Beyond patient safety Flatland

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A Flatland analogy for patient safety

When Edwin A Abbott published in 1884 his famous fantasy in geometry, *Flatland: A romance of many dimensions*,[1] his imagination sparked not so much a revolution in mathematics or physics as of perspective. Flatland is a universe in two dimensions – length and width – and the inhabitants (lines, triangles, squares and multisided polygons) in the plane cannot apprehend the complexities of the third dimension: height. It remains beyond their cognitive reach. This analogously describes the problem of patient safety, where we know a lot about two dimensions – the magnitude of the predicament (the length of the problem) and the categories of harm (its width) – but the nature of the third dimension, the lofty heights of what to do, and how to address problems, has proven elusive. We are on the brink of understanding this dimension more thoroughly, and thus better positioned to tackle the challenges it presents.

Dimension one: how much harm?

Our first dimension for understanding patient safety is the length of the problem, which is considerable. Of the problems testing medicine's ingenuity, iatrogenic harm (induced by healthcare itself) is among the most challenging.[2,3] But just as with trying to understand quantum mechanics, climate change or consciousness, complexity and difficulty are no excuse for inaction. Experts agree that errors and adverse events from care delivered to millions of patients across the world are at unacceptably high levels.[4] Estimates vary, depending on study variables, but the rate is of the order of 10% of all admissions.[5–9] In about 2% of all cases major iatrogenic disability or death occurs.[10] This equates to some 10,000 worldwide deaths per day.[11] In the world's most expensive health system, that of the USA, only half of recommended care reaches adults[12] and children.[13] Further, studies at autopsy reveal important, unsuspected diagnoses in about 30% of cases.[14] Such significant rates of misdiagnosis or poor detection at death underscore that there is room for better identification of disease and illness and subsequent targeting of treatment.

The statistical risk for groups and individuals is becoming clearer. Most would agree the odds are too high: a 1:2 chance of getting the right care; a 1:10 likelihood of being harmed in association with a hospital admission; a 1:50 possibility of system-induced death or major disability; and a 3:10 incidence of ultimately dying normally but with untreated pathology. If these factors overlap, then the chances are 50% of sustaining an error or near miss, or receiving inappropriate care. If, as is more likely, they are discrete factors, the chances are higher. However, if they are wholly independent (unlikely for groups of people but possible for any individual), the risk of misadventure or under-detection by health system act of omission or commission of some sort is more than 92%.

What might be the real extent of harm in health systems with fewer resources, especially those of developing nations, is not well-known but likely to be considerably worse. World Health Organization data[15,16] show that patients in developing countries may have a 2–20 times greater chance

than those in the rich world of getting a hospital-acquired infection, with a 3–20 times greater chance in the case of neonatal infections. The conclusion is that the dimension one phenomenon is a matter of concern – there is too much harm caused or presided over by both developed and developing health systems, and with a risk of receiving poor quality care between 50–90%, we have major opportunities for improvement in this dimension.

Dimension two: types of harm

Enter dimension two: the width of the problem, expressed as the types of errors from which patients can suffer. Optimally, the correct clinical care would be delivered to the right patient every time. This is merely a noble aspiration at this point. Patients can acquire an infection of the urinary tract or their wound while in hospital, suffer delays in getting necessary treatment, experience acute but avoidable pain as a result of care, or receive the wrong drug or dosage.[17] In rarer but recurring cases, a patient can undergo an operation at the wrong site, or a procedure meant for someone else, be seriously injured by a medical device, commit suicide despite having been in recent contact with a mental health service or suffer severe treatment-induced trauma or hemorrhages.[18,19]

As in other areas of life it is worse if you are poor. The types of harm in developing parts of the world are different to those in industrialized countries. Approximately 50% of injections in South East Asia are unsafe due to syringe reuse and the lack of proper sterilization and disposal of medical waste. Perhaps 50% of medical equipment is unstable and 40% of hospital beds are located in buildings intended for other purposes. Most (77%) of the world's counterfeit and substandard drugs are accounted for in developing countries and over half of all medications dispensed or sold are not justified.[15,16]

Current hypotheses about the hidden dimension

Abbott dubbed his third dimension Spaceland, and it could not be seen by inhabitants whose world view is restricted to two planes. For many decades, policymakers, managers, clinicians and researchers were Flatlanders, unable to perceive much that is solid about rectifying patient safety. Slowly but surely, however, we can glimpse what a third-dimensional solutions set might look like. Judicial and quasi-judicial inquiries investigating particularly salient examples of poor care such as at Bristol Royal Infirmary in England,[20] Manitoba Health Centre in Canada,[21] King Edward Memorial Hospital in Australia[22] and elsewhere[23] suggest that several prevalent matters need to be addressed if care is to be made safer. These include poor communication and teamwork within clinical groups,[24–26] between clinicians and managers,[27] and between services and their patients and carers.[28,29] There are also stretched interprofessional relationships and failures of political and organizational leadership to be tackled.[30,31] The casualization of clinical workforces[32] exacerbates problems such as handover from one shift to another.[33] Clinical supervision of junior staff[22] is less than perfect in many health facilities. External and internal quality monitoring procedures are deficient.[34] Patients, their carers and relatives are not sufficiently included in decision-making processes affecting them,[35] and they should be.

We see two groups of potential solutions to errors and harm, but the mix of strategies that are effective remains unclear. Technical aspects of care, the first group, are complicated – they centre on ensuring that the heart operation is skillfully performed, the dangerous drug is administered via the appropriate route or the right dose of radiotherapy is calibrated and delivered. Social and organizational factors, the second group, are even more complex. Modern healthcare can only be delivered through teamwork,[36,37] and effective organizational systems. Productive professional cultures are thought to be crucial determinants of reliable care.[38,39] Getting care to the patient in a timely fashion with effective monitoring to ensure things go well will no doubt require a more coordinated, focused effort.

How can this be done? No one has adduced a comprehensive answer to this question as it involves going to a dimension not yet completely accessible. Resolution of the problem is more likely to be a journey than a destination. For instance, some of Britain's best patient safety experts not long ago refused to put a figure on what the harm

rate could ultimately fall to, and told the House of Commons Committee of Public Accounts on patient safety that they thought that progress could be measured only in decades.[40]

The right mix of education, incentives for doing the right thing, deterrents against poor practices and learning from the good and the bad in clinical care will, it is believed by many, be important. Technical fixes are mostly predicated on skills development and acquiring more advanced technology such as new diagnostic machines and tests. This means that healthcare personnel have to ensure that new technology and techniques are effectively assimilated, and individuals are competent in their use. University and private research laboratories, innovative technology companies, and external educational providers including universities, medical, nursing and allied health colleges, regulatory agencies and representative bodies are the key providers.

Present-world thinking about how to proceed

But how can we address human systems improvements and engender concerted, collaborative efforts? The science of understanding how to change institutions for the better and involve people in improvements does not provide the most rigorous (level 1) evidence. Encouraging more open cultures with less emphasis on blaming the individual and more on learning, teamwork and support are thought to be important. Such claims are not based on data at the level of randomized controlled trials, and thus must be considered conjectural rather than a tested hypothesis. Innovators have designed an impressive array of tools, techniques and strategies even in the absence of information about the full scope and scale of the third dimension. Some of the most important of these are summarized in Table 1.

These efforts are commendable, and encouraging. For some skeptics, however, they represent mostly small-scale examples of success. Up to now there is no systematic evidence that the rates of adverse events have sustainably fallen across-the-board as a result of such initiatives beyond localized demonstrations. However, lack of evidence is not the same as evidence of lack, and some experts are encouraged as a result of these initiatives.[41] Yet widespread, cross-health system success eludes us, perhaps because of the historical difficulty of living in Flatland when we need to appreciate more deeply the contours of Spaceland.

Other worlds and universes

Nevertheless we are beginning to apprehend the third plane more clearly as we move from the two-dimensional stance of the past. To help us see more clearly, there are hints from other worlds addressing their own safety problems. Two appear to have accessed the third dimension of understanding and solution. Mining in developed countries has made inroads into safety principally through training, regulation, applied engineering advances and hazard reduction strategies. For example, coal mining disasters and fatalities declined throughout the 20th century in the USA,[42] Europe and other developed countries. The aviation sector has induced cultural change in reporting incidents systematically, and dealing with problems concertedly, including near misses. There is much to learn from these.[43] Elevating safety to the top of the agenda at every meeting, learning to be vigilant and promoting openness and transparency while relegating defensive behaviours are now thought to be crucial, but this was not always the *modus operandi* in aviation. Activities in the cockpit are now focused more on crew interdependence and sharing document technology, e.g. promoting teamwork and using comprehensive checklists instead of relying on individualized autonomy.[44]

Similar approaches are needed in the health system, but there is a general acceptance that medical care is more complex than mining and aviation, and professionalized, often tribal cultures remain a strong barrier to change. Clinical practice is now being characterized as a multitasking, interruption-riven environment,[45] in which errors emerge out of the complex interaction of work practices, individuals working beyond safe cognitive limits[46] and an asymmetry of information and evidence between different practitioners and patients.[47] As a result, change initiatives predicated on overly simplistic, linear models of error seem inevitably to generate unintended consequences and harm, along with any benefits that they bring.[48]

Table 1
Tools, techniques and approaches to address patient safety

- Using information technology to gather data about incidents and near-misses[59,60]
- Creating opportunities for learning from errors and near misses[61,62]
- Adopting new models for categorizing and managing harm such as severity assessment systems[63,64]
- Conducting root cause analysis,[65,66] a technique which asks what went wrong and why, going back to the original causes
- Delivering care through clinical pathways,[67,68] designed to promote a safer, evidence-based patient journey
- Training staff in quality improvement techniques and approaches[69,70]
- Encouraging the practice of evidence-based or evidence-informed medicine[71,72]
- Harnessing the use of forcing functions[73] whereby design features restrict how tasks are performed, such as prescribing drugs via computers with alerts for inappropriate dosage levels[74] or using automatically retracting syringes which only expose the needle at the time of injection
- Designing team-based, protocol-driven approaches in specific areas to target improved safety[49]
- Engendering a systems-wide social movement modeled on political campaigns, e.g. the 100,000 and 5 million lives campaigns of the Institute of Healthcare Improvement[75,76]
- Using checklists to improve surgical complications and deaths[50]
- Harnessing market-based control mechanisms to address adverse events – similar to carbon trading, we could have error trading[56]

Some elegant initiatives relying on sound safety science principles, taking a systems approach, are proving effective. Pronovost's use of education about safe systems of care, checklists, team leadership training, education of participants, discussions and external feedback and support are encouraging, showing that catheter-related bloodstream infections in US hospitals can be reduced markedly and the gains sustained over time.[49] The Safe Surgery Saves Lives Study Group reported reducing postoperative complications and death rates from surgical care in eight hospitals in eight countries by more than one-third by implementing the WHO 19-item surgical safety checklist.[50]

Notwithstanding this, evocatively, more than one commentator has used the jumbo jet exemplar.[51,52] If 30 Boeing 747s crashed every month in America, six in Britain and two in Australia, with no survivors, it is believed there would be an outcry and immediate, remedial action. That is the extent of unnecessary patient deaths in healthcare. Although many are believed to be preventable, the responses to date have not had the effect optimists had hoped. Because medical harm is delivered one patient at a time, it does not generate the collective societal concern needed to pressure the health system to address it. This may be a key reason why this dimension remains tantalizingly difficult to tackle, at least as measured by rates of errors and near misses demonstrably falling. Further concerted action is needed, not only to apply effectively and widely those activities listed in Table 1, but to find other solutions.

Medical care will always be risky. We could never imagine from a two-dimensional vantage point that there will emerge a third dimension in which surgery always works, all procedures are safe, complications are eradicated, each drug is accurately administered without side-effects and no patient falls inadvertently through the system's cracks. Yet exacerbating the quandary, ageing populations require more healthcare than younger populations for a variety of reasons, especially as they are burdened by more chronic and complex conditions. Most, and certainly all developed countries, are experiencing substantial ageing in their populations as baby-boomers reach retirement. The strain on healthcare is building as a consequence. Errors in pressurized, stretched health systems could increase rather than decrease, despite the third dimension gains.

Teleportation, the fourth dimension, or 10 dimensions?

The evidence supports the proposition, then, that we are moving from the patient safety version of Flatland to a more thorough appreciation of Spaceland. But there is more to it than this. We do know much more than previously about the magnitude of the patient safety problem and the categories of harm we need to tackle first (e.g. patient falls, medication errors, infections, delayed investigations, cardiac arrest while in hospital, pressure sores, ongoing pain and excessive bleeding). The best solutions or solution packages are increasingly evident, but there is a fourth dimension – time – that is not on our side.

That said, it will require a collaborative international effort in the same way as international space exploration efforts have broadened to include cooperation across national boundaries.

The recently-established WHO's World Alliance for Patient Safety (http://www.who.int/patientsafety/en/) and the older but increasingly important International Society for Quality in Health Care Inc (http://www.isqua.org/) offer hope and are striving to promote international collaborations. The strategies it produces may represent a set of robust, workable hypotheses, applicable widely across health jurisdictions, settings and cultures.

What will be needed to get to the next stage of understanding? What will a sustainable solution look like? A patient safety research agenda predicated on investigating and providing new knowledge on leadership and its contribution to improved care, inter-professional teamwork, and clinical cultures more focused on patient rather than provider interests seems essential. Effectively led,[53] resilient,[54] well-organized services with productive interactions between stakeholders is at the core of what is required. But there is a big difference in knowing that we need to do things differently, and even what, in patches, we need to do, and the creation of a system of care, re-designed with safety in mind, taken up across whole health sectors. This would be a fundamentally reformed health system, and one of which we could all be proud. So: is a new order such as this actually being enabled? This would be as thoroughgoing a third dimension change as we could hope. As yet, we have not witnessed an entire health system at this tipping point.[55]

This would involve converting many ideas, strategies and initiatives such as those in Table 1 into safe systems of work and care. What is missing is a way these can be aggregated into a systemic approach that routinely protects against error, adverse events and conditions of risk, or offers a mechanism to ameliorate these progressively.

One answer may lie in harnessing the power of markets. A recent proposal specified a framework for reducing adverse events using market-based control (MBC), modeled along the lines of carbon trading.[56] A regulator would establish a safety market, set a patient safety price for adverse events, designate system-wide and organizationally-specified targets and govern how safety credits would be traded. Health service organizations would beat their harm reduction targets and sell their earned credits on the market, or have to buy credits to offset performance over target. Third-party organizations would emerge to support improvements. As targets are met, aggregate systems-wide adverse events are reduced over time. MBC mechanisms are used to improve systems performance elsewhere[57] including carbon emissions reduction.[58]

Conclusion

We might heed the old adage that collectively humans have a much higher IQ than individually. Unlike Flatlanders of days gone by, who could not relate extra-dimensionally and thereby remained ignorant of a crucial way of thinking, we have the capacity to apprehend our missing dimension. Some insightful leaders are uncomfortable and increasingly vocal about how we need to fully exploit strategies in the third dimension. More support should be given to the internationalization of the efforts, which is being led not only by WHO and ISQua but key players such as the Institute for Healthcare Improvement and the Veterans Health Administration in the USA, the English NHS, and the Australian Patient Safety Foundation.

Unsettlingly, however, we would do well to remember that current versions of string theory in physics postulate 10 or 11 dimensions. This may be several dimensions too far for patient safety experts to contemplate right now, and if patient safety turns out to be that complex, we will find the solutions are a lot more multifaceted than we think today.

For all that, there is pressure to solve the patient safety Spaceland dilemma quickly. The urgency of the matter will not fail to be recognized by anyone who is likely to require care sometime in the future, is ageing, or both. That, of course, is all of us.

References

1 Abbott E. *Flatland: A romance of many dimensions*. 5th edn. London: Gutenberg Press; 1884
2 Moss F. Working differently for better, safer care. *Qual Saf Health Care* 2003;**12** (**Suppl. 1**):i1
3 Watcher RM. The end of the beginning: patient safety five years after 'To err is human'. *Health Aff* 2004;**Supp Web Exclusives**:534–45
4 Longo DR, Hewett JE, Ge B, Schubert S. The long road to patient safety: a status report on patient safety systems. *JAMA* 2005;**294**:2858–65
5 Baker GR, Norton PG, Flintoft V, *et al*. The Canadian Adverse Events Study: The incidence of adverse events among hospital patients in Canada. *Can Med Assoc J* 2004;**170**:1678–86
6 Brennan TA, Leape LL, Laird N, *et al*. Incidence of adverse events and negligence in hospitalized patients. Results of

the Harvard Medical Practice Study I. *N Engl J Med* 1991;**324**:370–6
7 Davis P, Lay-Yee R, Briant R, Ali W, Scott A, Schug S. Adverse events in New Zealand public hospitals I: occurrence and impact. *N Z Med J* 2002;**115**:271
8 Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *BMJ* 2001;**322**:517–19
9 Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The Quality in Australian Health Care study. *Med J Aust* 1995;**163**:458–71
10 Runciman WB, Webb RK, Helps SC, *et al*. A comparison of iatrogenic injury studies in Australia and the USA. II: Reviewer behaviour and quality of care. *Int J Qual Health Care* 2000;**12**:379–88
11 Runciman WB, Merry A, Walton M. *Safety and ethics in healthcare: a guide to getting it right*. Aldershot: Ashgate; 2007
12 McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;**348**:2635–45
13 Mangione-Smith R, DeCristofaro A, Setodji CM, *et al*. The quality of ambulatory care delivered to children in the United States. *N Engl J Med* 2007;**357**:1515–23
14 Kirch W, Schafii C. Misdiagnosis at a university hospital in four medical eras. *Medicine* 1996;**75**:29–40
15 World Health Organization. *Patient safety – a global priority*. Geneva: WHO; 2006
16 World Health Organization. *Fifty-fifth World Health Assembly Provision agenda item 13.9, 23 March 2002: Quality of care: patient safety – report by the Secretariat*. Geneva: WHO; 2002.
17 Runciman WB, Edmonds MJ, Pradhan M. Setting priorities for patient safety. *Qual Saf Health Care* 2002;**11**:224–9
18 National Health Service. *An organisation with a memory: a report of an expert group on learning from adverse events in the NHS*. London: Department of Health; 2000
19 Runciman WB, Moller J. *Iatrogenic injury in Australia*. Adelaide: Australian Patient Safety Foundation; 2001
20 Department of Health. *Report into Public Inquiry into Children's Heart Surgery at the Bristol Royal Infirmary 1984–1995: Learning from Bristol. The Bristol Royal Infirmary Inquiry*. London: The Stationery Office; 2001
21 Sinclair CM. *Report of the Manitoba pediatric cardiac surgery inquest*. Winnipeg: Manitoba Provincial Court; 1994
22 Douglas N, Robinson J, Fahy K. *Inquiry into obstetric and gynaecological services at King Edward Memorial Hospital 1990–2000*. Perth: Health Department of Western Australia; 2001
23 Hindle D, Braithwaite J, Travaglia JF, Iedema R. *Patient safety: A comparative analysis of eight inquiries in six countries*. Sydney: Centre for Clinical Governance Research in Health, University of New South Wales, Australia and Clinical Excellence Commission; 2006
24 Cassirer C, Anderson D, Hanson S, Fraser H. Abusive behavior is barrier to high-reliability health care systems, culture of patient safety. *Qrc Advis* 2000;**17**:1–6
25 Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. *BMJ* 1998;**316**:673–6
26 Lingard L, Reznick R, Espin S, Regehr G, DeVito I. Team communications in the operating room: talk patterns, sites of tension, and implications for novices. *Acad Med* 2002;**77**:232–7
27 Braithwaite J, Westbrook MT. A survey of staff attitudes and comparative managerial and non-managerial views in a clinical directorate. *Health Serv Manage Res* 2004;**17**: 141–66
28 Vincent CA, Coulter A. Patient safety: what about the patient? *Qual Saf Health Care* 2002;**11**:76–80
29 Penson RT, Kyriakou H, Zuckerman D, Chabner BA, Lynch TJ Jr. Teams: communication in multidisciplinary care. *Oncologist* 2006;**11**:520–6
30 Perry SJ. Profiles in patient safety: organizational barriers to patient safety. *Acad Emerg Med* 2002;**9**:848–50
31 Reeder JM. Patient safety: cultural changes needed. *Healthc Pap* 2001;**2**:48–54
32 Bradley C. Doing more with less in nursing work: a review of the literature. *Contemp Nurse* 1999;**8**:57–64
33 Alvarado K, Lee R, Christoffersen E, *et al*. Transfer of accountability: transforming shift handover to enhance patient safety. *Healthc Q* 2006;**9** (Special Issue No. 9): 75–9
34 Bolsin S. Professional misconduct: The Bristol case. *Med J Aust* 1998;**169**:369–72
35 Kohn LT, Corrigan JM, Donaldson MS, eds. *To err is human: building a safer health system*. Washington, DC: National Academy Press; 1999
36 Risser DT, Rice MM, Salisbury ML, Simon R, Jay GD, Berns DS. Potential for improved teamwork to reduce medical errors in the emergency department. *Ann Emerg Med* 1999;**34**:373–83
37 Thomas EJ, Sexton JB, Helmreich RL. Translating teamwork behaviours from aviation to healthcare: development of behavioural markers for neonatal resuscitation. *Qual Saf Health Care* 2004;**13** (**Suppl. 1**): i57–i64
38 Carroll JS, Quijada MA. Redirecting traditional professional values to support safety: changing organisational culture in healthcare. *Qual Saf Health Care* 2004;**13** (**Suppl. 2**):ii16–ii21
39 Ferlie EB, Shortell SM. Improving the quality of health care in the United Kingdom and the United States: a framework for change. *Milbank Q* 2001;**79**:281–315
40 House of Commons Committee of Public Accounts. *A safer place for patients: learning to improve patient safety – fifty-first report of session 2005–06*. London: The Stationery Office; 2006
41 Buerhaus PI. Is hospital patient care becoming safer? A conversation with Lucian Leape. *Health Aff* 2007;**26**: w687–w696
42 Stout NA, Linn HI. Occupational injury prevention research: progress and priorities. *Inj Prev* 2002;**8** (**Suppl. IV**):9–14
43 Toft B, Reynolds S. *Learning from disasters: a management approach*. 2nd edn. Leicester: Perpetuity Press; 1997
44 Hazlehurst B. The cockpit as multiple activity system: a computational model for understanding situated team performance. *Int J Aviat Psychol* 2003;**13**:1–22
45 Coiera E. When conversation is better than computation. *J Am Med Inform Assoc* 2000;**7**:277–86
46 Parker J, Coiera E. Improving clinical communication: a view from psychology. *J Am Med Inform Assoc* 2000;**7**: 453–61
47 Coiera E. Information economics and the Internet. *J Am Med Inform Assoc* 2000;**7**:215–21
48 Ash J, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. *J Am Med Inform Assoc* 2004;**11**:104–12
49 Pronovost P, Needham D, Berenholtz S, *et al*. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med* 2006;**355**:2725–32

50 Haynes AB, Weiser TG, Berry WR, *et al*. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med* 2009;**360**:491–9
51 Leape LL. Error in medicine. *BMJ* 1994;**272**:1851–7
52 Stelfox HT, Palmisani S, Scurlock C, Orav EJ, Bates DW. The "To Err is Human" report and the patient safety literature. *Qual Saf Health Care* 2006;**15**:174–8
53 Braithwaite J. L(H) $\neq \sum(m^1, m^2 \ldots m^n)$. *Leadership in Health Services* 2008;**21**:8–15
54 Weick K, Sutcliffe K. *Managing the unexpected: Resilient performance in an age of uncertainty*. 2nd edn. New York, NY: Jossey-Bass; 2007
55 Braithwaite J, Westbrook MT, Travaglia JF, *et al*. Are health systems changing in support of patient safety? A multi-methods evaluation of education, attitudes and practice. *Int J Health Care Qual Assur* 2007;**20**:585–601
56 Coiera E, Braithwaite J. Market-based control mechanisms for patient safety. *Qual Saf Health Care* 2009;**18**:99–103
57 Clearwater SH. *Market-based control: a paradigm for distributed research allocation*. River Edge, NJ: World Scientific; 1996
58 Mullins F, Baron R, Bosi M. *Kyoto mechanisms, monitoring and compliance – from Kyoto to The Hague*. Paris: Organisation for Economic Cooperation and Development; 2001
59 Beckmann U, West LF, Groombridge GJ, *et al*. The Australian Incident Monitoring Study in Intensive Care: AIMS-ICU. The development and evaluation of an incident reporting system in intensive care. *Anaesth Intensive Care* 1996;**24**:311–13
60 Westbrook MT, Braithwaite J, Travaglia JF, Long D, Jorm C, Iedema R. Promoting safety: varied reactions of doctors, nurses and allied health professionals to a safety improvement program. *Int J Health Care Qual Assur* 2007;**20**:555–71
61 Berwick DM, Leape LL. Reducing errors in medicine. *BMJ* 1999;**319**:136–7
62 Reason JT. Human error: models and management. *BMJ* 2000;**320**:768–70
63 Bagian JP, Lee C, Gosbee J, *et al*. Developing and deploying a patient safety program in a large health care delivery system: you can't fix what you don't know about *Jt Comm J Qual Improv* 2001;**27**:522–32
64 Braithwaite J, Travaglia JF, Mallock N, *et al*. *Evaluation of the patient safety program in New South Wales: overview of studies*. Sydney: Centre for Clinical Governance Research, University of New South Wales; 2005
65 Bagian JP, Gosbee J, Lee CZ, Williams L, McKnight SD, Mannos DM. The Veterans Affairs root cause analysis in action. *Jt Comm J Qual Improv* 2002;**28**:531–45
66 Braithwaite J, Westbrook MT, Mallock N, Travaglia JF, Iedema R. Experiences of health professionals who conducted root cause analyses after undergoing a safety improvement program. *Qual Saf Health Care* 2006;**15**:393–9
67 Miller PR, Fabian TC, Croce MA, *et al*. Improving outcomes following penetrating colon wounds: application of a clinical pathway. *Ann Surg* 2002;**235**:775–81
68 Mallock N, Braithwaite J. A template for clinical pathway design based on international evidence. *Clin Gov Bull* 2005;**5**:2–4
69 NSW Health Excellence IfC. *Taking steps to improve safety in the health system: Training manual*. North Sydney: NSW Department of Health and the Institute for Clinical Excellence; 2004
70 Barrett J, Gifford C, Morey J, Risser DT, Salisbury ML. Enhancing patient safety through teamwork training. *J Healthc Risk Manag* 2001;**21**:57–65
71 Gosling A, Westbrook J, Braithwaite J. Clinical team functioning and IT innovation: a study of the diffusion of a point-of-care online evidence system. *J Am Med Inform Assoc* 2003;**10**:244–51
72 Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. *Evidence-based medicine: how to practice and teach EBM*. 2nd ed. Edinburgh: Churchill Livingstone; 2000
73 Norman DA. *The psychology of everyday things*. New York, NY: Basic Books; 1988
74 Bates DW, Gawande A. Improving safety with information technology. *N Engl J Med* 2003;**348**:2526–34
75 Berwick DM, Calkins DR, McCannon CJ, Hackbarth A. The 100,000 lives campaign: setting a goal and a deadline for improving health care quality. *JAMA* 2006;**295**:324–7
76 Institute for Healthcare Improvement. *Protecting 5 million lives from harm*. Cambridge, MA: Institute for Healthcare Improvement; 2007