

Macintyre and Paul Hodkinson for commenting on draft manuscripts.

Contributors: All authors contributed to the design and writing up of the study. RY carried out the analysis and is guarantor.

Funding: All authors are supported financially by the Medical Research Council of Great Britain.

Competing interests: None declared.

Ethical approval: Glasgow University ethics committee.

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(Accepted 15 February 2006)

doi 10.1136/bmj.38790.495544.7C

## Origin and funding of the most frequently cited papers in medicine: database analysis

Nikolaos A Patsopoulos, Apostolos A Analatos, John P A Ioannidis

### Abstract

**Objective** To evaluate changes in the role of academics and the sources of funding for the medical research cited most frequently over the past decade.

**Design** Database analysis.

**Data sources** Web of Knowledge database.

**Methods** For each year from 1994 to 2003, articles in the domain of clinical medicine that had been cited most often by the end of 2004 were identified.

Changes in author's affiliations and funding sources were evaluated.

**Results** Of the 289 frequently cited articles, most had at least one author with a university (76%) or hospital (57%) affiliation, and the proportion of articles with each type of affiliation was constant over time.

Government or public funding was most common (60% of articles), followed by industry (36%). The proportion of most frequently cited articles funded by industry increased over time (odds ratio 1.17 per year,  $P=0.001$ ) and was equal to the proportion funded by government or public sources by 2001. 65 of the 77 most cited randomised controlled trials received funding from industry, and the proportion increased significantly over time (odds ratio 1.59 per year,  $P=0.003$ ). 18 of the 32 most cited trials published after 1999 were funded by industry alone.

**Conclusion** Academic affiliations remain prominent among the authors of the most frequently cited medical research. Such research is increasingly funded by industry, often exclusively so. Academics may be losing control of the clinical research agenda.

### Introduction

Medical research may depend on funding from the private sector, in particular from biotechnology and drug companies.<sup>1-2</sup> This funding may lead to conflicts of interest about the results of medical research.<sup>1-5</sup> Despite the importance of this issue, no quantitative evidence is available on the contribution of academics and the funding of studies, and how these might have changed during the past decade. We analysed the affiliations of authors and the funding sources of articles from clinical

medicine that had received the highest number of citations according to the essential science indicators module of the Web of Knowledge database. Citations do not reflect fully the quality of a paper, but they are a measure of the impact of research.<sup>6</sup> Our aim was to see whether the impact of academic institutions and the drug industry has changed during the past decade.

### Methods

#### Identification of the most frequently cited papers

We downloaded the most frequently cited papers in clinical medicine between 1994 and 2004 from the essential science indicators module of the Web of Knowledge produced by the Institute for Scientific Information (ISI). Each paper had been cited more than 325 times. Articles were ranked according to how many times they were cited by any journal indexed by ISI between 1 January 1994 and 31 December 2004. Clinical medicine is one of 21 scientific domains catalogued by ISI and covers all medical sciences and sub-specialties.

We screened 1846 articles and retained the 30 most cited articles from each year. We analysed papers from 2002-4 together (23 articles from 2002 and seven from 2003; no article published in 2004 had been cited more than 325 times by the end of the year).

Essential science indicators may have failed to classify a few earlier articles with group authorship, usually intervention studies and meta-analyses.<sup>7</sup> Therefore, we also performed a more detailed screen of the *New England Journal of Medicine*, *JAMA*, *Lancet*, and *BMJ*. This detailed search yielded another 19 articles. We analysed 289 articles in total (see appendix on [bmj.com](http://bmj.com)).

#### Data extraction

From the full text versions of the 289 articles we extracted data on the journal, year of publication, type

Department of Hygiene and Epidemiology, University of Ioannina School of Medicine, Ioannina, Greece

Nikolaos A Patsopoulos  
research associate  
John P A Ioannidis  
professor

University of Thessaly School of Medicine, Larissa, Greece  
Apostolos A Analatos  
medical student

Correspondence to:  
J P A Ioannidis  
[jioannid@cc.uoi.gr](mailto:jioannid@cc.uoi.gr)

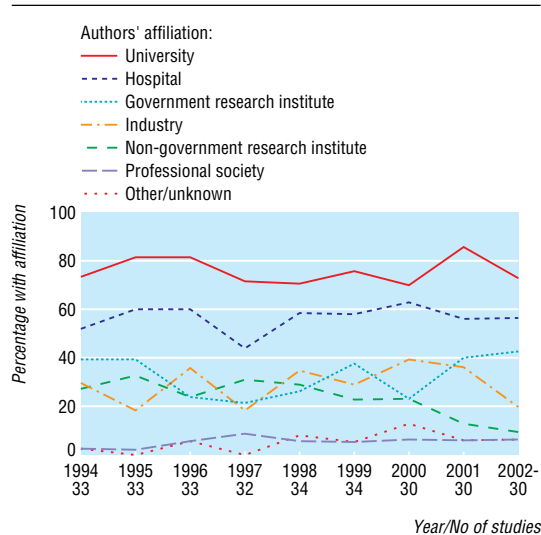
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An appendix with the 289 most frequently cited articles is on [bmj.com](http://bmj.com)



This is the abridged version of an article that was posted on [bmj.com](http://bmj.com) on 17 March 2006: <http://bmj.com/cgi/doi/10.1136/bmj.38768.420139.80>



**Fig 1** Proportion of most frequently cited articles published each year according to authors' affiliations. Studies with more than one category of affiliations are counted in all relevant categories

of study, countries of origin, listed authors' affiliations, and funding. For randomised controlled trials we recorded whether the interventions were effective, not effective, or harmful. Two independent investigators extracted the data.

**Analysis**

We used regression, with year of publication as the independent variable, to model changes over time in the proportion of affiliations of authors and sources of funding. We analysed randomised controlled trials separately.

**Results**

**Origin of eligible articles**

The median number of citations ranged from 420 for articles published in 2003 to 1409 for articles published in 1994. Half of the articles (145; 50%) had affiliations in the United States only, and a third (86; 30%) had affiliations from the US and at least one other country. A minority of articles had affiliations from countries other than the US (58; 20%). In all but 16 studies authors came from developed countries. Countries of origin did not change significantly.

**Authors' affiliations**

The proportion of articles with specific types of authors' affiliations did not change (fig 1). Over the decade, 220 (76%) articles had at least one author with a university affiliation and 164 (57%) had at least one author with a hospital affiliation. Authors had government, non-government research institute, industry, and professional society affiliations in 95 (33%), 70 (24%), 85 (29%), and 17 (6%) articles, respectively.

**Sources of funding**

Over the decade, proportions of the most cited articles funded by drug and biotechnology companies increased (fig 2). The odds of funding by industry increased 1.17-fold (95% confidence interval 1.06 to 1.28, P=0.001) per year. More than 50% of funding came from industry in 2001, surpassing funding from government or public sources. Over the decade, government or public sources,

industry, university, private foundations, and professional societies funded 173 (60%), 104 (36%), 29 (10%), 64 (22%), and 54 (19%) papers, respectively.

**Affiliations and funding for randomised controlled trials**

Most of the frequently cited randomised controlled trials (60 of 77) investigated drugs or biological agents. Most trials found that the interventions were effective (67 of 75). Trials typically had authors with university (66 of 77; 86%) or hospital (67; 87%) affiliations; almost half (36; 47%) had authors with industry affiliations. Fewer had government (21; 27%) affiliations, non-government research institute (10; 13%) affiliations, and professional society (1; 1%) affiliations. The author profile did not change significantly.

Funding by industry was common and increased over the 10 years. Sixty five of the 77 most frequently cited trials had funding from industry. Government and public sources funded only 32 trials. The proportion of trials funded by industry increased significantly over time (1.59 (1.17 to 2.15) per year, P=0.003). Thirty one of the 32 frequently cited trials published after 1999 were funded by industry.

**Discussion**

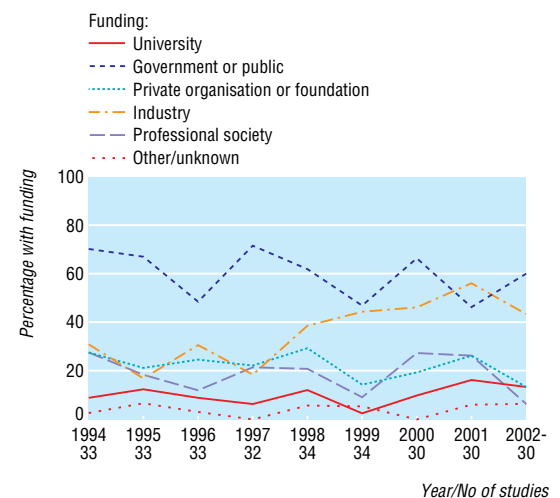
The participation of academics in the most cited medical research has remained strong over the past decade, despite the perceived crisis in academic medicine. However, industry funds an increasing proportion of this influential medical research, especially randomised controlled trials, most of which are currently funded exclusively by industry.

**Limitations**

The high citation counts of these papers do not necessarily mean that they represent the best or most important research.

**Implications**

Advances in biotechnology provide opportunities for collaboration between academics and the private sector, but safeguards are needed against financial



**Fig 2** Proportion of frequently cited articles published each year according to sources of funding. Studies with funding from diverse categories of support are counted in all relevant categories

conflicts of interest.<sup>2-5</sup> Clinical research is dictated by the need to promote products of industry. In this sense, academics may have indeed lost control of the clinical research agenda. Many important questions in clinical research have no connections with specific products and thus would not be supported by industry.<sup>8</sup> Such questions may never be funded or may not be cited frequently once published.

The recent increase in funding for profit may not be solely due to the need of industry to advertise. Recent cuts in government research budgets, together with the steady increase of applications for funding, provide an opening for the private sector.<sup>9-10</sup> Trials sponsored by industry are more likely to show favourable outcomes,<sup>11</sup> and be published in prestigious journals. Randomised controlled trials usually receive many citations,<sup>12</sup> especially if they show “positive” results. Citations strengthen the prestige of the journal, and journals may wish to publish only those papers that are likely to be cited often, thereby creating a vicious circle.

### The future of academic medicine

Our findings are in line with the scenario of “Academic Inc,” with academic medicine evolving into an efficient enterprise that is directed by profit with strong ties to other profit making corporate structures.<sup>13</sup> Our findings do not agree with a scenario where academic medicine disappears. Most influential research originates from the US and other wealthy countries, a situation that is dissonant with a global view of health needs. Government and the public sector still make major contributions to academic research, despite the rapid increase in industry sponsorship. Medical research should reflect public needs more closely.

NAP and AAA thank A Germentis for his encouragement. This work was conducted under the auspices of the International Campaign to Revitalise Academic Medicine (ICRAM) as part of the effort to evaluate the evidence base for academic medicine. Members of the ICRAM Working Party are listed on [bmj.com/academicmedicine](http://bmj.com/academicmedicine).

Contributors: See [bmj.com](http://bmj.com)

Funding: None.

Competing interests: None declared.

### What is known on this topic

Academics may be losing control of the research agenda and of clinical research at large

### What this study adds

Most of the frequently cited papers on medical research in the past decade continue to have authors with academic affiliations

Since 1994, biotechnology and drug companies have provided funding to an increasing proportion of frequently cited studies

Industry funding has become ubiquitous for frequently cited randomised controlled trials, and most of these influential trials have no other sources of funding

Ethical approval: Not required.

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doi 10.1136/bmj.38768.420139.80

## Commentary: Is society losing control of the medical research agenda?

Brendan Delaney

Funding for medical research comes from three sources: government, charities, and industry. Research funded by industry should benefit the public, but as an aside to commercial interests. Patsopoulos et al compared the proportion of the most frequently cited articles in the Institute for Scientific Information database that were funded by public or industry sources over the past decade.<sup>1</sup> They found a significant trend towards funding by industry, despite the continued dominance of academics as authors. If we take this as a robust finding, three questions arise: why is this happening; what are its implications; and what, if anything, should be done about it?

Clinical academic medicine has long had ties with industry—academics are funded to speak at conferences, provide consultancy, or help design and conduct studies. In many countries, academia is increasingly adopting a commercial approach, as universities seek alternative sources of income in response to declining public investment. The rise in the influence of industry may be as much pull as push, especially where science parks, commercial spin-offs, and intellectual property rights are concerned. However, this increasing

University of Birmingham, Primary Care Clinical Sciences, Birmingham B15 2TT  
Brendan Delaney  
professor of primary care

[b.c.delaney@bham.ac.uk](mailto:b.c.delaney@bham.ac.uk)

This article was posted on [bmj.com](http://bmj.com) on 17 March 2006: <http://bmj.com/cgi/doi/10.1136/bmj.38771.471563.80>