Effects of feedback of information on clinical practice: a review

Miranda Mugford, Philip Banfield, Moira O'Hanlon

Abstract

Objective—To establish what is known about the role of feedback of statistical information in changing clinical practice.

Design—Review of 36 studies of interventions entailing the use of statistical information for audit or practice review, which used a formal research design.

Subjects—Papers identified from computer searches of medical and health service management publications, of which 36 describing studies of interventions designed to influence clinical care and including information feedback from clinical or administrative data systems were reviewed.

Main outcome measures—Evidence for effect of information feedback on change in clinical practice.

Results—Information feedback was most likely to influence clinical practice if it was part of strategy to target decision makers who had already agreed to review their practice. A more direct effect was discernable if the information was presented close to the time of decision making. The questions of the optimum layout and quantity of information were not addressed; the 36 papers were insufficient for defining good formats for information to be used for audit or quality assurance.

Conclusions—Given the cost of information processing and the current emphasis on closing the audit loop in the health services, it is important that the use of information in the audit process should be critically evaluated.

service management publications by using the index terms: medical audit, surgical audit, nursing audit, professional review organisations, utilisation review, information systems, and feedback. Related subject areas already reviewed by others cover the overlapping topics of clinical audit,²⁻⁶ general practice,⁷ prescribing,⁸ cost control,⁹ physicians' practice patterns,¹⁰ and implementation of clinical practice recommendations.¹¹ Studies were chosen for this review from the papers identified if they had used a design which either made a historical comparison or used a concurrent control group for comparison.

In reading each paper we looked for evidence of how information was used in the intervention and what the effect was. Information derived from routine health data systems may allow individual clinicians to review their "own" practice over time or may be used to compare colleagues or hospitals. It is this use of comparative information from statistical systems which is generally referred to as "information feedback." Information feedback has been used in different contexts, and passive and active feedback may be distinguished. Passive feedback is the unsolicited provision of information with no stated requirement for action. Active feedback occurs where the interest of clinicians has been engaged in a particular aspect or aspects of practice: standards may have been agreed, the clinicians may be involved in continuing education, or the information may itself be the basis for a discussion about appropriate care.

Results

We identified 36 published studies of interventions designed to influence clinical care that included the use of statistical data. Tables I-IV summarise the type of intervention and the main results from each of these studies, grouped by the area of health care in which a change in practice was attempted. Twelve studies¹²⁻²³ aimed at altering the use of hospital diagnostic services (table I); five studies²⁴⁻²⁸ were concerned with altering the rates of surgical operation (table II); seven²⁹⁻³⁵ with altering the use of prescribed drugs (table III); and the remaining 12 studies³⁶⁻⁴⁷ examined the effect of educational and information interventions on clinical practice in general practice and hospital and other settings (table IV).

STUDY METHODS

Sixteen of the studies listed in the tables measured the target behaviour before and after the intervention. A controlled design was used in the 20 other studies, in 12 of which the subjects had been selected as cases or controls by randomisation. Even in randomised designs staff in different groups may communicate, and this might reduce any differences between the groups. In six studies this possibility was minimised by selecting groups which were geographically separated, the members of which were unlikely to meet socially or professionally.^{19 30 32 38 39 43} Out of 11 studies in which

Introduction

Formal audit of clinical practice is being introduced throughout the NHS, after the NHS Act 1990.¹ The success of audit may be judged by whether clinical practice moves closer to agreed standards of care. To ascertain whether this is happening both those involved in audit and the professional bodies and policymakers monitoring the impact of audit need statistical data about clinical practice. Recent changes in the NHS have resulted in considerable attention being given to clinical and management computer systems at hospital level for monitoring contracts for services, but the contribution of such systems to clinical audit and the quality of care has yet to be established.

In preparation for a research project designed to explore how data from the clinical obstetric computer system is used in audit in the maternity units in one English health region we reviewed the evidence from health services research about the effects of feedback of information from clinical or administrative data systems on clinical practice.

Methods

We identified titles and abstracts of papers from computer literature searches of medical and health

National Perinatal
Epidemiology Unit,
Radcliffe Infirmary, Oxford
OX2 6HE
Miranda Mugford, BA,
economist

Department of Obstetrics,
St Mary's Hospital Medical
School, London W2 1PG
Philip Banfield, MRCOG,
research fellow
Moira O'Hanlon, BSC,
research assistant

Correspondence to:
Ms Mugford.

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statistical tests were made between control and experimental groups, only four clearly based them on the number of units which they allocated to experimental groups—that is, hospitals, practice groups, or doctors.^{19 30 39 41} It may be inappropriate to base tests of significance on numbers of patients treated.⁴⁸

PASSIVE FEEDBACK

The intervention was restricted to passive feedback of statistical information in only four papers. The nearest to this model was the study of Wennberg *et al*,²⁵ who reported falling tonsillectomy rates in Vermont after presentation of statistics to the Vermont Medical Society. In contrast, no obvious effect was found in a study of the use of biochemical tests in Flinders Medical Centre, South Australia; information was given to clinicians but discussion of the results or decisions on appropriate rates was not required.¹³ A controlled study in Tennessee did not show any effect of a commercially designed brochure giving indications for antibiotic prescribing, either on contra-indicated prescribing or on prescriptions of oral cephalosporins.³⁰

Clinicians lack knowledge about costs of tests and materials.⁴⁹⁻⁵¹ Data on costs of tests may be provided passively by including the information on the test request sheet. This had a short term effect on number

of requests for preoperative chest radiographs in one hospital,¹⁸ but with a changeover of medical house staff, the number returned to that before the study. In another study fewer tests were ordered by physicians when the request forms carried information on their cost,¹⁵ and a similar effect was found more recently with a computerised test ordering system with and without price information available.²³ When clinical teams were given feedback about charges made to patients for laboratory tests and x ray examinations the effect was less in teams without “an interested leader.”⁷¹⁴

ACTIVE FEEDBACK

In most studies we reviewed, information feedback was preceded or accompanied by a standard setting exercise or other discussion of practice, which might have been educational programmes^{19 38 39 41 43} or professional audit activities^{18 24 31 34 37 42} or cost control measures.^{12-17 23} In all cases the first stage was to set criteria for the procedure in question, after which the recipients of information are more likely to be alerted to respond to signals of divergence from agreed good practice. This hypothesis is supported by the results of Fowkes's study comparing both active and passive strategies to reduce requests for routine preoperative chest radiography.¹⁸

TABLE I—Studies of effects of information feedback on use of hospital pathology and radiology services

Year	Author	Intervention	Research design	Effects
1980	Martin <i>et al</i> ¹²	Chart review with discussion of test ordering patterns	Controlled trial	Long term fall in tests per patient in experimental group, short term effect in control group
1981	Grivell <i>et al</i> ¹³	Feedback of laboratory use by individual clinicians	Observation of test use before and after	No significant effects
1982	Cohen <i>et al</i> ¹⁴	Feedback of cost information to clinicians	Randomised controlled trial	Short term effect on laboratory use, reversed at follow up. No clear effect on radiography requests
1982	Cummings <i>et al</i> ¹⁵	Test order forms with price information	Randomised controlled trial	Use of tests reduced in group with prices on order form
1983	Everett <i>et al</i> ¹⁶	(a) Feedback of cost and use of tests (b) Chart review and discussion, with feedback as in (a)	Randomised controlled trial by patient, ward, and medical team	(a) No significant effect (b) Reduced test use in intervention group
1984	Schroeder <i>et al</i> ¹⁷	(a) Lectures on cost containment with feedback of patients' bills (b) Chart audit with feedback on tests ordered (c) (a)+(b)	Controlled trial; patients randomly allocated to medical firm	Very little effect; (c) showed most difference
1985	Fowkes ¹⁸	Circulation of guidelines for use of preoperative radiography to all. Then (a) Utilization review committee (b) Information feedback (c) New request form	Controlled study by hospital	Significant fall in preoperative radiography requests between baseline period and final month of study in (a)+(b), and no change in control hospitals
1986	Chassin and McCue ¹⁹	Agreement on criteria for pelvimetry by intervention group. Educational programme monthly feedback about pelvimetry rates	Randomised controlled trial by professional standards review organisations or hospital within review organisations	Intervention group pelvimetry rate fell faster than in control group and difference was sustained
1987	Wones ²⁰	Low cost audit with feedback about use of tests	Observation before and after	No change in ordering
1988	Finn <i>et al</i> ²¹	Alteration of physicians' test orders by support staff	Observational	Inappropriate tests were less common for patients for whom non-physicians queried orders
1989	Pop and Winkens ²²	Twice yearly feedback to GPs about requests for diagnostic tests, with specialist comment	Before and after observations of test use	Overall reduction in use of unnecessary tests. GPs with low rates of ordering likely to react most positively to protocols for use of tests
1990	Tierney ²³	Financial ordering of tests with and without costings	Randomised controlled trial	Displaying charges reduced number and cost of tests ordered but effect did not last when intervention discontinued

TABLE II—Studies of effects of information feedback on operative procedures

Year	Author	Intervention	Research design	Effects
1977	Dyck <i>et al</i> ²⁴	Committee review of rates of hysterectomy in seven hospitals. Press coverage about excess hysterectomy	Prospective, no controls	Overall rates and the proportion done for “unacceptable” reasons fell
1977	Wennberg <i>et al</i> ²⁵	Presentation to state medical society about differences in tonsillectomy among hospitals	Observation of trends in practice	Fall in rates, greatest in hospital with peer review
1980	Gleicher ²⁶	National consensus development conference on caesarean section	Observation of practice after conference	No fall in rates
1988	Myers and Gleicher ²⁷	Audit of caesarean section in one hospital	Before and after	Rate of caesarean section fell with no increase in operative vaginal delivery or other adverse outcomes
1989	Lomas <i>et al</i> ²⁸	Guidelines for caesarean section from consensus development task force	Observation of knowledge of guidelines and change in practice after publication	One third reported change in practice; one third had incorrect knowledge of guidelines. Actual practice differed from that reported and did not show reported effect

TABLE III—Studies of effects of information feedback on prescribing

Year	Author	Intervention	Research design	Effects
1983	Mersey Regional Health Authority ²⁹	Letter with information and recommendations for prescribing	Observational	Changes in prescribing patterns, reflecting advice in letters
1983	Schaffner <i>et al</i> ³⁰	Comparison of 3 strategies to alter antibiotic prescribing (a) mailed brochure (b) visit by drug educator (c) visit by physician	Controlled study by physician	No effect of brochure (physician visit had an effect)
1984	Harris <i>et al</i> ³¹	Feedback to GPs about number and cost of prescriptions; meetings for discussion	Controlled study by GP group	Intervention groups' prescription rates per patient fell more than those of control group
1985	Grant <i>et al</i> ³²	Limited formulary agreed by intervention group	Controlled study by GP groups; teaching GPs in study group, non-teaching GPs as controls	Control group prescribed much higher proportion of drugs not in formulary
1987	Whiteside <i>et al</i> ³³	Educational guidelines on appropriate use of cephalosporins inserted in patient records	Observation of prescribing before and after	Change of prescription for 28% of patients within 48 h of intervention
1988	Anderson <i>et al</i> ³⁴	Analysis and feedback of data about digoxin to GP principals in 5 practices. Feedback included comparisons with "expert" protocol for digoxin use	Practice of those receiving feedback versus those in same practices not receiving feedback	Record keeping for pulse measurement increased in intervention group but not in control group
1989	Parrino ³⁵	Automated peer comparison feedback to attending physicians with higher than median costs for one year's antibiotic prescriptions	Observation of prescribing before and after. Comparison with unspecified control group	No reduction in prescribing costs or use of antibiotics

TABLE IV—Studies of effects of information feedback on other aspects of clinical care

Year	Author	Intervention	Research design	Effects
1976	Nelson ³⁶	Introduction of supra-hospital professional review programme; feedback of statistical data	Observational	Reaction to "bad" results was to query data or criteria
1978	Morgan <i>et al</i> ³⁷	Concurrent review of computer records of antenatal care for compliance with American College of Obstetricians and Gynecologists' standards, immediate feedback to physicians	Alternate allocation of patients to have computer record reviewed or not	Compliance with standards was higher when patient record was reviewed. In subsequent 12 months care of control group improved to same level
1980	Linn ³⁸	Educational package with feedback about compliance with preagreed criteria for emergency burn treatment	Randomised controlled trial by hospital	Improved care in intervention group; no change in controls
1982	Sibley <i>et al</i> ³⁹	Educational packages for GPs with feedback on compliance with treatment criteria	Randomised controlled trial by GP	In topics for which GPs expressed interest control group improved as much as study group. Differential improvement for in study group for topics for which GPs expressed little interest
1983	Schlager ⁴⁰	Computer medical summaries for patients of GPs	Observation of compliance with treatment and health outcomes before and after	Compliance with "health maintenance" advice increased; no change in blood pressure for people with chronic hypertension
1985	Cohen <i>et al</i> ⁴¹	Reading material targeted to specific preventive care practice recommendations	Randomised controlled trial	Those compliant before became more compliant. Less effect with group that needed most change
1985	Norton and Dempsey ⁴²	Standards for treatment of cystitis and vaginitis set by individual physicians who received immediate feedback about performance	Crossover design	Significant improvements in practice were seen with the intervention
1986	Evans <i>et al</i> ⁴³	Fourteen weekly instalments of educational material about antihypertensive care to primary care physicians	Randomised controlled trial by GP	Study group patients more likely to have blood pressure check. Patients in both groups received more medication. Physicians in both groups had same score in test of knowledge
1987	Braham and Ruchlin ⁴⁴	Computerised feedback of information to those who make decisions generating costs in ambulatory care	Observation of charges before and after	Reduction in charges for services
1989	McPhee <i>et al</i> ⁴⁵	Three methods to increase uptake of seven cancer screening tests. Resident doctors were (a) given reminders about patients not screened, (b) involved in audit meetings with feedback (c) controls. Patients of half the doctors in (a), (b), and (c) were given information about 2 tests and notice of overdue tests	Randomised controlled trial	Intervention (a) increased uptake of 6 out of 7 tests. Intervention (b) increased uptake of 4 tests. Patient education improved uptake in one of two tests.
1989	Weingarten <i>et al</i> ⁴⁶	Computerised protocol to prompt action on preventive measures in family practice	Randomised controlled trial. Patients randomised to computer or manual record	Recording of key items increased for both groups of patients. Computer group had more items recorded and longer consultation times. Less improvement for items requiring frequent measurement.
1990	Swor and Hoelzer ⁴⁷	Computer assisted quality assurance for emergency medical services by paramedics	Observation of compliance with protocol before and after quality assurance	Improvement in compliance with protocol

The level at which standard setting takes place may be important. For example, Nelson observed that data presented by the suprahospital professional review programme were not trusted by the clinicians.³⁶ Gleicher suggested that as caesarean section rates had not fallen in the United States since the national consensus development conference reported in 1980, their control in the United States must require peer review by individual physicians as well as nationally,²⁶ and he subsequently showed the effectiveness of such a policy in his own hospital.²⁷ In Canada Lomas *et al*²⁸ found that knowledge of the consensus conference guidelines on indications for caesarean section

remained poor, even with intensive circulation to practising clinicians. They emphasised the role of incentives, or removal of disincentives, in implementing changes in practice and also made the point that clinicians were often mistaken in their beliefs about their own practice patterns.

Six of the studies used data on tests that had been ordered, hospital costs, or prescriptions as a basis for discussing appropriate practice with the groups of clinicians involved,^{12 13 16-18 31} and in most cases this was effective in changing patterns of target behaviour in the short term.

When we examined trials of educational strategies to

inform clinicians about "best" evidence for managing common disorders in primary care the effect on practice was not clear. Sibley *et al* found the strongest effect of continuing education was in aspects of care for which family physicians had previously indicated a lack of interest.³⁹ Evans *et al* failed to detect any effect on knowledge or practice of a postal educational programme on management of hypertension.⁴³ In another controlled trial whose aim was to improve adherence to standards for care, reading material was sent to residents in internal medicine.⁴¹ Physicians who were already compliant were more likely to improve their practice than those whose practice deviated most from the recommended standards before the trial.

WHO RECEIVES THE INFORMATION?

Making sure that information reaches the right people is important. Braham and Ruchlin⁴⁴ identified the people responsible for decisions about use of resources in ambulatory care and found that giving them information about their use of services reduced overall patient charges. In studies of general practice individual general practitioners are responsible for their own decisions and are thus the appropriate target for education or information feedback. Harris *et al* aimed their intervention at practice level as well as at individual general practitioners,³¹ as discussions and policy at practice level may well affect individual decisions. In hospital, policies may be set at consultant level but are usually put into practice by junior staff. When information was sent only to consultants, as in Fowkes's study of the use of preoperative chest radiography,¹⁸ communication between senior and junior staff was being tested additionally. On the other hand, studies that concentrated only on junior staff, as was common in many of the American studies of laboratory use, found that the effect of the intervention was strengthened when senior staff were brought into the audit process.

Although we concentrated on the clinician as decision maker and therefore as the appropriate recipient of information, this focus may be inappropriate when other professionals are involved in care. In the studies by Finn *et al*²¹ and Swor and Hoelzer⁴⁷ non-medical staff with access to information influenced practice patterns. Public opinion may also influence the decisions made about types of care, and patients may take an active part in the choice of particular options.²⁴ The effect of public awareness of surgical intervention rates was illustrated in Switzerland.⁵² The high rate of hysterectomy in the canton of Ticino compared with the rates in the United Kingdom and Norwegian health regions was widely publicised during nine months. Subsequently the rate fell sharply in Ticino and remained low. In the neighbouring canton of Bern, where there was no publicity, the rate of hysterectomy did not change. Williams and Chen suggested that caesarean section rates might be similarly controlled.⁵³

WHAT FORMAT SHOULD THE INFORMATION TAKE?

The reviewed papers contained relatively little about the quantity or format of the data presented or about how recipients interpreted the feedback. None of the studies formally compared the effects of different formats for presenting information, but three factors may be especially important: numbers versus graphs, quantity of data, and computer screen versus paper.

The methods of presentation described varied between cost data from laboratories presented as weekly listings of tests ordered¹⁴ to histograms showing the position of an individual clinician in relation to his or her colleagues.¹³ The quantity of data presented was variable: Nelson described tables showing the degree of accord with standard criteria for hospital treatments in 120 diagnostic related groups.³⁶ Harris

et al described tables from routine analysis of prescriptions, running to many pages for each general practitioner, accompanied by practice summaries and occasional graphs and tables of national data for comparison.³¹ They showed a shift over time in which tables interested general practitioners most. Five of the studies reviewed evaluated the effects of some form of online prompts to practitioners by computerised recording or ordering systems.^{37 40 44 46 47} The results of these studies all suggested that this may be an effective medium for influencing practice.

HOW DOES TIMING OF FEEDBACK AFFECT PRACTICE?

The studies varied considerably in the timing and frequency of information feedback. For example, Linn described feedback after 48 hours about the quality of an individual clinician's treatment of patients with burns.³⁸ Many laboratory test studies in the United States included weekly feedback of test use and costs. Delay may occur when data are collected manually or are abstracted from case notes or have to be processed to provide a special output from routine systems. Data were fed back twice in a year in Fowkes's study of requests for preoperative chest radiography¹⁸ and twice a year for two years in the study of Harris *et al*.³¹

During the period of this review the possibilities for almost instantaneous feedback with computer information systems have been developing, and all of the five relevant studies suggested that concurrent reminders of costs or protocols for treatment increased compliance with standards.^{37 40 44 46 47}

VALIDATION OF STATISTICAL DATA

The quality of data and choice of specific indicators are often criticised when feedback from routine statistical systems is attempted. Nelson mentioned such criticism by medical staff at hospitals in the Utah Professional Standards Review Organisation.³⁶ Although not widely mentioned in the British studies, mistrust of routinely collected data is fairly widespread in the NHS.⁵⁴ Harris *et al* encouraged general practitioners to ask for additional data or for clarification of what they had received, and they responded by requesting further data about specific topics.³¹

Discussion

We found that feedback of information is necessary but not sufficient in the process of maintaining high quality clinical care. This review supports previous conclusions that feedback of information most probably influences clinical practice if it is part of an overall strategy which targets decision makers who have already agreed to review their practice. Information feedback is likely to have a more direct effect on practice if presented close to the time of decision making. We did not find answers to the questions of optimum layout and quantity of information, although these factors may significantly affect the interpretation of numerical data.⁵⁵ The introduction of clinical audit should improve access to data on clinical care and its quality. However, in the NHS the link between those responsible for routine data collection systems and those concerned with clinical research, audit, and practice review is often tenuous. In particular, as the health service and its information become more disaggregated it is uncertain whether data will be available for comparing care in different places within England.

Barr⁵⁶ and Mitchell and Fowkes⁵⁷ recommended that methods for feedback of information about practice or performance should be assessed experimentally over a sufficient time to establish whether change, if it occurs at all, is only transient. Wennberg suggested that variations in practice reflect uncertainty and disagreement about what constitutes appropriate care.⁵⁸ Health

authorities in Britain now have audit committees and audit assistants, but their roles are not yet clear. The official view of audit given in a recent health circular seems to suggest that though medical audit may identify the need for change in practice, continuing education would be the means to bring about that change.¹ The evidence supporting this premise is not strong or encouraging, and the use of educational methods would also need careful and controlled evaluation. The papers we reviewed suggest, for example, that postal education packages may influence practice less than prompts about treatment protocols given to clinicians at the time of a consultation. It is important for those who use the health services that the feedback loop of standard setting, information collection, review, and change in practice be completed. In the wake of the most recent NHS Act considerable efforts and resources are being used for that purpose, but less effort seems to be spent in establishing whether these resources are being used to best effect.

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- 1 Department of Health. *Medical audit in the hospital and community health services*. London: DoH, 1991. (HC(91)2.)
- 2 Shaw CD. Aspects of audit. I. The background. *BMJ* 1980;280:1256-8.
- 3 Shaw CD. Aspects of audit. II. Audit in British hospitals. *BMJ* 1980;280:1314-5.
- 4 Shaw CD. Aspects of audit. III. Audit in British general practice. *BMJ* 1980;280:1361-3.
- 5 Shaw CD. Aspects of audit. IV. Acceptability of audit. *BMJ* 1980;280:1443-6.
- 6 Shaw CD. Aspects of audit. V. Looking forward to audit. *BMJ* 1980;280:1509-11.
- 7 Horder J, Bosanquet N, Stocking B. Ways of influencing the behaviour of general practitioners. *J R Coll Gen Pract* 1986;36:517-21.
- 8 Hemminki E. Factors influencing drug prescribing—inquiry into research strategy. *Drug Intelligence and Clinical Pharmacy* 1976;10:321-9.
- 9 Grossman RM. A review of cost-containment strategies for laboratory testing. *Med Care* 1983;21:783-802.
- 10 Eisenberg JM. Physician utilization. The state of research about physicians' practice patterns. *Med Care* 1985;23:461-83.
- 11 Lomas J, Haynes RB. A taxonomy and critical review of tested strategies for the application of clinical practice recommendations: from "official" to "individual" clinical policy. *Am J Prev Med* 1988;suppl 4:77-94.
- 12 Martin AR, Wolf MA, Thibodeau LA, Dzau V, Braunwald E. A trial of two strategies to modify the test ordering behavior of medical residents. *New Engl J Med* 1980;303:1330-6.
- 13 Grivell AR, Forgie HJ, Fraser CG, Berry MN. Effect of feedback to clinical staff of information on clinical biochemistry requesting patterns. *Clin Chem* 1981;27:1717-20.
- 14 Cohen DI, Jones P, Littenberg B, Newhauser D. Does cost information availability reduce physician test usage? *Med Care* 1982;20:286-92.
- 15 Cummings KF, Frisof KB, Long MJ, Hryniewicz G. The effects of price information on physicians' test ordering behaviour. *Med Care* 1982;20:293-301.
- 16 Everett GC, De Blois S, Chang PF, Hollets T. Effect of cost education, cost audits and faculty chart review on the use of laboratory services. *Arch Intern Med* 1983;143:942-4.
- 17 Schroeder SA, Myers LP, McPhee SJ, Showstack JA, Simborg DW, Chapman SA, et al. The failure of physician education as a cost containment strategy. *JAMA* 1984;252:225-30.
- 18 Fowkes FGR. *Strategies for changing the use of diagnostic radiology*. London: King's Fund, 1985. King's Fund project paper No 57.
- 19 Chassin MR, McCue SM. A randomised controlled trial of medical quality assurance: improving physicians' use of pelvimetry. *JAMA* 1986;256:1012-6.
- 20 Wones RG. Failure of low-cost audits with feedback to reduce laboratory test utilization. *Med Care* 1987;25:78-82.
- 21 Finn AF, Valenstein PN, Burke MD. Alteration of physicians' orders by non-physicians. *JAMA* 1988;259:2549-52.
- 22 Pop P, Winkens R. A diagnostic centre for general practitioners: results of individual feedback on diagnostic actions. *J R Coll Gen Pract* 1989;39:507-8.

- 23 Tierney WM, Miller ME, McDonald CJ. The effect on test ordering of informing physicians of the charges for outpatient diagnostic tests. *New Engl J Med* 1990;322:1499-504.
- 24 Dyck FJ, Murphy FA, Murphy JK, Road DA, Boyd MS, Osborne E, et al. Effect of surveillance of the number of hysterectomies in the province of Saskatchewan. *New Engl J Med* 1977;296:1326-8.
- 25 Wennberg JE, Blowers L, Parker R, Gittelsohn AM. Changes in tonsillectomy rates associated with feedback and review. *Pediatrics* 1977;59:821-6.
- 26 Gleicher N. Cesarean section rates in the United States. The short term failure of the national consensus development conference in 1980. *JAMA* 1984;252:3273-6.
- 27 Myers SA, Gleicher N. A successful program to lower cesarean section rates. *New Engl J Med* 1987;319:1511-6.
- 28 Lomas J, Anderson GM, Domnick-Pierre K, Vayda E, Enkin MW, Hannah WJ. Do practice guidelines guide practice? *New Engl J Med* 1989;321:1306-11.
- 29 Mersey Regional Drug Information Service. *An assessment of whether the rational and economic use of drugs can be influenced by the Drug Information Service*. Liverpool: Mersey Regional Health Authority, 1983. (JR124/334.)
- 30 Schaffner W, Ray WA, Federspiel CF, Miller WO. Improving antibiotic prescribing in office practice. A controlled trial of three educational methods. *JAMA* 1983;250:1728-32.
- 31 Harris CM, Jarman B, Woodman E, White P, Fry JS. Prescribing—a suitable case for treatment. London: RCGP, 1984. (Occasional paper No 24.)
- 32 Grant GP, Gregory DA, Van Zwannenberg TD. Development of a limited formulary for general practice. *Lancet* 1985;i:1030-2.
- 33 Whiteside ME, Lefkowitz S, Justiniani FR, Ratzan K. Changing practice patterns, a program of physician education. *Hospital Formulary* 1987;22:561-3,566,568.
- 34 Anderson CM, Chambers S, Clamp M, Dunn I, McGhee M, Sumner K, et al. Can audit improve patient care? Effects of studying use of digoxin in general practice. *BMJ* 1988;297:113-4.
- 35 Parrino TA. The non-value of retrospective peer comparison feedback in containing hospital antibiotic costs. *Am J Med* 1989;86:442-8.
- 36 Nelson AR. Orphan data and the unclosed loop. A dilemma in PSRO and medical audit. *New Engl J Med* 1976;295:617-9.
- 37 Morgan M, Studney DR, Barnett GO, Winickoff RN. Computerized concurrent review of prenatal care. *QRB* 1978;4:33-6.
- 38 Linn BS. Continuing medical education: impact on emergency room burn care. *JAMA* 1980;244:565-70.
- 39 Sibley JC, Sackett DL, Neufeld V, Gerrard B, Rudnick KV, Fraser W. A randomised trial of continuing medical education. *New Engl J Med* 1982;306:511-5.
- 40 Schlager DD. A comprehensive patient care system for the family practice. *J Med Syst* 1983;7:137-45.
- 41 Cohen SJ, Weinberger M, Hui SL, Tierney WM, McDonald CJ. The impact of reading on physicians' nonadherence to recommended standards of medical care. *Soc Sci Med* 1985;21:909-14.
- 42 Norton PG, Dempsey LJ. Self-audit: its effect on quality of care. *J Fam Pract* 1985;21:289-91.
- 43 Evans CE, Haynes RB, Birkett NJ, Gilbert JR, Taylor DW, Sackett DL, et al. Does a mailed continuing education programme improve physician performance? Results of a randomized controlled trial in antihypertensive care. *JAMA* 1986;255:501-4.
- 44 Braham RL, Ruchlin HS. Physician practice profiles: a case study of the use of audit and feedback in an ambulatory care group practice. *Health Care Manage Rev* 1987;12:11-6.
- 45 McPhee SJ, Bird JA, Jenkins CN, Fordham D. Promoting cancer screening. A randomised controlled trial of three interventions. *Arch Intern Med* 1989;149:1866-72.
- 46 Weingarten MA, Bazel D, Shannon HS. Computerized protocol for preventive medicine, a controlled self audit in family practice. *Fam Pract* 1989;6:120-4.
- 47 Swor RA, Hoelzer M. A computer assisted quality assurance in a multi-provider EMS system. *Ann Emerg Med* 1990;19:286-90.
- 48 Whiting-O'Keefe QE, Henke C, Simborg D. Choosing the correct unit of analysis in medical care experiments. *Med Care* 1984;22:1101-14.
- 49 Fowkes FGR. Doctors' knowledge of the costs of medical care. *Med Educ* 1985;19:113-7.
- 50 Wynick D, Jessop JH. A survey of cost awareness among hospital medical staff. *Health Trends* 1985;17:24.
- 51 Long MJ, Cummings KM, Frisof KB. The role of perceived price in physicians' demand for diagnostic tests. *Med Care* 1983;21:243-50.
- 52 Domenighetti G, Luraschi P, Casabianca A, Gutzwiller F, Spinelli A, Pedrinis E, et al. Effect of information campaign by the mass media on hysterectomy rates. *Lancet* 1988;iii:1470-3.
- 53 Williams RL, Chen PM. Controlling the rise in cesarean section rates by dissemination of information from vital records. *Am J Publ Health* 1983;73:863-7.
- 54 Sunderland R. Inaccurate coding corrupts medical information. *Arch Dis Child* 1985;60:593-4.
- 55 Macdonald-Ross M. How numbers are shown: a review of research on the presentation of quantitative data in texts. *Audio-visual Communications Review* 1977;25:359-409.
- 56 Barr A. Measuring hospital performance: a proposed limited experiment. *Hospital and Health Services Review* 1986;82:70-1.
- 57 Mitchell MW, Fowkes FGR. Audit reviewed. Does feedback on performance change clinical behaviour? *J R Coll Physicians Lond* 1985;19:251-4.
- 58 Wennberg JE. Dealing with medical practice variations: a proposal for action. *Health Aff (Millwood)* 1984;3:6-32.

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