REVIEW

Hard work never hurt anyone—or did it? A review of occupational associations with soft tissue musculoskeletal disorders of the neck and upper limb

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Pain in the neck and upper limb is common and contributes greatly to absence due to sickness. Evidence is accumulating that factors such as prolonged abnormal posture and repetition contribute to these conditions. Psychosocial factors may also play a part and the relative importance of these is not yet known. Primary and secondary prevention trials are needed.

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Among the lay population and popular press, there is a widely held belief that certain types of work cause upper limb disorders (ULDs). Indeed, such an association was first proposed by Ramazzini in the early 18th century, who recorded that pain in the upper limb is related to "….constant sitting, the perpetual motion of the hand in the same manner, and the attention and application of the mind".[1] However, despite a substantial body of epidemiological and scientific publications, this is a field beset by controversy. A lack of consensus case definitions, lack of "gold standards" for the clinical diagnosis of most of these conditions, problems associated with the meaningful measurement of exposure, failure to control for known confounding factors, and an adversarial and acrimonious medicolegal climate that has grown owing, in large part, to claims for compensation, have all contributed to the uncertainty. This review aims at summarising the state of knowledge of this topic, highlighting the strengths and weaknesses of published reports, and identifying those issues that remain controversial and will require further study.

METHODS

Epidemiological surveys of neck or upper limb complaints were located through Embase (Excerpta Medica) and Medline (National Library of Medicine, USA) databases 1980–2001, searching for all upper extremity regions, including the neck, and terms for specific diagnoses of disorders considered to be musculoskeletal ULDs. The search was refined with the terms: diagnosis, classification, occupation, risk factors, mechanical, work related, or occupational. This is a vast number of publications (>2200 studies), and therefore, emphasis was placed on retrieved articles that furnished new information on the association between occupation and occupational exposures and the musculoskeletal disorders of interest, or authoritative systematic analyses of previous studies.

METHODOLOGICAL ISSUES

Classification of soft tissue disorders of the neck and upper limb

Epidemiological research relies upon the use of diagnostic criteria capable of separating states of disease with different causes, prognosis, or response to treatment. Soft tissue musculoskeletal disorders of the neck and upper limb comprise a heterogeneous group of conditions. At one end of the spectrum are relatively clear cut specific upper limb conditions—for example, de Quervain's tenosynovitis, lateral epicondylitis, rotator cuff tendonitis, carpal tunnel syndrome, but at the other end of the spectrum are non-specific regional pain syndromes (for example, forearm pain) with few objective physical findings and little in the way of demonstrable pathology.[2] In the latter group, labels such as "repetitive strain injury", "cumulative trauma disorder", and "work related upper limb pain" have often been used, but such terms are tautological and unhelpful.[3]

Until recently, epidemiological research in this field had been hampered by the absence of an agreed system of classification for these conditions.[4] Important developments were made recently, however, with the publication of two sets of consensus criteria for the diagnosis of ULDs in the UK[5] and Europe,[6] and even more recently, Helliwell and colleagues used a multivariate modelling technique to identify the core variables that classified cases of soft tissue ULDs[7] (table 1). Moreover, the Harrington criteria have been used as a basis for the development of a standardised system of examination for ULDs, and the resultant Southampton examination protocol has been shown to perform reliably[8] and have face validity for the diagnosis of these conditions.[9]

Study design

Soft tissue rheumatic disorders tend to be episodic and recurrent, making measurement of incidence methodologically challenging. Until recently, therefore, the design of most surveys has been cross sectional, focusing on prevalence. Such surveys provided useful evidence on the burden of disease and potential associations with

Abbreviations: CTS, carpal tunnel syndrome; NIOSH, National Institute for Occupational Safety and Health; RSI, repetitive strain injury; ULDs, upper limb disorders

Table 1 A comparison of new approaches to the classification of neck and ULDs

Anatomical site	Harrington[5]	Sluiter[6]	Helliwell[7]—significant variables among patients in diagnostic groups
Neck disorders	Not included	*Radiating neck complaints* At least intermittent pain or stiffness in the neck and pain or paraesthesia in one or more upper extremity regions, associated with head movements, for >4 days out of the past 7 days AND pain in upper extremity on active or passive cervical rotation	Not included
Shoulder disorders	*Rotator cuff tendonitis* History of pain in the deltoid region AND pain on resisted active movement (abduction—supraspinatus; external rotation—infraspinatus; internal rotation—subscapularis) *Bicipital tendonitis* History of anterior shoulder pain AND pain on resisted active flexion or supination of the forearm *Shoulder capsulitis* History of pain in the deltoid area AND equal restriction of active and passive glenohumeral movement with capsular pattern (external rotation>abduction>internal rotation)	*Rotator cuff syndrome* At least intermittent pain in the shoulder region without paraesthesia, which is worsened by actively raising the upper arm, for >4 days out of the past 7 days AND at least one of the following tests positive: (*a*) pain on resisted shoulder abduction, external rotation, or internal rotation; (*b*) resisted elbow flexion; or (*c*) painful arc	*Shoulder tendonitis* Limitation of abduction of the shoulder, painful arc on abduction of the shoulder, shoulder pain, sleep disturbance
Elbow disorders	*Lateral epicondylitis* Epicondylar pain AND epicondylar tenderness AND pain on resisted extension of the wrist *Medial epicondylitis* Epicondylar pain AND epicondylar tenderness AND pain on resisted flexion of the wrist	*Lateral and medial epicondylitis* At least intermittent, activity dependent pain localised around the lateral or medial epicondyle for >4 days out of the past 7 days AND local pain on resisted wrist extension (lateral) or wrist flexion (medial) *Cubital tunnel syndrome* At least intermittent paraesthesia in the 4th and/or 5th digit OR the ulnar border of the forearm, wrist, or hand for >4 days out of the past 7 days AND a positive combined pressure and flexion test *Radial tunnel syndrome* Pain in the lateral elbow region or forearm muscle mass of wrist extensors/supinator OR weakness on extending the wrist and fingers for >4 days out of the past 7 days AND tenderness in supinator region on palpation over the radial nerve 4–7 cm distal to the lateral epicondyle AND at least one of the following tests positive: (*a*) resisted forearm supination (*b*) resisted middle finger extension	*Lateral epicondylitis* Pain or tenderness, or pain on loading relevant muscle at lateral epicondyle
Wrist/hand disorders	*De Quervain's disease* Pain over the radial styloid AND tender swelling of the extensor compartment AND EITHER pain reproduced by resisted thumb extension OR positive Finkelstein test *Tenosynovitis of the wrist* Pain on movement localised to the tendon sheaths of the wrist AND reproduction of pain by resisted active movement	*De Quervain's tenosynovitis* Intermittent pain or tenderness localised over the radial side of the wrist, which may radiate proximally to the forearm or distally to the thumb, for >4 days out of the past 7 days AND at least one of the following tests positive: (*a*) Finkelstein's test; (*b*) resisted thumb extension; (*c*) resisted thumb abduction *Peritendonitis/tenosynovitis of the wrist* Intermittent pain/ache in the ventral or dorsal forearm or wrist region for >4 days out of the past 7 days AND provocation of symptoms during resisted movement of the muscles under the symptom area AND reproduction of pain during palpation of the affected tendons or palpable crepitus under the symptom area or visible swelling of the dorsum wrist/forearm *Guyon's canal syndrome* Intermittent paraesthesia in the palmar ulnar nerve distribution of the hand, distal to the wrist OR pain in the ulnar innervated area of the hand, which may radiate to the forearm, for >4 days out of the past 7 days AND at least one of the following tests positive: (*a*) weakness or atrophy in the ulnar innervated intrinsic hand muscles; (*b*) Tinel's sign; (*c*) reversed Phalen's test; (*d*) pressure test over the Guyon's canal	*Tenosynovitis* Pain on movement of tendon or swelling of tendon sheath or triggering/locking/nodule on tendon located in finger flexor or extensor tendon, or thumb flexor, extensor or abductor tendon
Carpal tunnel syndrome	Pain OR paraesthesia OR sensory loss in the median nerve distribution AND ONE OF (*a*) Tinel's test positive, (*b*) Phalen's test positive, (*c*) nocturnal exacerbation of symptoms, (*d*) motor loss with wasting of abductor pollicis brevis, (e)abnormal nerve conduction time	Intermittent paraesthesia or pain in at least two of digits I, II, or III, which may be present at night as well (allowing pain in the palm, wrist, or radiation proximal to the wrist) for >4 days out of the past 7 days AND at least one of the following tests positive: (*a*) flexion compression test; (*b*) carpal compression test; (*c*) Tinel's sign; (*d*) Phalen's sign; (*e*) two point discrimination test; (*f*) resisted thumb abduction or motor loss with wasting of abductor pollicis brevis	Paraesthesia or numbness in median nerve distribution, pain at night, paraesthesia in a peripheral nerve distribution, diminished power related to a peripheral nerve at the wrist
Non-specific forearm pain	*Non-specific diffuse forearm pain* Pain in the forearm in the absence of a specific diagnosis or pathology (sometimes includes loss of function, weakness, cramp, muscle tenderness, allodynia, slowing of fine movements)	*Non-specific UEMSDs* Diagnosis of exclusion	

risk factors, but were less helpful in establishing cause and effect. Cross sectional surveys cannot readily distinguish risk factors that prolong (as opposed to cause) a musculoskeletal disorder, and cross sectional occupational studies are prone to selection bias and the ''healthy worker effect'' (in which those worst affected tend to leave employment, leading to an underestimate of the true risk). As we will see below, our knowledge in this field has recently been considerably enhanced by the publication of prospective studies of the incidence of neck and ULDs, in community and occupational settings.

Assessment of exposure

The exposures that are suspected of causing or aggravating soft tissue ULDs are complex and difficult to measure.[10] Mechanical exposures combine elements of force, frequency, repetition, and movement. Techniques for direct observation and analysis of complex physical activities exist, but are generally time consuming, expensive, and suitable only for small scale application, while surrogates of exposure, such as job title, may be insufficiently sensitive, giving considerable variation in work activities between people in ostensibly similar jobs. Psychosocial risk factors in the work environment (too few or too many job demands, too little support from colleagues, job security, ambiguity of responsibilities) are also considered important, but no standard rubric exists for the measurement of these factors and, in consequence, assessment methods vary from study to study.[11]

Classification of outcomes and exposures

Given the above, random (unbiased) misclassifications of outcome and exposure are relatively common and the effect is generally to reduce estimates of risk to the no-effect level, thus impairing the ability of a study to detect associations which truly exist. However, non-random (biased) associations may arise if subjects with symptoms have an exaggerated recall of exposures, or if those with exposures that worry them pay more attention to their symptoms. The potential for this arises most readily in cross sectional studies, in which the assessment of exposure is self reported and subjective, and where the outcome is uncorroborated by independent physical examination (many of the available studies fit this description).

ASSOCIATION OF OCCUPATION WITH NECK DISORDERS

Neck pain is common among adults in developed countries and contributes importantly to the demand for medical services and the economic burden of absence from work due to sickness. Population based studies suggest a lifetime prevalence of over 70% and a point prevalence of between 12 and 34%.[12]

Given this high background prevalence, it is unsurprising that there have been more than 40 published epidemiological studies examining the associations between neck pain and occupation.[10] The studies are heterogeneous, varying in design, population (for example, automobile assembly workers, factory workers, secretaries, poultry workers, scissor makers, sewing machine operators, healthcare employees, grocery checkers), assessment of exposure, measurement of outcome (neck pain, neck/shoulder pain, physical examination), analysis, and presentation. When subjected to rigorous methodological criteria, few studies are found to be acceptable.[13] Several groups have undertaken systematic reviews of these publications[2 10 14] and, despite some heterogeneity of their conclusions owing to the application of different quality assessment criteria, the results suggest that neck pain is associated with exposure to sustained abnormal posture (for example, prolonged sitting, neck/trunk held in prolonged flexion or rotation), forceful and/or repetitive tasks, poor workplace support from supervisors/colleagues, high demands on the worker, and poor control over working patterns.

Many of the early epidemiological publications focused only on mechanical workplace factors, thereby omitting another potentially modifiable aspect of workplace design. Circumstantial evidence is beginning to suggest that the effects of mechanical workplace exposures—for example, abnormal posture, might be modified by psychosocial workplace factors such as decision latitude, psychological workload, and relationships within the workplace.

> ''The effect of mechanical factors in the workplace may be modified by psychosocial factors''

One such recent study is that of Croft and colleagues, in which poor self assessed health status and poor psychological health predicted subsequent neck pain after 1 year, regardless of the person's employment status.[15] According to the results of another longitudinal study, depressive symptoms predicted the subsequent incidence of neck pain.[16] The interaction between mechanical and psychosocial risk factors may therefore be complex, and well designed longitudinal studies, with validated criteria for the assessment of both types of characteristic, are desperately needed.

Taken together therefore, the evidence suggests that neck pain and neck disorders are associated with mechanical and psychosocial workplace factors. To date, the preventive effectiveness of neck schools, based predominantly upon ergonomic principles, is not convincing.[17] Therefore, high on the research agenda for the future must be an evaluation programme for workplace prevention strategies aimed at reducing both mechanical and psychosocial risk factors.

ASSOCIATION OF SHOULDER DISORDERS WITH OCCUPATION

Shoulder pain is common, with a lifetime prevalence of 7–10% and point prevalence of up to 26%.[12] In a number of studies in the past decade, shoulder pain was second only to back pain in workers' compensation insurance claims. The associations between shoulder disorders and occupational factors have been widely studied, but the quality and methodology applied is once again variable. Notwithstanding, it was the conclusion of two systematic reviews that overhead work was an established risk factor, and that repetitive work was probably a risk factor.[2 10] Evidence suggests that cumulative intensive shoulder work, particularly incorporating combinations of exposures (for example, working overhead with a heavy tool), is associated with a significantly increased prevalence of shoulder disorders.[18]

As with neck pain, however, the available evidence suggests that psychological and occupational psychosocial variables (for example, monotonous work) also have an important role.[10] Harkness and colleagues recently studied factors that predict new onset shoulder pain among newly employed workers in 12 diverse occupational settings.[19] The risk of incident shoulder pain was increased among workers exposed to lifting (odds ratio (OR) = 1.7, 95% confidence interval (CI) 0.9 to 3.0), lifting at or above shoulder level (OR = 1.6, 95% CI 1.0 to 2.5), and pushing or pulling (OR = 1.9, 95% CI 1.1 to 3.3). However, exposure to monotonous work was also predictive (OR = 1.7, 95% CI 0.9 to 1.9). Similarly, Andersen *et al* reported that new onset neck/shoulder pain among industrial and service workers was predicted by repetitive work with the shoulder, high job demands, and psychological distress.[20] The association with psychosocial risk factors also holds true even when the outcome studied is a specific shoulder disorder: a current diagnosis of adhesive capsulitis has been found recently to be independently associated with exposure to overhead work (OR = 2.8, 95% CI 1.4 to 5.5), work involving lifting weights (OR = 1.8, 95% CI 1.1 to 2.9), poor workplace support from colleagues/supervisors (OR = 2.3, 95% CI 1.1 to 4.6), and psychological morbidity (OR = 4.3, 95% CI 1.2 to 3.0).[21]

ASSOCIATION OF OCCUPATION WITH EPICONDYLITIS

In 1948, Lambrecht reported an increase in the number of cases of lateral epicondylitis in the Federal Republic of Germany after the second world war.[22] He observed that those affected were frequently employed in unaccustomed strenuous work and that the dominant arm was much more often affected than the non-dominant.

> ''Lateral epicondylitis often occurs in those taking part in unaccustomed strenuous work''

Since this observation, many studies in different occupations have suggested an increased risk with exposure to strenuous manual occupations. In the meat processing industry, for example, several studies, including one that was prospective, have shown that female sausage makers and packaging/folding workers and male meat cutters (all of whom were deemed to have exposure to strenuous manual tasks, as observed on factory visits) had an increased incidence of epicondylitis in comparison with their colleagues who were office workers or supervisors, with risk estimates ranging from 1.2- to 10.3-fold.[23] Importantly, however, many of these jobs involve exposure to combinations of force, repetition, and/or vibration. It is not currently clear whether exposure to one of these factors in isolation can be provocative and neither is it clear whether mechanical factors initiate the disorder or aggravate a tendency among predisposed subjects.

Until recently, the effect of psychological factors on epicondylitis has not been reported. However, a recent cross sectional community survey found that epicondylitis was statistically significantly associated with low levels of psychological wellbeing (OR = 7.9, 95% CI 2.5 to 24.5) and that these effects were independent of associations with mechanical factors such as bending and straightening the elbow repetitively.[24] To date, there are no prospective studies that elucidate the role of psychosocial factors in the aetiology of epicondylitis.

NON-SPECIFIC FOREARM PAIN (''REPETITIVE STRAIN INJURY'')

In the 1980s, an epidemic of ''repetitive strain injury'' (''RSI'') swept Australia, in which employees, predominantly female, with occupations involving the use of keyboards presented with incapacitating arm pain that defied classification by any existing system. Preventive ergonomic measures (setting of maximum keystrokes, posture, ergonomic workstations, job rotation, rest breaks) were advocated. However, controversy beset this new diagnostic label: alternative views of RSI were that it was an epidemic hysteria or occupational neurosis. The medical and lay press condemned the epidemic as a massive fraud perpetrated by Australian workers using arm pain as a way of securing large compensation payments from their employers, but proponents of the biomechanical aetiology published findings on muscle fatigability, histomorphometry, blood flow, and peripheral sensorineural functioning that perpetuated the controversy.

Whatever the truth about the Australian epidemic, the label ''RSI'' was at best tautological and at worst, probably harmful.[7] The term should not be used in clinical practice and has been abandoned in epidemiological research. Since the publication of consensus workshops in the UK and Europe,[5 6] non-specific forearm pain has been adopted as the diagnostic label for patients presenting with forearm pain without diagnostic physical signs.

> ''New onset forearm pain is independently predicted by psychological distress''

In their prospective study of the risk factors for non-specific forearm pain, Macfarlane and colleagues found that new onset forearm pain was independently predicted by psychological distress (OR = 1.8, 95% CI 0.8 to 4.1), aspects of illness behaviour (OR = 6.6, 95% CI 1.5 to 29), and other somatic symptoms, as well as psychosocial factors, such as level of satisfaction with support from supervisors/colleagues (OR = 2.6, 95% CI 1.1 to 5.8), and mechanical factors—for example, repetitive tasks (OR = 2.9, 95% CI 1.2 to 7.3).[25] The authors recently reported that non-specific forearm pain as diagnosed by a validated examination algorithm was rare among working age adults (point prevalence 0.5%) and that it was significantly associated with psychological distress (OR = 5.3, 95% CI 1.6 to 18.3) but not with any mechanical exposures, including keyboard use or repetitive tasks.[26]

CARPAL TUNNEL SYNDROME AND OCCUPATION

The relationship between carpal tunnel syndrome (CTS) and physical workplace factors has been the subject of more than 30 epidemiological studies, the findings of which have been extensively reviewed[2 10 27–29], and 17 of these studies met criteria for inclusion in a recent meta-analysis.[30] However, the putative role of workplace factors in the aetiology of CTS is one of the most hotly debated topics in current epidemiological publications. The principal source of controversy is the problem of case definition; ''What is carpal tunnel syndrome?'' has been the subject of recent publications.[31–35] Many of the available epidemiological studies, especially those undertaken in America, have used a case definition of symptoms and signs, in the absence of neurophysiological testing. As a result, studies of American populations have yielded consistently higher risk estimates than those derived from studies in Scandinavia, principally because more of the Scandinavian studies used neurophysiology. Overall, systematic reviews of published reports conclude that workplace factors probably contribute to CTS; exposure to force and/or repetitive motion are probably the most important factors, exposure to hand/wrist vibration, and awkward forearm, wrist, and finger postures may also play a part.

It is to be hoped that a more uniform approach to the diagnosis of CTS will clarify the role of physical workplace factors in this important, painful and debilitating condition. One recent Scandinavian study, using a consensus based case definition, found that CTS was more common in the dominant hand of people exposed to repetitive tasks (OR = 1.8, 95% CI 1.1 to 3.2) and that exposure to repetitive and forceful work increased the risk of CTS 1.4-fold.[34] The relationship of CTS with psychological morbidity has been largely unstudied, but a British study recently showed that 14% of adults presenting to outpatient departments with CTS had evidence of a major depressive disorder and that, in total, 22% had evidence of psychological comorbidity (rates comparable with those seen among outpatient adults with non-specific forearm pain in the same study).[36]

DISCUSSION

Since first mooted almost 300 years ago, there have been many epidemiological studies of the association between occupational factors and musculoskeletal problems. In general, this is a field beset with methodological difficulties. Differences of study design, classification criteria, outcome assessment, and interpretation have led to considerable confusion and controversy. Despite this, important developments have occurred in recent years. Starting with the NIOSH (National Institute for Occupational Safety and Health) review in 1997, which synthesised this heterogeneous literature and drew up recommendations for research, many more studies have been designed and carried out.[4–9 11–15 18–21 24–26 29–37] One of the priority areas, that of classification criteria for the diagnosis of ULDs, has been examined by two European groups,[5 6] who have developed consensus diagnostic criteria as a starting point for new epidemiological studies. Working from these, a new system of examination has been proposed, which has been shown to be reliable between observers and to have face validity.[8 9] These initiatives provide new tools suitable for use in epidemiological studies and capable of producing reliable and valid assessment of outcomes.

Another notable development in this field is the recognition that occupation may contribute to ULDs through psychosocial, as well as mechanical, mechanisms. In 1996, the NIOSH document synthesised the entire psychosocial literature into 16 pages out of the total 590 page document! Indeed, much of the early epidemiological literature focused only on mechanical workplace factors, thereby omitting a potentially modifiable aspect of workplace design. Since then, many more studies have focused on both mechanical and psychosocial factors,[11 12 15 19–21 24–26 31 35 36] and such studies have contributed additional insight into the relative importance of different workplace factors in the causation of ULDs. However, one of the other NIOSH recommendations, that valid and reliable measures of mechanical occupational exposures are needed,[10] remains a key objective not only for mechanical exposures but also for psychosocial exposures.[11]

An important research agenda still remains: understanding how best to develop programmes for the prevention of ULDs in the workplace. The results of recent studies may suggest that interventions aimed at altering workers' perceptions of monotonous or tedious work, perhaps through better job development opportunities, increasing latitude over working patterns, or improved communication between employers and employees, might be cost effective and beneficial as well as intervention based upon ergonomic interventions, but longitudinal prevention studies which deal with both mechanical and psychosocial factors are still urgently required.[37]

CONCLUSION

Neck and upper limb pain is a common problem among working age adults and contributes considerably to sick leave. An association between workplace factors and such symptoms has long been mooted, and evidence continues to accumulate that factors such as prolonged abnormal posture and repetition contribute markedly to such conditions. More recent studies that have considered psychosocial influences have suggested that the aetiology of these conditions is complex and that both types of factor may well be important. To date, however, the methodological weaknesses discussed in the first part of this review make it impossible for conclusions to be drawn about the relative importance of mechanical and psychosocial risk factors in the aetiology of ULDs. Although progress is slow, the quality of epidemiological studies has improved, and new developments in classification and study design will provide an important contribution to the evidence base in this field over the next decade. Primary and secondary prevention trials, however, still remain elusive.

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ECHO

Cost of manipulation is bearable for back pain

Please visit the *Annals of the Rheumatic Diseases* website [www.annrheumdis.com] for a link to the full text of this article.

Manipulation for low back pain is an effective and cost effective treatment for public sector primary care in the United Kingdom, according to an economic evaluation in a randomised trial.

However, it requires the health service to spend £10 000 or more for each extra quality of life year (QUALY) achieved by the treatment—actually less than recommended by NICE (National Institute for Clinical Excellence)—but offers better value than manipulation plus exercise.

The trial compared patient outcomes and costs of adding manipulation or exercise or manipulation followed by exercise (combined treatment) to ''best care in general practice''—consisting of practice teams trained in active management of back pain and giving patients the *Back Book*. Almost 1300 patients in 181 practices or 63 community settings around 14 centres took part for one year, and the number of patients per group ranged from 297 to 342.

Each extra QUALY delivered was costed to give an incremental cost effectiveness ratio. This value was £3800 for combined treatment over best care, when exercise and manipulation were available, and £8700 for manipulation alone, which produced a higher level of benefit over combined treatment. It was £4800 for manipulation over best care, if exercise was not available, and £8300 for exercise over best care if manipulation was not available.

Depending on the value accorded to extra QUALYs, future treatment policy might vary, possibly stretching staff resources. Further analysis showed that purchasing manipulation entirely from the private sector would not change cost effectiveness much, or patient outcomes.

▲ UK Beam Trial Team. *BMJ* 2004;**329**:1381–1385.