

## REVIEW

# Pathology tests: is the time for demand management ripe at last?

G Gopal Rao, M Crook, M L Tillyer

*J Clin Pathol* 2003;**56**:243–248

With the ever increasing demands for pathology testing within the National Health Service there is a need to manage the demand for these tests. This review discusses strategies for the demand management of requests made by clinicians in the disciplines of biochemistry, haematology, and microbiology. The various approaches that have been used to manage demand will be described, along with specific clinical strategies for demand management.

shown that the effects of such strategies are frequently short lived owing to changes in junior clinical staff, lack of interest of senior clinicians, and the redundancy of the guidelines.<sup>6</sup>

Hopeless as it may seem, it may now be possible to manage demand for laboratory tests. Three recent developments in the NHS might now provide important opportunities to introduce, implement, and above all sustain rational laboratory testing.

First, the increasing availability of bidirectional links between the laboratory and clinical areas is enabling clinicians to order tests and receive results using computers. Test ordering databases are currently available that incorporate decision support systems to prompt the clinician about the clinical need and the existence of previous or duplicate tests.<sup>7</sup> The introduction of electronic patient records will further facilitate this process (Sunrise Clinical Manager; ISOFT, Manchester, UK). Second, with the current emphasis on evidence based medicine, there is greater willingness to examine the evidence concerning clinical usefulness for many of the currently performed tests. Finally, greater recognition of the importance of multidisciplinary working and the development of care pathways is bringing about a closer working relationship between clinicians and laboratory staff. In turn, this will probably lead to a greater understanding of the usefulness and limitations of the laboratory tests. A recent survey of clinicians has shown that only a very few consider or are aware of test characteristics such as the sensitivity and specificity of tests.<sup>8</sup>

A major obstacle to successful implementation is “consumer resistance”. In the UK, neither the clinician nor the patient directly pays for the laboratory tests. Thus, there is little incentive for clinicians to alter their current patterns for requesting laboratory tests. Marketing strategies have to be developed to “sell” the concept of demand management to clinicians (consumers). This will require paying attention to the product (identifying areas for demand management in consultation with clinicians), placement (bidirectional ward test ordering systems), price (clear cost/benefit analysis), and promotion (use of

A recent report of The National Pathology Alliance Benchmarking Review indicated that nearly all laboratories in the UK continue to witness a rise of 5% to 10% each year in requests for laboratory tests.<sup>1</sup> In response to this increase in laboratory tests, hospitals in the National Health Service (NHS) are being urged to rationalise the number of laboratories and to create fewer, more modern laboratories to benefit from economies of scale.<sup>2</sup> Although rationalisation of laboratories is important for efficient management of resources, it is unlikely that the resources in the NHS will ever be able to keep up unless a serious attempt is made to manage demand for pathology tests.

Several studies have shown that between 25% and 40% of all tests sent to the laboratory are unnecessary, yet few laboratories in the UK have managed to reduce these unnecessary tests.<sup>3–5</sup>

Even where such reductions have been achieved, it has been difficult to sustain them. So, what is it that makes it difficult to manage demand? Several reasons have been suggested.<sup>6</sup> These include uncertainty of likely diagnosis (associated with junior and inexperienced doctors); lack of understanding of the basis, sensitivity, and specificity of the tests; and the desire for diagnostic completeness. Furthermore, recommendations of special interest groups, peer and commercial pressure, patient expectation, and more recently, fear of litigation have led to increased demand for laboratory tests. With all these barriers, it is not surprising that although attractive in concept demand management has failed to make appreciable inroads.

“Several studies have shown that between 25% and 40% of all tests sent to the laboratory are unnecessary”

Various strategies have been undertaken to manage demand. A recent systematic analysis has

See end of article for authors' affiliations

Correspondence to:  
Dr G Gopal Rao,  
Department of  
Microbiology, University  
Hospital Lewisham, London  
SE13 6LH, UK;  
[gopal.rao@uhl.nhs.uk](mailto:gopal.rao@uhl.nhs.uk)

Accepted for publication  
29 October 2002

**Abbreviations:** APTT, activated partial thromboplastin time; A&E, accident and emergency; BCSH, British Committee for Standards in Haematology; CSU, catheter specimen of urine; ESR, erythrocyte sedimentation rate; FBC, full blood count; HSVE, herpes simplex virus encephalitis; NHS, National Health Service; NPT, near patient test; PCR, polymerase chain reaction; VTE, venous thromboembolism

advertising material that appeals to both senior and junior medical colleagues).<sup>9</sup>

In this review, we discuss the role of demand management of requests made by clinicians in the fields of biochemistry, haematology, and microbiology. The various strategies that have been used to manage demand are described in the clinical biochemistry section. The sections on haematology and microbiology pay greater attention to specific clinical strategies for demand management. Although our review does not deal with intralaboratory demand management, we recognise that managing intralaboratory demand by rationalising the number of tests performed on a request is an important element of overall demand management.

Similarly, there are opportunities also available for demand management in the disciplines of histopathology and immunology. The Royal College of Pathologists (UK) is currently looking at several areas of practice where histopathology is of limited or no clinical value. However, these will not be discussed in our review.

## CLINICAL BIOCHEMISTRY

The number of unnecessary tests in the clinical biochemistry laboratory is reported to be legion, ranging from 26% to 98% of the total number of laboratory tests.<sup>10 11</sup>

### Routine biochemistry

Nearly a third (32%) of requests for biochemistry investigations from accident and emergency (A&E) departments were considered unnecessary, with a negative correlation between the tests requested on each visit and the quality of care.<sup>12</sup> Another study that compared two similar intensive care departments found that one of them performed far fewer investigations without detriment to the patients.<sup>13</sup> In fact, unnecessary testing may result in a significant reduction in blood volume in these critically ill patients.<sup>14</sup> In another study, it was interesting to note that in the assessment of hospitalised psychiatric patients only 4% had important medical conditions uncovered by laboratory testing.<sup>15</sup> Similarly, routine urinalysis on admission to hospital has been reported to be of very small benefit to patient management.<sup>16 17</sup>

Serum electrolytes and blood gases have been shown to be the most frequently "over requested" tests. Indiscriminate yet widespread requests for such "high volume, low cost" tests have a great impact on laboratory resources. Furthermore, such a high frequency of testing has been shown to give rise to the detection of "biochemical abnormalities" in otherwise normal patients. Pursuit of such biochemical abnormalities gives rise to further tests and above all mental anguish to patients.

Similarly, ignorance of the indications for thyroid function tests and misinterpretation of the results may lead to further unnecessary investigations.<sup>18</sup>

Therapeutic drug monitoring, such as monitoring for theophylline and digoxin, has also been shown to suffer from unnecessary and incorrect usage.<sup>19 20</sup>

### Near patient tests

Even point of care testing has not been exempt from misuse. For example, near patient testing of patients with diabetes has recently come under scrutiny. A recent study has shown that the NHS incurs huge costs for such tests. Interestingly, the authors observed that unnecessary near patient tests (NPTs) that do not make a positive contribution towards the management of the patient may in fact cause alarm to the patient.<sup>21 22</sup>

### Suggestions for reducing unnecessary tests

So what can be done to try and reduce unnecessary laboratory testing in clinical biochemistry? Several different approaches have been tried out with a greater or lesser degree of success.

Reduction of test duplication by improved communication between the clinician and the laboratory—in particular, feedback to clinical staff about test usage and the use of league tables of biochemical laboratory costs and test requests—has been found to be useful in some studies. However, not all researchers have found substantial benefit in feedback techniques, particularly if they are negative.<sup>23–30</sup>

The use of rule based decision support systems for the requesting doctor has been successful in reducing unnecessary thyroid function tests. Greater involvement of the pathologist in deciding whether a test is necessary demonstrated that it is possible to reduce protein electrophoresis testing by 67%.<sup>31 32</sup>

The use of continuing medical education through training programmes has also been reported to reduce the need for unnecessary thyroid function tests. Other education based strategies have resulted in 38% reductions in common biochemical tests.<sup>33–35</sup>

The use of computer ordering request menus has been found to reduce clinician requisitioning. In one report, a computer software system called DECIDE was used to evaluate test performance and suitability. Similar systems report that 4–17% of laboratory tests are unnecessary.<sup>36–40</sup>

"Greater involvement of the pathologist in deciding whether a test is necessary demonstrated that it is possible to reduce protein electrophoresis testing by 67%"

Careful scrutiny of requests by senior laboratory staff and avoiding test duplication has been reported in one study to reduce laboratory tests by nearly 20%. Verbal justification of tests may be required in some instances.<sup>41 42</sup>

Guidelines for test requesting have been used in various contexts.<sup>43</sup> However, there is no universal agreement about guidelines and to succeed they need to be locally agreed and kept up to date.<sup>44–47</sup> Thorough clinical assessment through medical history and physical examination has been shown to reduce the need for laboratory tests in preoperative patients.<sup>48</sup>

Redesigning of request forms into a problem orientated format may be an effective contribution by the laboratory, although this may be more appropriate to particular tests, such as thyroid function tests or therapeutic drug monitoring. Blank request forms may result in test misuse. In addition, modifying the range of tests offered by the laboratory may also influence clinicians' requesting behaviour.<sup>4</sup>

The use of financial incentives to reduce unnecessary testing has also been attempted but at least one study showed that rewarding clinicians for reducing tests may actually have led to increased testing.<sup>49–52</sup>

There are many other laboratory factors that may reduce test misuse, including the use of near patient testing, a convenient and efficient venepuncture service, and fast turnaround time of laboratory results.<sup>53 54</sup>

## HAEMATOLOGY

Strategies for demand management in haematology are generally similar to those described for biochemistry. In this section, we discuss some specific issues pertaining to haematology.

Compared with other pathology disciplines, haematology has a relatively small repertoire.

There are a handful of low cost, high volume investigations including full blood count (FBC), erythrocyte sedimentation rate (ESR), simple coagulation screens (prothrombin time and activated partial thromboplastin time (APTT)), and in transfusion the red cell group and antibody screen, and the crossmatching of blood.

Haematinic assays (vitamin B12, folate, and ferritin) and haemoglobin genotyping using electrophoresis, high performance liquid chromatography, column chromatography, and

isoelectric focusing are more expensive and time consuming tests that are still requested in large numbers, depending on the local population and screening policy.

More specialised investigations include coagulation factor assays, thrombophilia screening, bone marrow morphology, immunology and cytogenetics, red cell enzyme assays, autoimmune serology, and immunoglobulin assays. All these tests tend to be expensive although economies of scale may be possible.

#### Near patient tests

NPT is useful for out of hours work in A&E departments for FBCs, where it can lead to substantial reductions in the need to send urgent specimens to the laboratory at all times.<sup>55</sup> Near patient coagulation tests have become popular in anticoagulant clinics and A&E departments,<sup>56</sup> where faster turnaround times afforded by NPTs may optimise the management of venous thromboembolism and chest pain.<sup>57</sup> Similarly, but to a lesser extent, haematology and oncology clinics are beginning to appreciate the advantages of NPTs.

#### Routine haematology

Automated FBCs are one of the most commonly requested of all laboratory tests. High user departments such as A&E departments and intensive care units should be encouraged to develop agreements with the laboratory on the clinical indications for testing and repeat monitoring of blood counts.<sup>58-60</sup>

Similarly, there is good scope for rational guidelines limiting the use of the ESR.

#### Coagulation

Routine coagulation screens are often requested inappropriately. Too many are done on healthy patients preoperatively, and not enough are requested and acted upon in the bleeding patient.<sup>61-62</sup> Guidelines can help here.<sup>63</sup> The National Institute for Clinical Excellence in the UK is reviewing the guidance and will be publishing its recommendations shortly.

There is a steady rise in the number of patients on oral anti-coagulants who require regular monitoring with the prothrombin time. Managing this demand depends on developing an anticoagulant management plan for the patient group, which might be through centralised one stop clinics, community testing in general practitioner surgeries, peripatetic anti-coagulant nurses, or patient self testing. In a randomised controlled trial, Poller *et al* compared the use of manual dosing with computer generated dosing.<sup>64</sup> They found that the quality of care was equivalent in both arms of the study and that the patients whose dose was regulated by using the computer were less frequently tested. This was because of improved quality of control in these patients. This is a good example of how a decision support system can lead not only to better patient management but also to fewer test requests.

The management of patients on heparin has been greatly simplified and improved with the widespread introduction of low molecular weight heparins, which have a much more predictable antithrombotic effect, and generally do not require laboratory monitoring. This has had the welcome effect of reducing the number of APTT requests in most laboratories while improving patients' anticoagulation.<sup>65-66</sup>

There has been an exponential rise in the number of D-dimer requests in recent years, with the accumulation of evidence that they have a useful and reliable role as a negative predictor for venous thromboembolism (VTE).<sup>67-68</sup> Although this may lead to increasing demand for pathology testing, it probably reduces demand for more expensive clinical imaging.

Thrombophilia screening is another rapidly expanding area in haematology. There is increasing public awareness of the risks of VTE, especially in association with long haul flights and oral contraceptives. The British Committee for Standards in Haematology (BCSH) has recently published useful guidelines on who should be tested and which tests are appropriate in particular risk groups.<sup>69-70</sup>

#### Haemoglobinopathy testing

Haemoglobin genotyping is performed both for diagnostic purposes in patients with symptoms suggestive of haemoglobinopathy, and when assessing genetic risk in potential carriers. Screening of neonates, pregnant women, and their partners to detect haemoglobinopathies has been recommended to enable early intervention and counselling. As with any large scale screening programmes, centralised automated laboratory testing may be both cost effective and beneficial in managing demand.

Pre-operative screening in healthy adults of non-white origin for sickle cell trait is widely practised in the UK. A BCSH guideline from 1988 recommends that there is very little evidence to support it, certainly in patients in the ASA I (American Association of Anaesthetists score) category having day surgery.<sup>71-72</sup>

#### Haematinics

Screening for iron deficiency is a useful public health measure in groups such as pregnant women and young children. The most definitive measures of iron status are the plasma ferritin or soluble transferrin receptor assay, although both are relatively expensive tests. Red cell distribution width, available as an automated red cell parameter, and red cell zinc protoporphyrin can be used as cheaper screening tests.<sup>73</sup>

Vitamin B12 and folate values are among the most repeated and inappropriately requested tests (personal experience). It may be necessary to develop guidelines for the appropriate use of these tests.

#### Bone marrow tests, immunohaematology, and cytogenetics

At the outset managing demand for bone marrow examination appears relatively easy. Haematologists usually perform the sampling and report the findings, and thus can easily assess the appropriateness of the test. Interestingly, however, the National Pathology Alliance Benchmarking review found that, irrespective of the size and type of the hospital, there was a wide variation in the number of bone marrow examinations performed.<sup>1</sup> Thus, it would appear that there is a wide variation in the indications for bone marrow examination even among haematologists!

Trephine biopsy is increasingly carried out in addition to an aspirate, and is indicated when malignancy (either haematological or secondary), fibrosis, or hypoplasia is suspected. Immunophenotyping and cytogenetic studies on bone marrow and peripheral blood are useful mainly in haematological malignancies. These tests are relatively expensive and the development of guidelines may be necessary, especially in the light of clinical trends for more intensive chemotherapeutic interventions, longer periods of bone marrow suppression, and increasing needs for haematological monitoring.

#### Blood transfusion

Some of the best practice in demand management can be achieved in the discipline of blood transfusion. The technology of compatibility testing has been improved with the advent of rapid and sensitive grouping and antibody screening techniques. This has led to a reduction in the need for blood to be crossmatched for many elective operations. The implementation of maximum blood ordering schedules can be highly effective in managing demand.<sup>74-77</sup>

Major concerns remain about the availability of blood for transfusion and its cost. Donor numbers are sensitive to the increased perception of risk of blood transfusion, as well as potential recipients. The use of cell salvage during orthopaedic surgery and acute normovolemic haemodilution perioperatively reduces the demand for donor blood, and may prove cost effective. Increased demand for autologous donation in certain patient groups also lessens the use of donor blood, but is unlikely to save on costs.<sup>78-80</sup>

More conservative use of blood transfusion can be clinically beneficial as well as cost effective in obstetric, orthopaedic, and cancer patients, and those with chronic anaemia, and can be encouraged with the implementation of audited local guidelines.<sup>81, 82</sup>

“The implementation of maximum blood ordering schedules can be highly effective in managing demand”

Similarly, there is evidence that a restrictive strategy for red cell transfusion is as effective as liberal transfusion in critically ill patients.<sup>83</sup>

It is conceivable that the implementation of rule based electronic ordering systems will further facilitate the appropriate usage of blood products.

The use of iron and recombinant erythropoietin in postoperative anaemia instead of transfusion has been shown to be effective, although erythropoietin is expensive.<sup>84</sup> Erythropoietin may also spare the use of blood in patients with myelodysplasia and anaemia associated with cancer chemotherapy.<sup>85, 86</sup>

Careful consideration of the threshold platelet count for triggering prophylactic platelet transfusion may conserve platelet usage.<sup>87</sup>

## MICROBIOLOGY

Microbiology requests offer the greatest potential for demand management. Review of the literature suggests that some of the greatest gains of demand management have been in the field of microbiology. In this section, we discuss some key areas of practice where demand for tests can be managed successfully.

### Urinary tract infection

It is now widely accepted that currently available urine “dipsticks”, which detect nitrites and leucocyte esterase, have high negative predictive value (90–95%) and can be used to exclude urinary tract infection in most patients.<sup>88</sup> Similarly, catheter specimens of urine (CSUs) should be tested only in the presence of symptoms. Routine testing of CSUs is wasteful and may lead to unnecessary antibiotic treatment.<sup>89</sup>

### Faeces microbiology

The microbiological examination of faeces specimens is highly labour intensive. Rationalising laboratory testing of these specimens can result in substantial savings in laboratory resources. In particular, several recent studies have shown that laboratories need to perform only a very limited range of tests in patients with hospital acquired diarrhoea. Most patients with hospital acquired diarrhoea will require tests for the detection of *Clostridium difficile* toxin only to diagnose *C difficile* associated diarrhoea. Good communications between the medical, nursing, infection control, and laboratory staff is vital for safe and successful implementation of this strategy.<sup>90, 91</sup>

Indiscriminate requests for the examination of faeces for ova, cysts, and parasites are a great nuisance to microbiology laboratories.<sup>92</sup> Furthermore, laboratories can rationalise the range of pathogens that they test for routinely. This will depend on the prevalence of the infections in the community or indeed the ability of the tests to detect the pathogens with accuracy. For example, routine examination for enteropathogenic *Escherichia coli* is acknowledged to be unnecessary in the UK because of its extremely low prevalence and the inability of the routine serological tests to detect these organisms accurately.<sup>93</sup>

### Blood cultures

Blood cultures are the most important routine specimens tested in microbiology laboratories. Blood cultures collected by

## Take home messages

- There is great need to manage demand for pathology testing so that the most appropriate tests for the clinical management of the patient are requested with minimal wastage of resources
- The availability of information technology and greater acceptability of evidence based medicine will probably be the most important factors in making demand management a reality
- The availability of electronic patient records and laboratory information software, which incorporate decision support systems, will hopefully guide clinicians to request both rational and appropriate tests in the context of individual patients and their clinical features

junior medical staff are more likely to be contaminated than those taken by trained phlebotomists.<sup>94</sup> Because A&E departments often account for a substantial proportion of blood cultures tested, and most of the contaminants, a rational approach in the A&E department will result in a substantial reduction in both the number of blood cultures and contaminants. Kelly estimates that only 1.6% of all blood cultures taken in the A&E department alter management.<sup>95</sup>

At a recent workshop on the management of community acquired pneumonia, the Association of Medical Microbiologists (UK) concluded that blood cultures are only necessary in patients admitted to intensive care units or those who fail to respond to empirical treatment.<sup>96</sup>

“Kelly estimates that only 1.6% of all blood cultures taken in the A&E department alter management”

### Requests for the polymerase chain reaction

The development of diagnostic tests using polymerase chain reaction (PCR) based technology is probably the most important advance in laboratory medicine. PCR based tests have now become available for traditionally “difficult to diagnose” infections, such as herpes simplex virus encephalitis (HSVE), tuberculosis, and chlamydial infections. Because the technology is relatively new, PCR based tests are expensive. Therefore, it is important to make rational use of these tests. For example, recent studies have shown that in immunocompetent patients, PCR tests for HSVE and viral meningitis are highly unlikely to be positive if the cerebrospinal fluid does not have an excess of leucocytes ( $> 4$  cells/mm<sup>3</sup>) or protein ( $> 600$  mg/litre).<sup>97–99</sup>

## CONCLUSIONS

In conclusion, several approaches can be harnessed today to make requests for pathology tests more rational and cost effective. The availability of information technology and greater acceptability of evidence based medicine are likely to be the catalysts for making demand management a reality. In practice, clinicians and pathologists need to work closely to review in a critical manner the need for various investigations from the point of view of clinical management, cost effectiveness, and the availability of alternative means of diagnosis. The use of currently available electronic patient records and laboratory information software, which incorporate decision support systems, can guide clinicians to request both rational and appropriate tests in the context of individual patients and their clinical features. Ultimately, demand management is about ordering the most appropriate tests that will facilitate good clinical management of the patient with minimal wastage of resources.

.....

### Authors' affiliations

**G Gopal Rao**, Department of Microbiology, University Hospital Lewisham, London SE13 6LH, UK  
**M Crook**, Department of Biochemistry, University Hospital Lewisham  
**M L Tillyer**, Department of Haematology, University Hospital Lewisham

### REFERENCES

- 1 **Newchurch Ltd.** *National Pathology Alliance Benchmarking Report 2000/1*. London: Newchurch, 2002.
- 2 **Department of Health.** *Modernisation of pathology services*. HSC 1999/170. London: Department of Health.
- 3 **Winkens RAG**, Ament AJ, Pop P, *et al.* Routine individual feedback on requests for diagnostic tests: an economic evaluation. *Med Decis Making* 1996;**16**:309–14.
- 4 **Fraser CG**, Woodford FP. Strategies to modify the test-requesting patterns of clinicians. *Ann Clin Biochem* 1987;**24**:223–31.
- 5 **van Walraven C**, Goel V, Chan B. Effect of population-based interventions on laboratory utilization: a time-series analysis. *JAMA* 1998;**280**:2028–33.
- 6 **Axt-Adam P**, Johannes C, Van der Wouden MA, *et al.* Influencing behaviour of physicians ordering laboratory tests: a literature study. *Med Care* 1993;**31**:784–94.
- 7 **Smith BJ**, McNeely MD. The influence of an expert system for test ordering and interpretation on laboratory investigations. *Clin Chem* 1999;**45**:1168–75.
- 8 **Reid MC**, Lane DA, Feinstein AR. Academic calculations versus clinical judgments: practising physicians' use of quantitative measures of test accuracy. *Am J Med* 1998;**104**:374–80.
- 9 **Gopal Rao G**, Jeanes A, Osman M, *et al.* Marketing hand hygiene in hospitals—a case study. *J Hosp Infect* 2002;**50**:42–7.
- 10 **Wong ET**, Lincoln TL. Ready, fire! Aim! An enquiry into laboratory test ordering. *JAMA* 1983;**250**:2510–13.
- 11 **Peterson SE**, Rodin AE. Prudent laboratory usage, cost containment and high quality medical care. *Hum Pathol* 1987;**18**:105–8.
- 12 **Smith ADS**, Shenkin A, Dryburgh FJ, *et al.* Emergency biochemistry services: are they being abused? *Ann Clin Biochem* 1982;**19**:325–8.
- 13 **Bell DD**, Ostryzniuk T, Verhoff B, *et al.* Postoperative laboratory and imaging investigations in the intensive care units following coronary artery bypass grafting: comparison of two Canadian hospitals. *Can J Cardiol* 1998;**14**:379–84.
- 14 **McPherson RA**. Blood sample volumes: emerging trends in clinical practice and laboratory medicine. *Clin Leadersh Manag Rev* 2001;**15**:3–10.
- 15 **Dolan JG**, Mushlin AI. Routine laboratory testing for medical disorders in psychiatric inpatients. *Arch Intern Med* 1985;**145**:2085–8.
- 16 **Akin BV**, Hubbell FA, Frye EB, *et al.* Efficacy of the routine admission urinalysis. *Am J Med* 1987;**82**:719–22.
- 17 **Cruickshank JG**, Gawler AH, Hart RJ. Costs of unnecessary tests: nonsense urines. *BMJ* 1980;**280**:1355–6.
- 18 **Campbell JP**, Pillsbury HC. Management of the thyroid nodule. *Head Neck* 1989;**11**:414–25.
- 19 **Guernsey BG**, Ingram NB, Hokanson JA, *et al.* A utilization review of theophylline assays. *Drug Intelligence Clinical Pharmacy* 1984;**18**:906–12.
- 20 **Guernsey BG**, Hokanson JA, Ingram NB, *et al.* A utilization review of digoxin assays. *Hosp Pharm* 1984;**19**:187–200.
- 21 **Bloomgarden Z**, Sidel VW. Evaluation of utilization of laboratory tests in a hospital emergency room. *Am J Public Health* 1980;**70**:525–8.
- 22 **Gallichan M**. Self monitoring of glucose by people with diabetes. *BMJ* 1997;**314**:964–6.
- 23 **Martin AR**, Wolf MA, Thibodeau IA, *et al.* A trial of two strategies to modify the test ordering behaviour of medical residents. *N Engl J Med* 1980;**303**:1330–6.
- 24 **Gama R**, Swain DG, Nightingale P, *et al.* Effect of educational feedback on clinician's requesting of cardiac enzymes. *Ann Clin Biochem* 1992;**29**:224–5.
- 25 **Gama R**, Nightingale P, Broughton PMG, *et al.* Feedback of laboratory usage and cost data to clinicians. Does it alter requesting behaviour? *Ann Clin Biochem* 1991;**28**:143–9.
- 26 **Branger PJ**, Van Oers RJ, Van der Wouden JC. Laboratory services utilization: a survey of repeat investigations in ambulatory care. *Neth J Med* 1995;**47**:208–13.
- 27 **Grivell AR**, Forgie HJ, Fraser CG, *et al.* Effect of feedback to clinical staff of information on clinical biochemistry requesting patterns. *Clin Chem* 1981;**27**:1717–20.
- 28 **Grivell AR**, Forgie HJ, Fraser CG, *et al.* League tables of biochemical laboratory costs. An attempt to modify requesting patterns. *Med J Aust* 1982;**2**:326–8.
- 29 **Forrest JB**, Ritchie WP, Hudson M, *et al.* Cost containment through cost awareness. A strategy that failed. *Surgery* 1981;**90**:154–8.
- 30 **Long MJ**, Cummings KM, Frisshof KB. The role of perceived price in physicians' demand for diagnostic tests. *Med Care* 1983;**21**:243–50.
- 31 **Boon-Fuller L**, Sokal E, Nightingale PG, *et al.* Utilization of laboratory resources: developments in knowledge based ordering systems. *Int J Biomed Comput* 1995;**40**:17–30.
- 32 **Rao KM**, Bordine SL, Keren DF. Decision making by pathologists. A strategy for curtailing the number of inappropriate tests. *Arch Pathol Lab Med* 1982;**106**:55–6.
- 33 **Baral N**, Koner BC, Lamsal M, *et al.* Thyroid function testing in eastern Nepal and the impact of CME on subsequent requests. *Trop Doct* 2001;**31**:155–7.
- 34 **Dowling PT**, Alfonsi G, Brown MI, *et al.* An education program to reduce laboratory tests by residents. *Acad Med* 1989;**64**:410–12.
- 35 **Lyon AW**, Greenway DC, Hindmarsh JT. A strategy to promote rational clinical chemistry test utilization. *Am J Clin Pathol* 1995;**103**:718–24.
- 36 **Finn AF**, Valenstein PN, Burke MD. Alteration of physicians' orders by nonphysicians. *JAMA* 1988;**259**:2549–52.
- 37 **Chiecchio A**, Bo A, Manzone P, *et al.* DECIDE; a software for computer assisted evaluation of diagnostic test performance. *Comput Methods Programs Biomed* 1993;**40**:55–65.
- 38 **Young DW**. An aid to reducing unnecessary investigations. *BMJ* 1980;**281**:1610–11.
- 39 **de Wide EJ**, Pop P, Hasman A, *et al.* Open labs services for ordering laboratory investigations. *Computer Methods Programs Biomed* 1996;**50**:135–41.
- 40 **Sussman E**, Goodwin P, Rosen H. Administration change and diagnostic test use. The effect of eliminating standing orders. *Med Care* 1984;**22**:569–72.
- 41 **Grantham P**, Weinstein S. Reducing pathology test misuse. *Aust Health Rev* 1993;**16**:16–23.
- 42 **Guterman SJ**, VanRooyan MJ. Cost-effective medicine; the financial impact that practice guidelines have on outpatient hospital charges in the emergency department. *J Emerg Med* 1998;**16**:215–19.
- 43 **Kroenke K**, Hanley JF, Copley JB, *et al.* Improving house staff ordering of three common laboratory tests. *Med Care* 1987;**25**:928–35.
- 44 **Lowe RA**, Arst HF, Ellis BK. Rational ordering of electrolytes in the emergency department. *Ann Emerg Med* 1991;**20**:16–21.
- 45 **McGinn TG**, Guyatt GH, Wyer PC, *et al.* Users guides to the medical literature. Evidence based medicine working group. *JAMA* 2000;**284**:79–84.
- 46 **Pannall P**, Marshall W, Jabor A, *et al.* A strategy to promote the rational use of laboratory tests. *Clin Chim Acta* 1996;**244**:121–7.
- 47 **Gama R**, Featherstone S. Investigations. Getting from guidelines to protocols. *BMJ* 1991;**303**:522–3.
- 48 **Meneghini L**, Zadra N, Zanette G, *et al.* The usefulness of routine preoperative laboratory tests for one day surgery in healthy children. *Paediatr Anaesth* 1998;**8**:11–15.
- 49 **Kerr D**, Malcolm L, Schousboe J, *et al.* Successful implementation of laboratory budget holding by Pegasus Medical Group. *N Z Med J* 1996;**109**:334–7.
- 50 **Allen R**. Bravo, bravo BMJ. *BMJ* 2002;**325**:223.
- 51 **McConnell TS**, Berger PR, Dayton HH, *et al.* Professional review of laboratory utilization. *Hum Pathol* 1982;**13**:399–403.
- 52 **Marton AR**, Tul V, Sox HC. Modifying test ordering behaviour in the outpatient medical clinic. *Ann Intern Med* 1985;**145**:816–21.
- 53 **Sussman E**, Goodwin P. Administration change and diagnostic test use. *Med Care* 1984;**22**:569–72.
- 54 **Crook M**. Near patient testing. *J Clin Pathol* 2000;**53**:27–30.
- 55 **Kendell J**, Reeves B, Clancy U. Point of care testing: randomised controlled trial of clinical outcome. *BMJ* 1998;**316**:1052–7.
- 56 **Becker RC**. Exploring the medical needs for alternate site testing. A clinician's perspective. *Arch Pathol Lab Med* 1995;**119**:894–7.
- 57 **Valenstein P**. Turnaround time. Can we satisfy clinicians' demands for a faster service? Should we try? *Am J Clin Pathol* 1989;**92**:705–6.
- 58 **Guterman SJ**, VanRooyan MJ. Cost-effective medicine: the financial impact that practice guidelines have on outpatient hospital charges in the emergency department. *J Emerg Med* 1998;**16**:215–19.
- 59 **Sucov A**, Bazarian JJ, delahunta EA, *et al.* Test ordering guidelines can alter ordering patterns in an academic emergency department. *J Emerg Med* 1999;**17**:391–7.
- 60 **Kirton OC**, Civetta JM, Hudson-Civetta J. Cost effectiveness in the intensive care unit. *Surg Clin North Am* 1996;**76**:175–200.
- 61 **Munro J**, Booth A, Nicholl J. Routine pre-operative testing: a systematic review. *Health Technol Assess* 1997;**1**:21–7.
- 62 **Donaldson MD**, Seaman MJ, Park GR. Massive blood transfusion. *Br J Anaesth* 1992;**69**:621–30.
- 63 **British Committee for Standards in Haematology**, Blood Transfusion Task Force. Guidelines for the use of fresh frozen plasma. *Transfus Med* 1992;**2**:57–63.
- 64 **Poller L**, Shiach CR, MacCallum PK, *et al.* Multicentre randomised study of computerised anticoagulant dosage. European concerted action on anticoagulation. *Lancet* 1998;**352**:1505–9.
- 65 **Boneu B**. Low molecular weight heparin therapy: is monitoring needed? *Thromb Haemost* 1994;**72**:330–4.
- 66 **Kitchen S**. Problems in laboratory monitoring of heparin dosage. *Br J Haematol* 2000;**111**:397–406.
- 67 **Lee AY**, Ginsberg JS. The role of D-dimer in the diagnosis of venous thromboembolism. *Curr Opin Pulm Med* 1997;**3**:275–9.
- 68 **Bernardi E**, Prandoni P, Lensing AW, *et al.* D-dimer testing as an adjunct to ultrasonography in patients with clinically suspected deep vein thrombosis: prospective cohort study. The multicentre Italian D-dimer ultrasound study investigators group. *BMJ* 1998;**317**:1037–40.
- 69 **British Committee for Standards in Haematology**, Haemostasis and Thrombosis Task Force. Guidelines on oral anticoagulation: third edition. *Br J Haematol* 1998;**101**:374–87.
- 70 **British Committee for Standards in Haematology**, Haemostasis and Thrombosis Task Force. Guideline: investigation and management of heritable thrombophilia. *Br J Haematol* 2001;**114**:512–28.
- 71 **British Committee for Standards in Haematology**, General Haematology Task Force. Haemoglobinopathy screening. *Clin Lab Haematol* 1988;**10**:87–94.

- 72 **Wong E-M**, Tillyer ML, Saunders PRI. Pre-operative screening for sickle cell trait in adult day surgery; is it necessary? *Ambul Surg* 1996;**4**:41–5.
- 73 **Hershko C**, Konijn AM, Link G, *et al*. Combined use of zinc protoporphyrin (ZPP), mean corpuscular volume and haemoglobin measurements for classifying microcytic RBC disorders in children and young adults. *Clin Lab Haematol* 1985;**7**:259–69.
- 74 **NHS Executive**. *Better blood transfusion*. Circular HSC 1998/224. London: NHS Executive 1998.
- 75 **British Committee for Standards in Haematology**, Blood Transfusion Task Force. Guidelines for the clinical use of red cell transfusions. *Br J Haematol* 2001;**113**:24–31.
- 76 **American Society of Anesthesiologists Task Force on Blood Component Therapy**. Practice guidelines for blood component therapy. *Anesthesiology* 1996;**84**:732–47.
- 77 **Torella F**, Haynes SL, Bennett J, *et al*. Can hospital transfusion committees change transfusion practice? *J R Soc Med* 2002;**95**:450–2.
- 78 **Clarke AM**, Dorman T, Bell MJ. Blood loss and transfusion requirements in total joint arthroplasty. *Ann R Coll Surg Engl* 1992;**74**:360–3.
- 79 **Han CD**, Shin DE. Postoperative blood salvage and reinfusion after total joint arthroplasty. *J Arthroplasty* 1997;**12**:511–16.
- 80 **Monk TG**, Goodnough LT. Acute normovolemic hemodilution. *Clin Orthop* 1998;**2**:74–81.
- 81 **Viele MK**, Weiskopf RB. What can we learn about the need for transfusion from patients who refuse blood? The experience with Jehovah's witnesses. *Transfusion* 1994;**34**:396–401.
- 82 **Olivieri NF**. The beta-thalassemias. *N Engl J Med* 1999;**341**:99–109.
- 83 **Herbert PC**, Wells G, Blajchman MA, *et al*. A multicentre randomised clinical trial of transfusion requirements in critical care. Transfusion requirements in critical care investigators, Canadian clinical trials group. *N Engl J Med* 1999;**340**:409–17.
- 84 **Faris PM**, Ritter MA. Epoetin alfa. A bloodless approach for the treatment of perioperative anemia. *Clin Orthop* 1998;**357**:60–7.
- 85 **Hellstrom-Lindberg E**. Efficacy of erythropoietin in the myelodysplastic syndromes: a meta-analysis of 205 patients from 17 studies. *Br J Haematol* 1995;**89**:67–71.
- 86 **Griggs JJ**, Blumberg N. Recombinant erythropoietin and blood transfusions in cancer chemotherapy-induced anemia. *Anticancer Drugs* 1998;**9**:925–32.
- 87 **British Committee for Standards in Haematology**, Blood Transfusion Task Force. Guidelines for platelet transfusions. *Transfus Med* 1992;**2**:311–18.
- 88 **Hobbs FD**, Delaney BC, Fitzmaurice DA, *et al*. A review of near patient testing in primary care. *Health Technol Assess* 1997;**1**:1–4.
- 89 **Rao GG**, Henton J, Curry JB. Ordering of microbiology investigations by nursing personnel in a district general hospital. *J Hosp Infect* 1993;**25**:219–22.
- 90 **Gopal Rao G**, Ozerek AE, Jeanes A. Rational protocols for testing faeces in the investigation of sporadic hospital-acquired diarrhoea. *J Hosp Infect* 2001;**47**:79–83.
- 91 **Ozerek AE**, Rao GG. Is routine screening for conventional enteric pathogens necessary in sporadic hospital-acquired diarrhoea? *J Hosp Infect* 1999;**41**:159–61.
- 92 **Morris AJ**, Wilson ML, Reller LB. Application of rejection criteria for stool ovum and parasite examinations. *J Clin Microbiol* 1992;**30**:3213–16.
- 93 **Morris KJ**, Rao GG. Conventional screening for enteropathogenic *Escherichia coli* in the UK. Is it appropriate or necessary? *J Hosp Infect* 1992;**21**:163–7.
- 94 **Schifman RB**, Strand CL, Meier FA, *et al*. Blood culture contamination: a College of American Pathologists Q-Probes study involving 640 institutions and 49 7134 specimens from adult patients. *Arch Pathol Lab Med* 1998;**144**:216–21.
- 95 **Kelly AM**. Clinical impact of blood cultures taken in the emergency department. *J Accid Emerg Med* 1998;**15**:254–6.
- 96 **Educational Workshops 2000**. Focus on lower respiratory tract infections. *Microbe Matters* 2001;**3**:2–6.
- 97 **Tang YW**, Hibbs JR, Tau KR, *et al*. Effective use of polymerase chain reaction for diagnosis of central nervous system infections. *Clin Infect Dis* 1999;**29**:803–6.
- 98 **Jeffery KJ**, Read SJ, Peto TE, *et al*. Diagnosis of viral infections of the central nervous system: clinical interpretation of PCR results. *Lancet* 1997;**349**:313–17.
- 99 **Chakrabarti S**, Garvie D, Ray Chaudhuri, *et al*. Rationalising the use of polymerase chain reaction (PCR) based tests for the diagnosis of common viral infections of the central nervous system. *J Clin Pathol* 2002;**55**:560.



## Pathology tests: is the time for demand management ripe at last?

G Gopal Rao, M Crook and M L Tillyer

*J Clin Pathol* 2003 56: 243-248

doi: 10.1136/jcp.56.4.243

---

Updated information and services can be found at:

<http://jcp.bmj.com/content/56/4/243.full.html>

---

### References

*These include:*

This article cites 84 articles, 18 of which can be accessed free at:

<http://jcp.bmj.com/content/56/4/243.full.html#ref-list-1>

Article cited in:

<http://jcp.bmj.com/content/56/4/243.full.html#related-urls>

### Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

---

### Notes

---

To request permissions go to:

<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:

<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:

<http://group.bmj.com/subscribe/>