arrest (unconscious with no pulse and no blood pressure), I've encountered patients unable to move one side of their body as a result of a massive stroke, and patients with arterial bleeders spurting like pulsating red geysers. Of course, I've also come upon patients in a deep slumber who woke up wondering what all the fuss was about (this situation is more than a little embarrassing). When the code beeper goes off, your adrenaline spikes instantaneously. It is medicine's scariest moment—certainly for patients (if they are conscious) and their families, but for doctors, too.

When the Code Blue page shattered the calm of what had been an uneventful evening on call, Burton ran to the patient's room. The nurse had discovered that her patient, a man in his seventies recovering from an uncomplicated surgical procedure, was short of breath and confused, and had a dangerously low blood pressure. Burton and the nurse worked on him, but the patient's condition spiraled downward; within a few minutes, he had lost both pulse and blood pressure, and the team began full-bore CPR.

Burton wondered about the whereabouts of his senior resident, who also carried the code beeper and would normally have been there to supervise the code (as an intern, Burton was too junior to be given this responsibility on his own). He quickly learned that his "senior" was stuck in the OR, operating on an elderly woman with a dying bowel. It dawned on Burton that he was the only doctor available to run the code. During his med school cardiology

rotation, he had carried one of the code beepers and had even started running a few codes before senior physicians arrived, an unusual experience for a student. *I can do this*, he thought as he worked through the protocol and tried to figure out what was wrong with the patient.

Just then, his Code Blue beeper went off again.

This time it was for a patient on another floor who appeared to be having a massive heart attack. Burton couldn't abandon the first patient, now receiving CPR and still a diagnostic mystery, so he tried to manage the second patient by phone, commanding the floor nurses to hightail the patient to the intensive care unit. At least there were nurses there who could start advanced cardiac life support, although without any physicians around, there were limits on what they could accomplish.

Keeping these two plates spinning—running the code for Patient 1 and orchestrating the code for Patient 2—was a remarkable test for this newly minted physician. It was hard to believe that things could get worse. But about 20 minutes later, they did: Burton's code beeper went off again, this time for a woman having a grand mal seizure. One saving grace was that she was on Burton's floor, so that he was able to toggle between the rooms of Patients 1 and 3, giving orders sequentially to the nurses and respiratory therapists in the two rooms like an army drill sergeant trying to keep two groups of new recruits in line—except that, in this case, the recruits were far more experienced in running codes than their leader.

Lest you think this was an average day at an American hospital, you should know that the situation Matt Burton found himself in is remarkably rare. A busy hospital might see a single Code Blue in a day; seeing two is rare, and in 30 years of hospital practice, I've never seen three in an hour; my 600-bed academic medical center averages about 300 Code Blues each year. In fact, the odds of having three codes in an hour are so low that Burton briefly entertained the possibility that something, or someone, was poisoning the patients.

The survival rate for in-hospital codes is about one in six, and those who make it depend on a physician arriving within moments and leading the team through the complicated CPR protocol effectively. While automatic defibrillators—the kind you now see in gyms and hotel lobbies—have made CPR seem easy, running a code in the hospital is much more complicated, since the deterioration is usually related to the patient's underlying illness, which also needs to be addressed. It's rarely a simple matter of applying the paddles, listening for the electronic whir to signify a full battery charge, and pushing a green button.

Burton steeled himself as he tried to figure out what to do. His instinct was to call for help. He contacted the doctor in the emergency room, only to learn that this physician had a "strict policy" never to leave the ER during a shift, come hell or high water. Burton knew there were a few other senior residents from his program stationed at nearby hospitals (and probably sitting with their feet up on their call room beds, watching TV), but there was no way to get information out of the paper medical record to them. Without that information, and without any ability to order treatments remotely, they couldn't be of much help. Counting the patients, family members, clinicians, and support staff, at that moment Burton was sharing the Gates Hospital building with some 250 other people. Yet he had never felt more alone.

Incredibly enough, as Burton worked to revive Patients 1 and 3, checked in to see whether Patient 2 had made it to the ICU, and struggled to tamp down his swirling emotions, his Code Blue beeper went off yet again. At that point, all that the overwhelmed intern could do for the fourth patient—who, like Patient 2, was on a different floor—was to enjoin this patient's nurses to rush him to the ICU. And hope.

By the time the dust settled, three of Burton's four Code Blue patients were dead, as was his senior resident's patient in the operating room. It was the kind of death toll that an unlucky intern might expect in an exceptionally bad month. Not in an hour.

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Matt Burton is now 39 years old. With his shaven head, handsome, unlined face, and neat goatee, he bears a passing resemblance to a young Bruce Willis. His broad shoulders are clues to his athleticism; in his Bloomington, Indiana, high school, he was a defensive tackle, a shot-putter, and a champion weight lifter who still holds a few school records. I notice his build, but I can't see the scars covering his thighs, remnants of the fourth-degree burns he suffered when a high school chemistry experiment went awry. His botched treatment by a local surgeon—he should have been referred to a specialized burn center but wasn't—triggered his decision to devote his professional life to improving the healthcare system.

It is no surprise that Matt Burton found his way to the Mayo Clinic, even if his path to southeastern Minnesota was not exactly straight. The Clinic, the most storied brand in healthcare, was founded by the two Mayo brothers, Will and Charlie, in 1889 on a simple principle: patients deserved the world's

best care, and they could receive it only from physicians working in high-functioning teams, embedded in a system that supported their efforts.

The practice of medicine is all about information, from making a diagnosis to picking the best medication to offering an accurate prognosis. Unsurprisingly, Mayo has been home to many of the critical innovations in information management. The idea of a centralized medical record and patient registration system was developed there, as was a remarkable network of pneumatic tubes for moving paper charts and x-rays around. At its height, Mayo had some 10,000 tubes traversing more than 10 miles, including one tube that was nine blocks long, connecting the two main campuses.

The year 2003—when Burton had his call night from hell—was iconic in the world of medical training. Following a report by the Institute of Medicine that estimated that nearly 100,000 Americans were dying each year from medical mistakes, regulators had limited the number of hours that residents could work to 80 a week. However, in most training programs, the volume of work was not pruned; it was simply compressed. "Now we were doing 120 hours' worth of work in 80 hours," Burton recalled. "But I realized that most of my time was spent moving information from one place to another, doing what we in computer science would call 'simple transforms'"—like transforming the fact that a patient was on insulin, which lived on a medication list, into "diabetes mellitus" on a different page, the problem list. With Burton's background as a computer expert, he knew that information technology could help with this kind of task, but in the hospitals and clinics he worked in, computers either were absent or, when they were around, often made things worse through their frequent crashes, rigid work flows, and dreadful user interfaces.

During Burton's years working at Otis, he had learned an important lesson: although his work was ostensibly about computers, cables, and controls, solving the technical puzzles wasn't nearly as hard, or as important, as fixing the underlying business, cultural, and political problems. That's what really determined how well the system worked.

In 1997, Burton began medical school in Ann Arbor, where he was quickly pegged as a computer geek ("Oh, you know how to write *code*!") and ended up on several technology-related committees. One of his projects was to write a program to deliver the pathology curriculum to his fellow students. "I wasn't learning histopathology," he realized. "I was learning how to develop good software, and how to engage users in the design." Burton enjoyed the computer work but regarded it as a future hobby, for he had decided to be a surgeon, a

career that demands slavish devotion. "I loved surgery," he said wistfully when recalling his first few times in the operating room. "I loved the adrenaline. I thought it was the coolest thing in the world."

And now, six weeks into his surgical training, he had faced a trial that few physicians experience over a lifetime of practice. I asked him how he felt on that August night, once the code beeper finally, mercifully, went silent; when all that was left to do for his three patients was remove their IVs and call the next of kin. "I was a deer in the headlights," he said. When the senior resident finally emerged from the operating room, Burton gave him a playback of the astonishing events of the prior few hours. "He and I were, like, '*What* just happened here?'" As Burton described this night to me, using the dispassionate shorthand that doctors often employ when talking to colleagues ("My senior was in the OR with the lady with the mesenteric artery embolus . . ."), something happened that I was not prepared for. He began to cry.

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A few months after that terrible night, Matt Burton sat down with the director of his surgical residency program. To the program's credit, Burton had not detected any finger-pointing aimed in his direction. Quite the opposite, in fact—he got mostly sympathy, and even a little street cred, for having lived through a night so awful that none of the old-timers had seen its like.

He and his program director talked about what had happened, and, while they touched on the medical issues, both of them recognized that the real breakdowns were those of the system: a system that placed too many residents where they weren't needed and too few where they were; a system that missed the early signs of patient deterioration whose recognition might avert a Code Blue; a system that did not allow an overwhelmed young physician to summon help; a system that made it impossible for clinicians to access patients' information or order treatments remotely. In Burton's world, all these systems were nonexistent or had been slapped together. Yet not only were the technologies to support them available, they were already being used in other industries. "There are tens of thousands of people who can be surgeons," his program director told him. "But there aren't tens of thousands of people who can help solve these problems."

Burton finished his internship and then left the practice of medicine. I asked him how he could make such a monumental decision, one I can barely imagine for myself. "Medicine is the most information-rich, knowledge-intensive human activity, probably ever," he said. "I was angry, because I knew that there

were technological solutions to these problems, and we weren't using them." After receiving advanced training in informatics[1] at the Regenstrief Institute in Indianapolis, he took a position at Mayo, where he is now one of dozens of doctors, nurses, and pharmacists working to bridge the worlds of clinical medicine and information technology.

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These should be glorious times for the Mayo Clinic. President Obama highlighted the Clinic time and time again during the run-up to healthcare reform. The patient safety movement has cast a bright light on the need for effective healthcare delivery systems, and nobody has a better one than the folks in Rochester. Today, instead of charts whooshing their way through pneumatic tubes, there is a computer in every hospital room, in every operating room, and in every clinic, placing information at the fingertips of doctors and nurses. Telemedicine is coming of age—Mayo physicians now deliver care to patients who are hundreds, even thousands, of miles away. And we can now test new ways of improving care through the magic of sensors and big data analytics.

It is Burton's job to ensure that these great ideas make the jump from polished PowerPoint presentations to the big, messy realities of the wards without stumbling along the way. In one of his first studies, he asked nurses and doctors how they organized their work. Many told him, "We're managing to the plan." He asked them to show him this "plan." "They said stuff like, 'Well, it's kind of in the note, and it's kind of on this piece of paper, and it's kind of in our conversations,'" Burton recalled. In other words, this central piece of knowledge—what computer scientists refer to as the "information artifact"—was everywhere. And nowhere.

Burton and his colleagues followed a few nurse practitioners on the colorectal surgery service. One of the NPs' jobs was to gather the relevant data during a ritual we call prerounds. So they tracked what the NPs actually did on these early-morning expeditions. At Mayo, a lack of resources usually isn't the problem—private jets ferrying billionaires from Dubai swoop in with metronomic regularity. "There is a downside to being flush with money," Burton said, "because you end up throwing resources at any problem that you have."

Burton's observations on the surgery service reflected this haphazard abundance. The NPs had to log in to *11 different information systems*—an OR sched-

[1] Informatics is the field of medicine that concerns itself with "the interactions among and between humans and information tools and systems." In 2013, it became an official specialty, like cardiology or obstetrics, with its own board certification.

uling system, a separate clinic scheduling system, an outpatient medication system, and so on—to gather what they needed. This digital Easter egg hunt required more than 600 clicks, accompanied by more than 200 screen transitions. Besides the sheer insanity of the enterprise, the problem is that with each screen flip, your brain must process the new visual information—which generates the neuronal equivalent of the brief static you sometimes see on the TV screen when you're channel surfing—and before long, all of your cognitive bandwidth is exhausted. He recalled a few cases in which the NPs missed obvious things, like a significant fall in the blood count, because "all they're doing is foraging for information, writing it down, not even paying attention."

Burton and his team developed a patient summary screen that the NPs could fill in with just 25 clicks. This dramatically reduced the amount of time they spent completing their prerounds—from 35 minutes to less than 5. Not only did this free up huge chunks of their days, but it also liberated tons of cognitive space to actually think about the patients. As a result, the NPs made fewer mistakes.

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Mayo's computer systems were built by some of the best companies in the business, including household names like GE and IBM (the latter runs a large facility in Rochester) and specialized healthcare companies like Cerner. Knowing how crucial it is to observe how real people actually do their work in order to design functioning computer systems, Burton is irritated by how little attention these vendors have given to the plight of frontline clinicians and their patients. Having worked for a healthcare computer vendor and for Mayo, he knows why this is: the systems that support clinical care are inseparable from the systems that send out the bills, and the latter often trump the former on the priority list. "The vendors are selling to a CEO," he said, not to doctors and nurses.

I asked him about the massive federal push to get these vendor-built systems installed in doctors' offices and hospitals, a push enlivened by $30 billion in incentive payments doled out between 2010 and 2014. I expected that this physician—a man who gave up a promising surgical career to commit himself to the computerization of healthcare—would be enthusiastic, perhaps even ecstatic, about this turn of events. I was wrong.

"They are mandating the use of snake oil," he said, his voice a mixture of frustration and sadness.