Picture archiving and communication systems: a systematic review of published studies of diagnostic accuracy, radiology work processes, outcomes of care, and cost

Anderson D, Flynn K

Authors' objectives
To assess the diagnostic accuracy, the work process efficiency, the effects on clinical care and patient outcomes, and the cost-savings associated with the use of picture archiving and communications systems (PACS) in comparison with conventional film-screening radiology in clinical settings.

Searching
MEDLINE, EMBASE and the Health Planning and Administration database (all from 1975 to June, 1997) and Current Contents (from 1990 to June 1997) were searched for publications in the English language; the search terms were listed in an appendix to the report. End-references from relevant studies and assessments produced by other organisations were also retrieved.

Study selection
Study designs of evaluations included in the review
All study designs were eligible for inclusion. However, only observational and case-control studies were identified, plus economic evaluations meeting Health Economic Research Group (HERG) stage I and II criteria (see Other Publications of Related Interest)

Specific interventions included in the review
Studies comparing PACS and teleradiology systems with conventional film-based radiology were included in the review.

Reference standard test against which the new test was compared
The included studies were required to define a reference standard. A variety of reference standards were used based upon combinations of imaging techniques and patient follow-up.

Participants included in the review
The participants were adults, children and neonates undergoing diagnostic radiology procedures.

Outcomes assessed in the review
The inclusion criteria relating to the outcomes were not defined. The studies included in the review employed the following outcome measures: accuracy of detection of a disorder (using receiver operating characteristic curves), work process efficiency (time taken to transfer, retrieve and interpret images, time to initiate clinical action, system reliability, percentage of images lost) and costs. The authors stated a priori that effects on clinical care and patient outcomes would be assessed, but only one study was found which assessed time to initiate clinical action and was included in the 'Work Process Efficiency' section of the report.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.

Assessment of study quality
Diagnostic accuracy studies were graded from A (high-quality evidence) to D (non-contributory evidence) using the criteria of the American College of Physicians. Studies of processes and outcomes of care were graded by study design from I (anecdote, clinical hunches or case history) to VI (randomised controlled trials, community randomised trials or systematic reviews of RCTs). Where possible, cost studies were graded from I to VI using the same criteria. The authors did not state how the papers were assessed for validity, or how many reviewers performed the validity assessment.
Data extraction
The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction.

Methods of synthesis
How were the studies combined?
A narrative synthesis of the studies was undertaken.

How were differences between studies investigated?
No formal investigation of heterogeneity was reported. Study heterogeneity was not addressed in the narrative summary.

Results of the review
Twenty-two studies containing 41 observations were identified. There were 21 comparisons of diagnostic accuracy (n=3,655), 17 comparisons of process efficiency (n=11,567), 1 comparison of patient care and 2 observations of cost-savings (n not known).

Diagnostic accuracy.
The use of low resolution displays (approximately 0.5K x 0.5K pixels) to make a primary diagnosis from chest and bone images was not supported (1 study). Ten out of 20 observations suggested that conventional film was either equivalent to, or more accurate than digital images viewed on a workstation or printed to film; however, this was based on, at best, weak evidence and may vary according to the diagnosis. The available data suggested that conventional imaging is more accurate than digital imaging, particularly for primary diagnosis of subtle manifestations of diseases. The data also suggested that printing digital images to film does not reduce their diagnostic accuracy. As yet, there has not been a definitive demonstration that digital imaging, either viewed on a workstation or printed to film, is equivalent to analogue film for making a primary diagnosis of all the clinical conditions that present in a varied patient population.

Work process efficiency.
The evidence of work process efficiency was limited. However, there was a suggestion that PACS are more efficient at generating and delivering images than film-based systems. Two studies reported that the time interval between the completion of an examination and the image being available for viewing was longer for film images than for workstation images. Two studies noted that the time taken to retrieve archived images was significantly shorter for PACS than for films. Four of the 6 studies reported no significant difference between the time taken to interpret film versus workstation images, while one study was in favour of film and one in favour of PACS. One study found that lost images were twice as common for film as for images archived electronically in a PACS, and another found that PACS led to no statistically significant decrease in the time interval between when the imaging exam was completed to the time at which the ordering physician first encountered imaging information.

Clinical care and patient outcomes.
In one study, for the subset of patients in which an image-based clinical action was reported and timed, it was reported that the clinical action was taken significantly faster when workstation imaging was used (2.5 hours) than when films were reviewed (4.4 hours).

Cost information
Two published reviews were found which met the HERG stage I criteria. Both reviewed pre-1990 data and are now outdated. One review of 5 studies reported that the annual costs of hospital-wide PACS varied between 2 and 4 million dollars; the other findings were varied. The other publication reviewed 12 studies and could reach no conclusion about whether PACS would be more or less cost-effective than film.
Authors' conclusions
The published data reflected the changing nature of the technology and the complexity of implementing and assessing infrastructure changes. In some cases, published studies also suggested how to ask the appropriate questions and how to design stronger studies. However, the published evidence did not answer critical questions about the productivity, efficiency or cost-effectiveness of PACS.

CRD commentary
This was a comprehensive review with a broad research question and a rigorous literature search. Description of the review methodology was, however, weak. Details of the included studies were provided in the appendices, and there was some discussion of validity in the narrative. Supporting data from the included studies was absent from the main narrative summary of diagnostic accuracy, making interpretation difficult. The studies found were of insufficiently high quality to permit any conclusions about the effectiveness of PACS to be drawn. The authors' conclusions were suitably cautious.

Implications of the review for practice and research
Practice: The authors did not state any implications for practice.

Research: The authors suggested areas for further research. Such areas included: the integration of management and economic research methods into PACS assessments to better capture the costs and effects (implicit in this is the need to strengthen the working relationships among health care economists, management researchers and clinical researchers); an assessment of information technologies from an institutional perspective; and continued support for 'test beds' for the refinement and evaluation of commercial PACS and in-house image management systems.

Bibliographic details

Other publications of related interest

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Record Status
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on
the reliability of the review and the conclusions drawn.