our bank, under constant replenishment, we could provide a donation matched for more than 5 HLA antigens for a high proportion of local patients. A recent review of 50 consecutive patients with acute leukaemia seen at the Royal Victoria Infirmary, Newcastle, showed that from our bank (which currently has 630 donations) 15 of 50 received a 6 out of 6 HLA match and 22 had a 5 out of 6 match. The issues remain that of volume[10 11] and the potential for use in adult patients, something undergoing further investigation in both Bristol and Newcastle.[10 11]

The true value of a cord bank was seen in a recent case where a baby with severe combined immunodeficiency was born in Dublin, diagnosed on day 10, transplanted with a 6/6 matched cord blood in Newcastle on day 20, discharged four weeks later, and six months was haematologically and immunologically normal.[12] To date, more than 40 cord bloods have been issued by the British banks for use in Britain and internationally.

The evolution of cord blood banks within Britain has achieved adequate geographical coverage and level of interest from transfusionists, experimental haematologists, and immunologists linked to transplant centres. So far, however, funding has been inconsistent, with money coming from the National Blood Service, regional health authority grants, and research charities. Now that the technique of cord blood transplantation and these banks have proved their worth the time has come to provide a more coordinated and secure financial infrastructure.

S J Proctor *professor of haematological medicine*
A M Dickinson *senior lecturer in marrow transplant biology*
T Parekh *research medical student*

University of Newcastle upon Tyne, Newcastle upon Tyne NE1 4LP

C Chapman *consultant in transfusion medicine*

Blood Transfusion Service, Newcastle upon Tyne NE2 4NQ

1 Lennard AL, Jackson GH. Stem cell transplantation. *BMJ* 2000;321:433-7.
2 Noort WA, Falkenburg JHF. Haematopoietic content of cord blood. In: Cohen SBA, Gluckman E, Rubinstein P, Madrigal JA, eds. *Cord blood characteristics. Role in stem cell transplantation.* London: Martin Dunitz, 2000:13-37.
3 Wang JC, Doedens M, Dick JE. Primitive human hematopoietic cells are enriched in cord blood compared with adult bone marrow or mobilized peripheral blood as measured by the quantitive in vivo SCID-repopulating cell assay. *Blood* 1997;89:3919-24.
4 Rubinstein P, Carrier C, Scaradavou A, Kurtzberg J, Adamson J, Migliaccio AR, et al. Outcomes among 562 recipients of placental blood transplants from unrelated donors. *N Engl J Med* 1998;339:1565-77.
5 Gluckman E, Rocha V, Chevret S. Related and unrelated cord blood transplantation. In: Cohen SBA, Gluckman E, Rubinstein P, Madrigal JA, eds. *Cord blood characteristics. Role in stem cell transplantation*. London: Martin Dunitz, 2000:205-16.
6 Rocha V, Sobocinski KA, Klein JP, Zhang MJ, Horowitz MM, Gluckman E. Graft-versus-host disease in children who have received a cord-blood or bone marrow transplant from an HLA-identical sibling. Eurocord and International Bone Marrow Transplant Registry Working Committee on Alternative Donor and Stem Cell Sources. *N Engl J Med* 2000;342:1846-54.
7 Cohen SBA, Wang XN, Dickinson AM. Can cord blood cells support the cytokine storm in GvHD? *Cytokine and Growth Factor Reviews* 2000;11:185-7.
8 Gluckman E, Rocha V, Boyer-Chammard A, Locatelli F, Arcase W, Pasquini R, et al. Outcome of cord-blood transplantation from related and unrelated donors. Eurocord Transplant Group and the European Blood and Marrow Transplantation Group. *N Engl J Med* 1997;337:373-81.
9 Chalmers IM, Janossy G, Contreras M, Navarrete C. Intracellular cytokine profile of cord and adult blood lymphocytes. *Blood* 1998;92:11-8.
10 Ademokun JA, Chapman C, Dunn J, Lander D, Mair K, Proctor SJ, et al. Umbilical cord blood collection and separation for haematopoietic progenitor cell banking. *Bone Marrow Transplant* 1997;19:1023-8.
11 Armitage S, Fehily D, Dickinson A, Chapman C, Navarette C, Contreras M. Cord blood banking; volume reduction of cord blood units using a semi-automated closed system. *Bone Marrow Transplant* 1999;23:505-9.
12 US lab is selling "biological insurance": Newcastle has one of three NHS "banks." *The Journal* 2001;24 Mar:9.

Bridging the quality chasm

To improve health care we need to understand the motivations of those who work in it

Earlier this year the Institute of Medicine issued another report on health care quality, following its much heralded report on patient safety in 1999. *Crossing the Quality Chasm* is unequivocal in its assertion: the defects of American health care are so widespread that they detract from the "health, functioning, dignity, comfort, satisfaction, and resources of Americans."[1] The report fails, however, to create an equally compelling vision of how health care in the United States can be transformed. We are not given a sense of how hundreds of thousands of healthcare workers will be engaged in this enormous task.

The authors of this report characterise their earlier one, *To Err is Human: Building a Safer Health System*,[2] as a "small part of an unfolding story of quality in American health care." Yet that report, on medical errors, provoked universal, dramatic calls for action, while this latest report has received only a subdued response. Perhaps to the public and those who provide their care the quality problem is "old news." Or perhaps the problem is too large and too close to grasp. The indictment of our current system acknowledges both the tremendous advances in medical science and the good intentions and dedicated work of the vast majority of care givers. Nevertheless, the report describes a system that is wasteful, often redundant, and lacking even the most basic information systems to support clinical care. Patients see long waiting times, delays, errors, and unnecessary services that pose risk without benefit. The authors contend that mergers, acquisitions, and downsizing in health care has led to little or no substantive improvement in the patient's experience.[3]

To rectify this situation the report offers six key characteristics for ideal health care (see box). The report exhorts employers, professional organisations, educators, regulators, payers, and the Department of Health and Human Services to create "an environment that fosters and rewards health care that is evidence based, facilitated by a sophisticated information technology, where quality is rewarded, and where the work force is prepared for rapid change in the interest of better service to patients."

BMJ 2001;323:61–2

These ambitious goals are at a very general level. Although the authors make an occasional foray into more detailed recommendations for improvement (such as the 15 priority focus conditions recommended to the Agency for Health Care Research and Quality), they do not outline a sequence of steps describing how health care in America will be transformed. Their reason for not doing so lies in complex adaptive systems theory, which is described in the report's appendix. As in other complex adaptive systems, health care is populated by highly adaptable elements (healthcare professionals); inputs have non-linear effects (small changes that create large effects); there is a continuous production of new, "emergent behaviours"; like the weather, the future state of the system is intrinsically not predictable in detail; and, finally, simple rules can yield complex outcomes. These simple rules may also be used to describe those outcomes in a way that makes sense of them.

Using this theory, the authors have concluded that "mechanical systems thinking" won't produce a way out of our current healthcare problems. Instead of a detailed blueprint for re-engineering health care in the US, the authors suggest we rely on a "good enough vision" (the six key aims), 10 simple rules, and experiments on a small scale that will result in disproportionately large outcomes (non-linearity). The ideas for innovation will come from those who actually provide the care (adaptable elements), driven by an intrinsic tendency for emergent behaviour—novelty. The authors call for support of this experimentation in care process design and information systems, guided by the evidence of medical science by payers, employers, and the federal government. The report suggests that a complex adaptive system such as health care will adopt the learning from successful experiments in care innovation. The authors are not naïve about the barriers to the process of experimentation and adoption. One chapter is devoted to the key barrier of financial incentives to maintain the status quo.

Yet the report is at its weakest in its exploration of the barriers and incentives to change. In complex systems and chaos theory human behaviour is influenced by "strange attractors," which are often hidden or poorly articulated values or needs.[4] When understood, these attractors often explain complex, seemingly unintelligible behaviour. They may be used to convert behaviour that seems impossible to influence into behaviour that can be channelled to meet the needs of patients in new and more effective ways.

To influence the elements of a complex adaptive system such as health care, one must understand how such systems differ from machines. Take the problem of throwing a rock and getting it to land where one wishes. Understand the mass of the rock, the distance of the target, the force of gravity, etc, and one can calculate the force and trajectory needed. Try the same approach throwing a bird and the results will be different. The complex behaviour of the bird becomes intelligible once we know that birds are insatiable food seekers; we then know how to influence their behaviour—for example, by placing food where we wish the bird to land. We have used our knowledge of the "attractor" for this element of our system to both understand and influence its complex behaviours. It is unfortunate that the institute's report does not explore this key concept because it lies at the heart of why our healthcare system has not changed. Such change cannot occur without understanding and using the values and needs of those who directly care for patients.

Six key aims …

(1) Safe—avoiding injuries to patients
(2) Effective—based on scientific knowledge (avoiding overuse and underuse)
(3) Patient centred—respectful of and responsive to individuals' preferences, needs, and values
(4) Timely—reducing wasteful delays
(5) Efficient—avoiding waits
(6) Equitable—the same quality care provided to all, regardless of race, gender, geographic location, or ability to pay

… and 10 simple rules

(1) Care based on continuous healing relationships
(2) Customisation based on patient needs and values
(3) The patient as the source of control
(4) Shared knowledge and the free flow of information
(5) Evidence based decision making
(6) Evidence as a system property
(7) The need for transparency
(8) Anticipation of needs
(9) Continuous decrease in waste
(10) Cooperation among clinicians

This is particularly important in the US, where health care remains fragmented with no common information systems, no national payment standards, and only a handful of national quality standards. Most Americans are treated by physicians who practise alone or in very small groups linked to the outside world only by poorly understood health insurance plans. Hospitals have little control over physician practices outside their walls. Despite rhetoric to the contrary, American health care remains a cottage industry, where providers are preoccupied with financial survival and the challenges of regulation and litigation. They are driven by highly individualised value needs, not by an abstract or common desire to improve health care.

Before we invite and support experimentation in this challenging environment, we should candidly explore the motivation and incentives of those who provide care in the current environment. Without the knowledge and use of internal rewards to create and sustain key behaviours in providers, we have little chance of widespread, enduring improvement in the processes and systems of health care.

Mark A Kelley *executive vice president and chief medical officer*
James M Tucci *vice president and senior medical director, clinical quality and safety*

Henry Ford Health System, One Ford Place 5B, Detroit, MI 48202-3450, USA

1 Committee on Quality of Health Care in America. *Crossing the quality chasm: a new health system for the 21st century.* Washington, DC: National Academy Press, 2001.
2 Institute of Medicine. *To err is human: building a safer health system.* Washington, DC: National Academy Press, 2000.
3 Picker Institute and American Hospital Association. *Eye on patients report.* Washington, DC: Picker Institute, 1996.
4 Pierce JC. The paradox of physicians and administrators in health care organizations. *Health Care Management Review* 2000;25:7-28.