Int J Biomed Comput, 30 (1992) 181–186
Elsevier Scientific Publishers Ireland Ltd.

OVERVIEW OF SOME METHODOLOGICAL PROBLEMS IN ASSESSMENT OF PACS

B.L. CROWE

Australian Institute of Health, Canberra (Australia)

The purpose of technology assessment of picture archiving and communications systems (PACS) is to establish the need for the technology, provide a measure of functionality and to establish the costs and benefits associated with the introduction of the system. Given concerns about the clinical acceptability of PACS, it is unlikely that radiologists will change from existing film based systems until a clear demonstration of costs and benefits has been performed. The major need at present is to quantify the benefits which may flow from the introduction of PACS system in a standard manner which can be accepted by all parties involved.

Keywords: Technology Assessment; PACS; Cost-benefit

Introduction

It is indeed an honour to be asked to provide an overview of the methodological problems involved in assessment at this first international workshop on technology assessment of PACS. The fact that The Netherlands Ministry of Health Care has seen fit to fund this workshop involving major PACS participants from Europe, United States and Japan is indicative of the importance of the area. However, the need for an international workshop of this kind indicates that there are a number of uncertainties in the area of technology assessment of PACS.

I believe that this point is worth making at the outset — the benefits of PACS in relation to the costs and effort involved in its introduction are not unambiguously clear — to quote an earlier BAZIS report on PACS [1]. It is my perception that PACS is at present going through a crisis with a number of large systems either being stalled or having difficulty with funding and a number of major PACS manufacturers re-appraising the marketing and support of PACS.

In many ways this crisis is not unexpected if one is aware of the history of technical development of other complex systems. I recall that the computer industry went through a similar period in the mid-1960s. The crisis usually takes the form of a technically sound idea looking for an application on a sufficiently large scale to justify expenditure on research, manufacture, development and support. The end

Correspondence to: B.L. Crowe, Health Technology Division, Australian Institute of Health, GPO Box 570, Canberra ACT 2601, Australia.

0020-7101/92/$05.00
Printed and Published in Ireland

result of such a crisis may be the termination of the technology, stagnation or a leap forward with greater confidence and widespread application.

Technology Assessment

The seven stage model of technology development and diffusion developed by McKinlay [2] in the late 1970s is somewhat simplistic in that it outlines an overall trend from acceptance to implementation to decay and perhaps implies a certain inevitability to the process.

The concept of the 'technological imperative' assumes that just because a technology is there, it will be adopted and used by the 'technology junkies' of the latter part of the twentieth century. This is indeed not necessarily the case and the history of technology is littered with good ideas which were never implemented for one reason or another.

Thus, one has to consider the major question as to what are the reasons or features of a technology which will lead to its widespread introduction and acceptance. I believe that the major factors are:

- the technology must meet a deeply felt need of a large group of potential users
- the technology must be capable of performing a function better than existing technology
- the technology must be available at the same cost or less cost than existing systems or products.

Many users of an existing technology have both a psychological and financial investment in such systems and are unlikely to be easily influenced to change to a new system. This concept has been defined by Hilsenrath [3] as 'sunk' costs. I believe that a new technology will not be successful until a strategy has been developed to address the depreciation of the investment, both financial and psychological, in existing technology and the subsequent effect on the training and structure of the workforce.

Discussion of strategies leads directly to the concept of Technology Assessment, a process designed to lead to informed policy formulation about the allocation of scarce resources. I assume that by now we are in general agreement of the points developed by Drummond et al. [4] about the need for assessment and the concept of opportunity costs — i.e. that resources devoted to one technology are resources denied to another. Therefore there is a need for a process of Technology Assessment to ensure that competing technologies are assessed on a uniform basis and that the determination of the three factors mentioned before, i.e. (a) the need for a technology; (b) the measurement of functionality; (c) the establishment of the costs and benefits are developed on a standard basis.

Key Factors in Technology Assessment

Addressing the issues of Technology Assessment presents a number of problems. The first issue, the establishment of the need for a technology, involves a number of subjective factors. Perhaps the most important of these is perceived or

demonstrated dissatisfaction with existing systems. In the case of PACS one assumes that the present system involves the generation of film, the reading of films on a light box or alternator, and the physical filing and storing of these films for subsequent manual retrieval.

There is a need to seek the assistance of our colleagues in psychology to establish measures of dissatisfaction and then to develop measurement instruments to determine the levels of disfunction in the present system. Indeed the PACS group at Georgetown University Medical School developed a survey of the activities of the film room and in fact found that the performance was actually better than expected [5]. However, and this involves the psychological overlay, if the perception of the users is that the existing system is less than satisfactory, then they will tend not to rely on it, so that measurement or activity statistics may not provide the complete answer to the problem of system functionality.

The next point is that the level of dissatisfaction, if present, must be such that users are prepared to involve themselves in the inconvenience associated with the introduction of new systems and the associated learning curves. I believe that with modern organisation theory we are talking about group decisions rather than a decision taken by a dictator, so that the consensus of a group of specialists is involved.

This in turn is a difficult matter to measure, complicated as it is by the age structure of the user group. In simple terms, a group of users aged 50 or so may well prefer to continue with the existing system, despite its known disadvantages, for the next few years to retirement, rather than be involved in the inevitable disruption to professional procedures and practices associated with the introduction of new technology. This view may be reinforced by manufacturers and suppliers of consumables to the existing systems and by the reluctance of hospital administrators to undertake substantial capital expenditure at a time of financial stringency.

It is my perception that the present level of dissatisfaction with existing systems is not sufficient to lead to strong demand by the users for the introduction of new PACS systems. I am not certain that Technology Assessment has much to offer in this area of satisfaction or dissatisfaction, as we are discussing group dynamics and perceptions of utility, overlaid by resistance to change and reluctance to invest capital for uncertain outcomes at a time of major restructuring in a volatile PACS industry. When in doubt, systems tend to favour a state of inertia. However, the process of technology assessment may serveto document in depth the failings of the existing system and this of itself may provide the stimulus for change.

Functional Assessment

It is in this area of determining if a new technology is capable of performing a function better than an existing technology that quantitative approaches to technology assessment can be applied. By this I mean the application of scientific theory such as the Receiver Operating Characteristic (ROC) — developed by Green and Swets [6] to the standardised measurement of performance. This aspect is discussed by Ottes in this issue.

As with all approaches to Technology Assessment there are areas of uncertainty. Two problems occur, the 'moving target' in which the hardware and software being

measured are constantly changing and the technique itself (ROC) which is under criticism for methodological inadequacies [7]. Apart from methodological problems there are the more routine problems of equipment performance under test [8]. Issues of work station design have been addressed in detail by Horii [9] and Arenson et al. [10] and are well covered in literature on the ergonomic design of visual display stations.

In terms of the clinical acceptability of PACS systems, the doubts raised about image acceptability on monitors are reinforced by radiologists concerns about the day-to-day operation of PACS systems in a clinical setting. Compared to light boxes and films, PACS systems have been criticised for lack of ability to display sufficient multiple images in reasonable time and for the difficulty of manipulating images [11].

In view of these difficulties with viewing screens one must conclude that PACS technology is not at this stage capable of performing the image interpretation function better than existing technology used by radiologists. The general impression remains that while current 1024 × 1024 monitor technology is suitable for viewing images produced by digital modalities, the availability of 2048 × 2048 high definition monitors will be necessary for performing screen based diagnosis from digitised chest images.

Fraser [12] captured the general feelings of the radiological community when he noted 'Although studies with a variety of digital techniques have been carried out on several fronts, we still do not possess a method that has captured the imagination of the majority of radiologists and other physicians to a point where it would replace conventional screen-film imaging.'

Assessment of Costs and Benefits of PACS

The third factor that I have suggested is necessary for the acceptance of a new technology is that it must be available at the same or lower cost than existing systems. Obviously this is an over-simplification of a complex area and there are clear exceptions where, for example, some organisations may be prepared to pay a high premium to be seen as innovative in the use of new technology. However, in general, hospital administrators and radiologists in private practice will demand the conduct of cost-benefit or cost-effectiveness studies before considering an investment in PACS. The consideration of costs and benefits leads to the requirement for standard definitions of what is to be measured. The attempt to gain agreement on these issues is the major purpose of this international workshop in PACS.

The issues involved were reviewed by Van Gennip et al. [13] at the Montpellier conference on the Assessment of Medical Informatics Technology. It was noted that while several evaluation studies have focused on cost analysis, the resulting estimates of the costs of PACS varied widely. Nevertheless some excellent economic evaluation studies have been performed, such as that by Warburton et al. [14] in British Columbia. The conclusion of the study, which saw costs of PACS as being of the order of 12–17% higher than conventional systems needs to be examined in relation to the expected benefits from the introduction of the PACS system. The particular benefits which might apply to different groups involved [15] are:

Category 1 — Benefits to the diagnostician

- improved access to current patient records
- improved access to patient history records
- file integrity and speed of retrieval
- better diagnosis
- quicker diagnosis/improved productivity.

Category 2 — Benefits to the referring physician

- better patient management/earlier intervention
- better patient outcome
- reduced length of stay
- reduced legal costs due to mal-administration claims, based on loss of films, lack of patient history, etc.

Category 3 — Benefits to the patient

- reduced radiation exposure from X-ray equipment
- shorter examination times
- reduced radiation exposure as a result of less need for re-takes of images
- reduced patient inconvenience in attending hospitals for examination and re-examinations
- reduced chance of adverse reaction from contrast agents.

Category 4 — Benefits to the hospital

- better communication with physicians
- better hospital administration
- better training of radiology and other students through access to on-line image files and to digital teaching files
- greater staff retention due to improved morale.

No progress can be made in convincing radiologists and hospital administrators of the value of PACS until clear and agreed monetary amounts can be attributed to these benefits. In addition, there is the need to avoid double-counting of benefits, a difficulty which is inherent in the process of dissecting a complex activity into separate tasks, so that the accumulated monetary benefits of a proposed PACS installation are not over-stated.

I would hope that this workshop develops a standard approach to the assignment of monetary benefits to PACS systems. My belief is that far too much attention has been paid to the itemisation of costs of PACS systems, without sufficient attention being paid to the discrimination of benefits. Possibly this represents the accounting background of the researchers in the area. However, until benefits of PACS systems can be clearly quantified in a standardised and acceptable manner, then I believe that the radiology profession will continue to remain unconvinced of the advantages of digital radiology systems.

Conclusion

The purpose of this paper has been to provide an overview of the methodological problems in assessment of PACS. The paper has addressed the three areas of the perceived need for PACS systems to replace existing film systems, the need to establish clinical acceptability of screen-based image systems and the need to demonstrate that PACS systems are cost effective. I suggest that, despite assertions by some suppliers of equipment, the answers in each of these three areas are uncertain and, if anything, the balance is in the negative rather than the positive. I am of the opinion that this international workshop in technology assessment of PACS needs to address these issues and to develop a standardised approach (the ISO standard of Technology Assessment of PACS) which will be seen as creditable and coherent by the radiological community.

Acknowledgements

I would like to thank Dr David Hailey and other members of the Health Technology Division at the Australian Institute of Health for their support and encouragement in the development of this paper.

References

1 Dutch PACS Project. Phase I (1986–1989). Concluding report. Utrecht University Hospital, BAZIS and Philips. Leiden, The Netherlands, 1990.
2 McKinlay GB: From promising report to standard procedure: seven stages in the career of a medical innovation. *Milbank Memorial Fund Quart*, 59 (1981) 374–411.
3 Hilsenrath PE, Smith WL, Berbaum KS, Franken EA and Owen DA: Analysis of the cost-effectiveness of PACS, *Am J Roentgenol*, 156 (1991) 177–180.
4 Drummond MF, Stoddard GL and Torrance GW: *Methods for the Economic Evaluation of Health Care Programs*, Oxford Medical Publications, Oxford, 1987.
5 Elliott LP: *Digital Imaging Network System (DINS) Evaluation Report*, Department of Radiology, Georgetown University Medical Center, Washington, D.C. 1990.
6 Green DM and Swets JA: *Signal Detection and Psychophysics*, Krieger, New York, 1974.
7 Harrington MB: Some methodological questions concerning receiver operating characteristics (ROC) analysis as a method for assessing image quality in radiology, *J Dig Imag*, 3 (1990) 211–218.
8 Dawood RM, Todd-Pokropek A and Craig JOMC: Monitor quality and its importance in PACS work stations, *Radiology*, 169 (P) (1988) 358.
9 Horii SC: Environmental design for reading from imaging work stations: ergonomic and architectural features, *J Dig Imag*, 2 (1989) 156–162.
10 Arenson RL, Chakraborty DP, Seshadri SB and Kundel HL: The digital imaging workstation, *Radiology*, 176 (1990) 303–315.
11 Foley WD: Display of CT studies in a two-screen electronic workstation versus a film panel alternator: sensitivity and efficiency among radiologists, *Radiology*, 174 (1990) 769–773.
12 Fraser RG: Digital imaging of the chest, *Radiology*, 171 (1989) 297–307.
13 Van Gennip EMSJ, Bakker AR, Van Poppel BM et al.: Uniformity in methods required in technology assessment of PACS. *Proceedings of the Joint Working Conference on Assessment of Medical Informatics Technology, Montpellier*, Editions ENSP, Rennes, 1991, pp. 239–247.
14 Warburton RN, Fisher PD and Nosil J: Digital diagnostic imaging with a comprehensive PACS: hypothetical economic evaluation at a large community hospital. *J Dig Imag*, 2 (1990) 101–107.
15 Crowe BL and Hailey DM: Cost and benefit considerations in the introduction of digital radiology systems to Australian hospitals. In *Economics and Health 1990* (Ed: C Selby-Smith), Monash University, Victoria, 1991, pp. 278–285.