

A prescription for the future

## How hospitals could be rebuilt, better than before

*Technology could revolutionise the way they work*



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IN A nondescript part of Cleveland, in a room known as the bunker, a doctor, nurses and medical technicians gather to keep watch over 150 patients in special-care units and intensive-care beds. Their patients are scattered around the region, in clinics that have no specialists covering the night shift. On a wall of beeping

screens the bunker team members track their charges' vital signs. They can zoom in on any patient via a camera at the foot of each bed. "These here are PVCs [premature ventricular contractions]; they're bad things," says Jim Goldstein, a cardiac technician, pointing to a graph of a patient's heartbeat. The PVCs are getting worse, warns a flashing light. It's time to alert a nurse on the ground.

Health-care providers such as the Cleveland Clinic, the big American hospital group that runs this remote intensive-care unit (ICU), are rethinking the way hospitals work. Today, hospitals are where patients go for consultations with specialists, and where specialists, with the help of medical technicians and pricey machinery, diagnose their ills. They are also the main setting for surgery and medical interventions such as chemotherapy; and where sick people go for monitoring and care. But high-speed internet, remote-monitoring technology and the crunching of vast amounts of data are about to change all that. In the coming years a big chunk of those activities—and nearly all the monitoring and care—could move elsewhere.

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grab some of the work—and profits—that will be displaced, including primary-care groups, insurers and health-management organisations. And technology firms are already playing a bigger part in health care as phones become more powerful and

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"When I think of the hospital of the future, I think of a bunch of people sitting in a room full of screens and phones," says Toby Cosgrove, the Cleveland Clinic's head.

In such a vision, a hospital would resemble an air-traffic control tower, from which medical teams would monitor patients near and far to a standard until recently only possible in an ICU. The institution itself would house only emergency cases and the priciest equipment. The only in-hospital consultations would be those requiring the expertise of several specialists working in a team. Patients inside the building would be cared for better. But fewer people would be admitted, as hospitals co-ordinated care remotely and led population-wide efforts to keep people well.

Hospitals have already been reinvented several times. During the Middle Ages they were run by religious institutions and offered little more than shelter and palliative care for the poor, and a place to die. After the advent of modern medicine during the Enlightenment, ambitious institutions such as Westminster and Guy's, in London, developed into complex organisations that combined care, treatment, research and education. Poor-relief moved elsewhere; smaller institutions closed or merged; doctors specialised and clustered in big cities; and nursing was professionalised under Florence Nightingale and her successors.

### **Temples to healing**

The transformation in the coming decades will be as wrenching as any hospitals have yet seen. And health-care reform is always difficult, as is clear from a glance at Britain's creaking National Health Service, France's near-bankrupt system—or the interminable battles in America over the future of Obamacare. Fast-ageing populations and the rising cost of new treatments will further complicate the transition. But the need for change is pressing. In the past half-century the burden of disease in all but the poorest countries has shifted. Communicable diseases are no longer the big problem; now it is chronic ones related to unhealthy lifestyles and longer lifespans. The gap between populations' health needs and the care offered by systems organised around hospitals has grown ever wider.

Picturing what hospitals could be, if the various obstacles are overcome, means abandoning long-held assumptions about the delivery of care, the role of the patient and what makes a good doctor. The first is what should happen where. “A hospital can also be at home,” says Lord Ara Darzi, a surgeon and professor at Imperial College London, a university that runs teaching hospitals. Just as online banking made life more convenient for consumers and freed up branch staff for complex queries, online health care could mean fewer people need to come to hospitals to be cared for by them. Last year half of consultations offered by Kaiser Permanente, an integrated American health-care firm that runs many hospitals, were virtual, with medical professionals communicating with patients by phone, e-mail or videoconference.

The main limitations today, says Kari Gali, a paediatric nurse-practitioner for the Cleveland Clinic who takes such video-calls, are that she cannot look into children’s ears or listen to their chests. As these and more sophisticated diagnostics, including blood tests and virtual imaging, become available remotely, more patients could receive hospital-quality care without leaving home. Gupta Strategists, a Dutch research company, reckons that around 45% of care now given in Dutch hospitals could be done better at home.

Shifting almost all dialysis and chemotherapy out of hospitals is further off, but is on the way. And with better remote monitoring some chronically ill patients who now need to be in hospitals will be able to stay at home, only coming in when their conditions deteriorate. Moving care outside institutions will both save money and raise standards, by making patients more comfortable and reducing infection rates.

### **Each to their own**

For all this to happen, primary care and home support will need to improve. Kaiser shows what such “integrated care” might look like. It offers a host of alternatives to a hospital visit, from its website to kiosks to urgent-care centres, which are cheaper, often more convenient for minor ailments and equipped to deal with

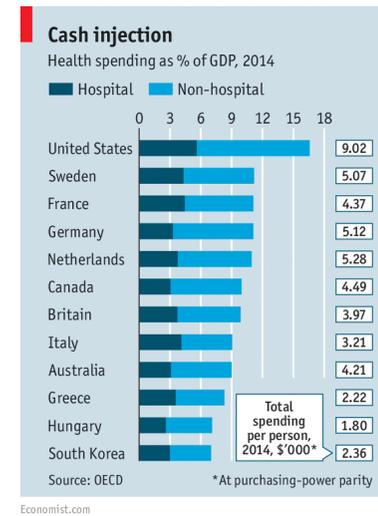
disease management and prevention, and the social issues that increase ill-health. “If we get a hospitalisation of a diabetic patient in a coma, that’s a failure of our system,” says Bernard Tyson, Kaiser’s boss. He blames skewed financial incentives to have “heads in beds” for much over-hospitalisation.

Banner Health, a large non-profit American health system, runs 28 hospitals and several specialised facilities across six states. Its Tele-ICU programme, for which Philips, a Dutch health technology firm, provides equipment, programming and software support, has its headquarters in Phoenix. It manages care for critically ill patients who may be thousands of miles away. Under its “intensive ambulatory care programme”, patients are helped to leave hospital earlier than is usual for their conditions. They remain under constant monitoring and care in their own homes, and can “beam in” by video to talk to a doctor or nurse at any time of day. After a pilot study with Philips, Banner Health thinks this telehealth programme could reduce admissions by nearly half, and cut costs by a third.

For patients who must still be admitted to hospital, the experience could be much more convenient and pleasant. Hospitals could operate more like a cross between a modern airport and a swish hotel, with mobile check-in, self-service kiosks for blood and urine tests and the like, and updates on patients’ and relatives’ phones. For pre-planned visits an algorithm could decide which tests are needed before a patient leaves home. Some of these could be done in advance and the results streamed directly to patients’ electronic records.

Health-care managers are already waking up to the fact that a patient’s environment affects outcomes such as recovery times and success rates. Some are aiming for pristine, white and clinical; others for pastels, seashells and classical music. The latter can all be found in Kaiser’s Manhattan Beach Medical Office, in Los Angeles, which is also planning yoga and cooking classes for patients. The new Karolinska University Hospital, in Stockholm, has SKr118m (\$13.2m) worth of art and lots of glass to maximise light, both intended to aid healing. It will be much

quieter and calmer than a typical city hospital, says Annika Tibell, the medical director; instead of flashing alarms and loudspeakers, staff will have discreet personal buzzers. Kaiser has switched from neonatal wards to private rooms in its new hospitals. All these may seem like luxuries, but patients who cannot sleep recover more slowly. Some hospitals have had acoustic levels at night of over 70 decibels, the equivalent of a nearby vacuum-cleaner.



But the biggest upgrades to hospitals are needed behind the scenes. Johns Hopkins Hospital, in Baltimore, has built a NASA-inspired “command centre” to manage its patient flows. Surrounded by 22 beeping flat-screens, live video-streams and lots of phones, staff members wearing headsets orchestrate the 1,100-bed institution around the clock. GE Healthcare, a medical-technology firm, helped mix, filter and present data streams in new ways—even including information such as the weather. Bed-planning has gone from an art to a science with the help of programs that predict demand with great precision and warn when a crunch is approaching. The centre stays in touch with nearby institutions whose patients require its specialists’ input, but not to be physically present. The aim is to “maximise the number of patients with access to Hopkins’ expertise”, says Jim Scheulen, the director.

In future, rather than checking patients’ vital signs only at intervals, or parking ICU-nurses next to beds, live data-streams from medical machines and wearable devices could flow straight to such command centres, where supercomputers could screen them for anything worth bringing to the attention of medical staff. Doctors in the command centre, or even in their own homes, could be at patients’ bedsides

virtually with a swipe of a touchscreen. All this would not only make the hospital safer and more efficient; it would also give medical staff a more complete record of patients' progress.

In Kaiser's Oakland Medical Centre, the nurses in the neonatal unit, among the most sensitive departments in any hospital, do not need to watch the babies as closely as they used to, because algorithms ping an alarm to their phones whenever there is something to worry about. The unit automatically goes into lockdown if anyone takes an infant, tagged with a bar code, to the exit. Soon Karolinska hospital will equip every patient with a vital-signs tracker. In the Cleveland Clinic's recently opened Avon Hospital, sensors track whether staff have washed their hands before entering a patient room: lights flash on their badges if not.

### **Cleared for landing**

A command centre could watch over patients not only in hospitals, but also at home. Wearable devices that track vital signs, contact lenses that monitor blood-sugar levels and smart-stitches that measure the pH level of fluid in wounds would all mean fewer patients in hospital for monitoring. When he speaks of how such remote monitoring could improve care for his leukaemia patients, the eyes of Matthew Kalaycio, an oncologist at the Cleveland Clinic, light up. If his phone warned him of a worrying change in a patient's temperature, he could wake the patient with a call even before he felt anything and tell him to come to hospital or, if caught early enough, to take medication to resolve the problem at home.

All this monitoring would bring two new risks: mass hypochondria, as patients obsessed over their data and flooded hospitals with requests for consultations; and alarm fatigue, in both patients and medics. The antidote would be an intelligent monitoring system combining all the different data-streams, filtering out the least relevant and alerting staff only when needed. A computer taught to recognise deviations from standard recovery would be able to alert medical staff to aberrations. For example, a pneumonia patient who does not shake off a fever after

two days of antibiotics needs attention. Most others simply need to complete the course of drugs, and get some rest.

### **Physician, heal thyself**

As well as enabling doctors to monitor patients more effectively, technology could also improve their skills, increase their reach—and, sometimes, take their jobs. Although hospital managers insist that technology would not replace staff, this is of course nonsense. Basic tasks, such as carting laundry around, are already being taken over by robots. Everyday care, such as keeping patients clean, could be next. Radiologists and pathologists, whose skills are primarily visual, are at risk of being elbowed aside by machines.

Engineers at Imperial College London recently developed Deep Medic, a computer program that assesses scans of patients with head injuries for signs of brain trauma. Today, these are diagnosed by a doctor who pores over MRI scans. Deep Medic can do the job in seconds. Brain tumours could be next. Such diagnoses would be cheaper and more accurate than possible with the human eye.

But mostly such technological advances would make doctors better, not replace them. The Cleveland Clinic is putting Watson, IBM's robot that learns to reason as it is fed data, through medical school. It could soon join doctors on their rounds. University Hospital Marburg, in Germany, recently began using Watson to improve the diagnosis and treatment of rare diseases (one early success was to help trace mysterious stomach symptoms to water snails in a patient's aquarium, leading to a diagnosis of bilharzia, a tropical disease). The smartphones in doctors' pockets could replace the stethoscopes around their necks. Machines do not get emotional or tired, nor do they struggle to distinguish whether a newborn baby is blue (and thus in need of urgent intervention) or pink.

The surgeon's job, too, could be transformed. Today, the use of robots in the operating room is limited because they must be steered manually with a joystick.

In future robots might be able to carry out some standard procedures such as hip replacements autonomously, with a surgeon getting things started and the robot doing the rest. With more complex operations, a supercomputer linked to a real-time virtual-reality (VR) machine could help walk surgeons through their operations. It could, for example, highlight where a tumour sits in the liver and warn a surgeon about impinging on an artery, just as a satnav warns of traffic jams ahead.

Sricharan Chalikonda, a surgeon at the Cleveland Clinic, says he can imagine scrubbing up “full Robocop-style”, with a helmet with built-in VR goggles giving him fighter-pilot “super-vision” and gloves that give him “super-hands”. His team has already worked with 3D prints of patients’ organs; the next big leap would be to project live images, showing the blood flowing through them. Microsoft HoloLens, clever virtual-reality goggles, is already being used to teach students about anatomy; cadavers can be cut up, which is useful, but to observe biological processes such as circulation in action only a live or VR body will do. In the future, every big hospital could have a Star Trek-style holodeck where surgeons could plan and rehearse complex operations on a 3D projection of the patient. Advances in minuscule robotic tools could correct for the imperfections of the shaky, too-large human hand, allowing fewer and smaller cuts than keyhole surgery as it is currently practised.

With quicker and less invasive treatments, recovery times would fall. Medical errors would become less frequent, as would the need for repeat operations. Surgeons in the control tower might, eventually, operate on patients all round the world. “I can totally see myself sitting here at my desk, guiding three operations in three different locations,” says Mr Chalikonda, as he leans back in his chair.

As technology amplified the reach of each health-care professional, one useful consequence would be to ease a looming labour shortage. Without a big leap in productivity America alone will lack up to 90,000 doctors by 2025. And worldwide

demand for health care is growing as lives—and that part of them lived in poor health—grow longer. The World Bank estimates that by 2030 the number of health-care workers will need to double, compared with 2013—an extra 40m workers globally. High rates of stress and burnout are



already a problem in health care; if workloads continue to increase they will only rise further. But if medical staff are made more productive with the help of computers, monitoring devices and robots, they can be freed up to do the work that only humans can do, and helped to do it better and more happily.

If full advantage is to be taken of new medical technologies, not only medical professionals, but patients, too, will have to take on a new role: more like co-pilot than passenger. Illegible charts at the end of the bed—literally out of patients' reach—would be replaced by a constantly updated electronic health record accessible on any device, by doctor, nurse or patient. The Cleveland Clinic already streams patient records, including test results, to “MyChart”, a site and app through which patients can also contact their physicians.

In many Kaiser hospitals, a flat-screen television on the wall gives patients information about their recovery and what they must do before they can go home. It may not be long before patients can be given access to the same sights and sounds as their doctors, for example by streaming the sound of a stethoscope to a headset or the view from an otoscope to a screen. Mr Tyson wants people to become as interested and engaged in their bodies as they are (or, at least, as he is) in their cars. He thinks that with the right technological and medical support they would be able to spot, and respond to, raised cholesterol as quickly as they would to low tyre pressure.

The modern hospital is a great achievement. And, in some form, it is sure to survive. “There will always be hospitals where patients with complex needs go for

multidisciplinary diagnosis and treatment by teams of specialists,” says John Deverill of GE. He predicts that separate facilities will spring up to provide common surgical interventions, such as joint replacements or cataract removals, to benefit from scale. And hospitals will also continue to be needed to treat emergency cases.

### **Beam me better, Scotty**

The next iteration of the hospital, however, is tantalisingly within reach—and it is more the co-ordinating node in a network than a self-contained institution. “We have reached the peak of bringing patients to the healing centres—our hospitals,” says Samuel Smits of Gupta. “We are on the brink of bringing the healing to patients.”

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