PUTTING NHS RESEARCH ON THE MAP

An analysis of scientific publications in England, 1990–97

NHS Executive

THE WELLCOME TRUST

PUTTING NHS RESEARCH ON THE MAP

An analysis of scientific publications in England, 1990–97

Acknowledgements

Contributors: Jonathan Grant and Sally Davies conceived and coordinated the study. The protocol was developed by Jonathan Grant and Michael Yare. Data analysis and report writing was undertaken by Jonathan Grant, Michael Yare, Sonya Kelly and Philip Green. Helpful comments on early drafts were received from Sally Davies, Mark Taylor, Howard Scarffe and the project's steering group.

We would like to express our thanks for the valuable contribution made by the project's steering group: Professor A Aynsley-Green, Professor Tom Burns, Mr David Highton, Professor Richard J Lilford, Mr Marc Taylor, Dr Stuart Turner and Professor Jennifer Wilson-Barnet. We would also like to thank Professor Martin Buxton and Dr Steve Hanney for commenting on various drafts of this report. The clinical subfield analysis, included in this report, was made possible by the work of a number of external experts, who kindly volunteered their time. We would also like to acknowledge the valuable support this research received from Grant Lewison, Robert Cottrell and Terry Cacutt.

Contents

List of Figures, Tables and Boxes

Foreword

The NHS Research and Development (R&D) Programme was established in direct response to a House of Lords Select Committee on Science and Technology report in 1988. It was felt that the NHS as 'customer' for research should not only 'articulate its needs' but also 'assist in meeting'. Since that time funding mechanisms have and continue to change and develop while the core aims of the over £400 million R&D budget spent each year by the NHS remain.

Research funders need to be able to review the output and impact resulting from their support in order to plan future strategies at the macro level and make decisions at the micro level. A number of studies and evaluations to inform policy development have been funded by the NHS R&D Directorate.

This study was commissioned by the London NHS region on behalf of the NHS R&D Directorate of England and co-funded by the Wellcome Trust in order to benchmark NHS research outputs. The aims were to act as an information source for policy makers to support decision making and funding allocations, to demonstrate the usefulness of bibliometric indicators in R&D evaluation, and to develop a standard set of indicators for future evaluations of research outputs.

Further development of the NHS R&D funding system means this work takes on a new relevance. Better understanding of measures of research outputs – of which publications will form one part – will be important as research programmes are assessed through reports of activity, productivity and output against milestones.

NHS Priorities & Needs (R&D) Funding will strongly favour ministerial priority areas and work designed to maximize its impact on NHS decision making. Bibliometric indicators may provide one strand of evidence to help in assessing which research active NHS organizations can be considered the leaders in a particular field.

Similarly, for the Wellcome Trust, this research is timely. Last year the Trust published its first Corporate Plan which highlighted clinical, patient-oriented research as an area where the Trust would enhance funding. This report will provide a useful insight into how the Trust's funds have been used to undertake research within the NHS and guide our planning processes for the future.

Improved understanding of the impact of research outputs is consistent with the push towards improving NHS knowledge management and the desire of funding bodies to show payback for their research spend. Bibliometrics takes account of the relative impact of articles emanating from different specialties according to where they are published instead of being just a crude measure of the number of publications. Bibliometric analysis repeated over time might provide a means of assessing the impact of organizational change or variations in funding.

The methodology presented, this report and the Research Outputs Database (ROD) itself are an essential part of the evaluation evidence base for research funding in the health sector in the future.

Professor Sally C Davies
Regional Director of Research & Development
NHSE London

Dr Howard Scarffe
Medical Director
The Wellcome Trust

Executive summary

The United Kingdom invests nearly £3.5 billion in medical research from public and private sources per year. Bibliometric indicators are one of a number of techniques that can be used to assess the impact of research. This project aims to 'map' research outputs for the National Health Service (NHS) in England, in order to:

- provide an information source for policy makers;
- demonstrate the usefulness of bibliometric indicators in research and development (R&D) evaluation;
- develop a standard set of indicators for future evaluations of research outputs;
- support decision making in funding allocations.

A dataset of NHS research outputs (i.e. research publications) was defined using peer-reviewed literature in England for the years 1990–97, collated from the Wellcome Trust's Research Outputs Database (ROD). Funding acknowledgements, an address filter and a comprehensive list of NHS postcodes and addresses were combined to create an NHS dataset. The research papers were also classified by a number of other criteria: by 24 biomedical subfields; by the nature of the research into four levels from 'basic' to 'clinical observation'; and by impact.

The NHS in England supports over 13 500 research publications a year. Between the years 1990–97 the average annual growth of NHS research outputs was 2.96%, compared to 3.87% for England as a whole. The Wellcome Trust, whilst supporting just under 8000 papers in the NHS between 1990–97, has a far greater average annual growth (9.67%). The London region of the NHS accounts for half of all research outputs. The next largest region in terms of output is the South East (14%), followed by the North West (13%), Trent (12%), Northern and Yorkshire (9%), West Midlands (8%), South West (7%) and Eastern (6%).

Investigation of the collaborative nature of the NHS research revealed that:

- there was an increased tendency for researchers and institutions to collaborate and, on average, NHS papers have more authors and more addresses than other papers in England;
- around 6% of NHS papers include a USA address;

- the level of international collaboration on NHS papers is less than it is for England;
- the London NHS region is co-authoring more interregional research with the other NHS regions;
- Wellcome Trust papers have a greater number of authors and addresses than either the NHS or England as a whole.

Examination of funding support showed that:

- for 47% of NHS papers, funding was 'unacknowledged' – a considerably greater proportion than that of papers for England as a whole (37%);
- multiple funding was associated with high-impact journals;
- between 1990 and 1997, the UK Government contributed to 29% of all NHS biomedical research papers; the private non-profit-sector contributed to 32% (the Wellcome Trust 7%); and the industrial sector 13%. The combined public sector contributed to 76% of all outputs. These proportions add up to more than 100% because it is possible for more than one sector to fund each paper;
- during the study period Government funding, as a proportion of all funding, declined, whilst the private non-profit sector and industry increased their relative share of research outputs;
- explicitly acknowledged support from the Government sector, private non-profit sector and industry is lower in the NHS than for England.

The exploration of the balance between basic and clinical research, unsurprisingly, showed that the NHS produces proportionately more clinical observation papers than England as a whole. Interestingly, over the eight-year period of the study, basic research in the NHS has increased in terms of output by over 5% a year, although there was a decline in 1996 and 1997. This seems in part due to increased funding by the Wellcome Trust whose basic research funding increased year on year by 13%. In contrast, NHS clinical research outputs were relatively stable over this period, growing at a rate less than that for all NHS publications.

Finally, the report assesses whether bibliometrics are an appropriate tool to evaluate clinical research and identify the major policy issues arising from the study.

1 Introduction

The United Kingdom invests nearly £3.5 billion[a] in medical research from public and private sources per year[1,2]. In some cases, this is spent on improving our understanding of biology. Elsewhere, it is used to test the effectiveness of new drugs, devices or techniques on patient populations. In between this spectrum of 'basic' and 'applied' research is a breadth of activity that is ultimately united by its aim in improving health.

What sort of return do we get from this investment? A recent report from the USA, *Exceptional Returns* (see Box A), estimated that the total economic value of reduced cardiovascular mortality averaged $1.5 trillion annually between 1970 and 1990. The report surmises that if just one-third of this was because of medical research, then the return on the investment would be about $500 billion a year – a figure 20 times greater than the average annual spend on medical research in the USA[3]. This is an astonishing return on investment, albeit based on a number of potentially heroic assumptions. However, this type of aggregate statistic does not help inform the day-to-day decisions faced by research funders, whether Government, industry or the medical research charities. Not independent from the need for more specific management information, funding organizations – especially those financed by the taxpayer – are being asked to show value for their research expenditure. Therefore, the ability to measure accurately the outputs and outcomes of research, and to attribute this to a funding source, is becoming ever more important.

Such data enable funders to demonstrate accountability and good research governance to stakeholders; have the potential to enhance public perception and understanding of biomedical science and the scientific process; and help to develop more effective R&D strategies to increase the likelihood of 'successful' research outcomes[4,5].

The use and abuse of bibliometrics

Traditionally, the output of scientific research has focused on contributions to knowledge, as measured by the number and impact of scientific papers in the peer-reviewed literature. For example, the US National Science Board makes an annual assessment of national performance by publishing counts of scientific papers and patents in its *National Indicators* series[6]. Likewise, in the UK, the Research Assessment Exercise evaluation of university departments includes the submission of scientific papers as part of assessment procedures[7]. These types of bibliometric analyses have attracted their critics[8], not least because they have been used in isolation of other methodologies and failed to use multiple indicators in the assessment of research[9].

a This estimate is derived from: (a) Office of Science and Technology's 1999 *Forward Look* (reference 1) for Government-sponsored R&D combining medical science R&D and SET expenditure for the Medical Research Council (£302.1 m); England's NHS Executive (£400.6 m) and Department of Health [Policy Research Programme (£30.3 m), sponsored Non-Departmental Public Bodies (£33.5 m), and other Department of Health initiatives (£6.4 m)]; the Department of Culture Media and Sport's National Institute of Sport's Medicine (£0.26 m); the Higher Education Funding Councils for England (£202.2 m); Scotland (£24.5 m) and Wales (£9.9 m); the Scottish Department of Health (£11 m); and the Northern Ireland Department of Health (£8.4 m) and the Welsh Office of R&D for Health and Social Care (£16 m) and; (b) Office of Science and Technology's 1999 *Science, Engineering and Technology Statistics* (reference 2) for pharmaceutical company R&D expenditure (£2151 m); and (c) and an assumed £600 m for the medical research charities including the Wellcome Trust.

Box A - Economic returns from research

The primary reason why most organizations fund biomedical research is to improve human health. However, since research programmes involve the expenditure of considerable quantities of public (and private) funds, those advocating increases or maintenance in funding for research often seek to quantify the benefits of such research in economic terms.

Recently, the US-based Mary Woodward Lasker Charitable Trust commissioned research from nine leading economists which allowed the economic value of extended life to be compared with national Gross Domestic Product. The conclusion was that the likely returns from future medical research are extremely high and that increases in life expectancy between 1970 and 1990 were worth $57 trillion to Americans.

While it is very difficult, and offensive to some, to attempt to put a dollar value on human life, this is precisely what this report attempts to do. The value of lives saved by medical research was calculated in two steps:

1. Estimating the monetary value of better health and longer life.
   - A value of approximately $5 million per life was inferred from studies asking people how much they would need to be compensated for incurring some known risk to their lives.
   - It was recognized that the economic value of saving a life will be different for people at different ages (e.g. less for a person of 90 than one of 30 years of age) and the economic value for life used in this study reflected this.
   - In the absence of a plausible measure for improvements in health and wellbeing it was considered that the benefits calculated solely on the basis of longevity will be conservative.
2. Deciding how much of the life gain experienced over the period 1970–1990 is due to medical research.
   - Some of the gains in life over this period were a result of new drugs and treatment protocols – a result of medical research.
   - Other gains in life can be attributed to changes in public policy and lifestyle, some of which can be attributed to information derived from medical research.

Of course the benefits of people living longer must be weighed against the increased costs of pensions as people live for many years past the current retirement age[16]. However, it is possible that as the age structure in developed countries changes and the ratio of young people in the workforce decreases, many people may be encouraged to remain working beyond the age of 65.

The idea that a clinician would make a decision which is based on a single piece of observational data would be universally rejected in this era of 'evidence-based medicine'. Yet, medical audit – which is based on observational data – is an accepted tool for identifying best practice, benchmarking, and improving clinical standards. The analogy between medical audit and bibliometric analysis is strong – in both cases such information is useful, but it should never be used in isolation from other independent sources of evidence. Fundamentally, both sets of information should be used to generate hypotheses, rather than to provide conclusive evidence on a particular policy or intervention. In other words, bibliometric indicators provide one element of a research evaluator's toolkit and there are a number of other techniques that could and should be used in assessing the impact of research[10] (see Box B, p. 10). Indeed, in evaluating research, the most important decision is to choose the appropriate methodology for the research objectives of a particular programme or funder.

Over the past decade an increasing body of literature has been published looking at methodologies for measuring the 'payback' on research[11,12,13]. The seminal thesis of this work is the identification of a number of multidimensional 'payback categories' as listed in Figure 1.1 (p. 12). The relative importance of each category will depend upon the (often not stated) objectives of the research. For example, one of the purposes of the NHS R&D Strategy is to 'provide new

Box B - An evaluator's toolkit

As a result of a set of budget reform measures in the USA, intended to increase the effectiveness and efficiency of Government, there was a need for all US Government-funded agencies to develop outcome measures. In early 1998 a series of workshops were held to generate ideas on how to develop performance assessments for organizations funding research[10]. These workshops identified six methods of evaluating research – the pros and cons of each are summarized below.

Method	Pro	Con
Bibliometric analysis	• Quantitative – measures volume of output • Useful to see global trends • Objective, repeatable analysis possible	• Estimates of quality may not be reliable • Difficult to compare across fields • Careful interpretation needed • May be skewed by the biases in the available data
Economic rate of return	• Quantitative – estimates the economic benefits of research	• Focuses on financial benefits rather than social or health/quality • Requires many assumptions which may be controversial/unreliable
Peer review	• Well understood and accepted • Provides qualitative informed evaluation	• Time consuming for experts • Concerns regarding objectivity and variability of results • Focuses mainly on quality to the exclusion of relevance etc.
Case studies	• Provides in-depth understanding • Informs reform of systems • Illustrates all types of benefits of research	• Not necessarily comparable • Single study may not be representative
Retrospective analysis	• Useful to identify linkages between funding programmmes and innovations over time	• Not useful for short-term evaluation as time lag between research and outcomes may be many years
Benchmarking	• Useful tool for comparison across programmes and countries	• Focuses on fields not research programmes

Other observations made at these workshops include:

- it is important to choose carefully what will be measured and how, since the method chosen will usually change the behaviour of the people being measured;
- measuring performance is often more difficult for basic research compared to applied research due to time lags and the range of external contributing factors;
- the practical outcomes of research cannot be captured by quantitative methods alone.

See: www.nap.edu/catalog/6416.html

knowledge'[14] (see Box C). Likewise, in its recently published Corporate Plan, a key objective of the Wellcome Trust is 'advancing the dissemination of results of Trust-funded research' (see Box D, p. 13). In other words, publications are not in themselves the end point, but a basis for providing improved healthcare. This is best illustrated with reference to the 'payback model' shown in Figures 1.1 and 1.2 (p. 12). The creation of knowledge payback, category a), (Figure 1.1) is a Stage III – primary output (Figure 1.2), that is dependent on a research question or needs assessment (Stage 0), review by peers (Interface a), funding (Stage I), and the actual research (Stage II). However, this new knowledge will only improve healthcare if it continues to progress in the linear model[b] to the final, Stage VI, of the payback model. That is, the new knowledge has to be disseminated (Interface b) and picked up in secondary

Box C - The NHS R&D Strategy

The establishment of the NHS R&D Strategy[17] in 1991 aimed to provide the basis to ensure that the clinical, policy and managerial decisions within the NHS were based on evidence. A major outcome of this early work was the establishment of the Research and Development Taskforce, chaired by Anthony Culyer, and the subsequent *Culyer Report*[18] of 1994, which laid the foundation and principles for NHS R&D funding to be built.

The *Culyer Report* defined NHS R&D as that designed to provide *new knowledge* needed to improve the performance of the NHS in improving the health of the nation, but which was also *generalizable* and of value across the service.

A single stream of funding was created for NHS R&D raised by a levy on health authorities; this brought together existing central and regional budgets[14]. The NHS Executive (NHSE) takes advice on how to invest these funds from the Central Research and Development Committee (CRDC). The levy provides two budgets for research costs:

- Budget 1. This budget is effectively split into two strands. The first covers infrastructure and other indirect costs of research funded by non-commercial external organizations, such as charities. The second, often referred to as *own account* research, funds work that the NHS initiates and pays in full.
- Budget 2. This is used by the NHSE/Department of Health directly for R&D to address health and health service needs identified by Ministers and the NHS that the research councils and charities do not meet.

A number of priority setting exercises have been undertaken by the CRDC, through the establishment of multidisciplinary expert advisory groups. Broad areas have been selected for review on the basis of disease burden, policy relevance, timeliness and the likely benefits of research. This has led to the establishment of a number of time-limited National R&D Programmes (see box below), which commissioned research alongside the long standing Health Technology Assessment (HTA) programme and the various regional initiatives.

More recently a tri-partite framework has been created with the HTA Programme being joined by two further permanent national programmes – *Service Development and Organization* and *New and Emerging Applications of Technology*.

Through the levy, NHS providers are also able to bid for funds to support R&D. This has come in two forms: *Portfolio Funding* and *Task-Linked Funding*. Both these types of funding enable NHS providers to undertake own account research, particularly the former where the providers have considerable discretion to use the funds as they think best.

In addition to the NHS R&D funding through the levy, the Department of Health also funds a range of R&D activity across a number of policy areas, primarily through the Policy Research Programme (PRP), but also through the budgets of Non-Departmental Public Bodies. The PRP funds a number of research centres (e.g. Centre for Health Economics), units (Social Policy Research Unit) and programmes, strategic initiatives and projects (e.g. Environmental Health).

Earlier this year, the NHS announced[19] some changes to the way R&D is managed in the service and these are described in Box G in Chapter 4.

• Mental health	• Mother and child health
• Cardiovascular disease and stroke	• Primary dental care
• Physical and complex disabilities	• Asthma management
• Primary and secondary care interface	• Methods of implementing research findings
• Cancer	• Forensic mental health

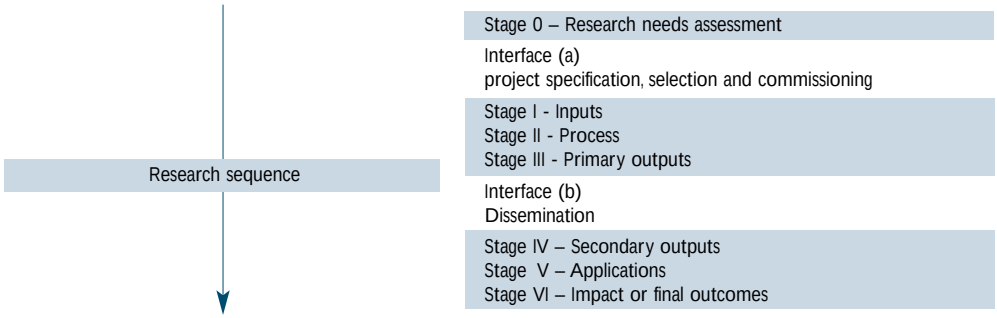
b The authors of the payback model acknowledge that the linear process is an over-simplification and in their work they have developed more complex models with feedback loops etc. For the purposes of the current study, and for modelling payback in general, we would argue that a linear model is an adequate representation of the scientific process.

Figure 1.1: Categories of payback

a) Knowledge
b) Benefits to future research and research use:
   i. the better targeting of future research;
   ii the development of research skills, personnel and overall research capacity;
   iii. a critical capability to appropriately utilize existing research, including that from overseas;
   iv. staff development/educational benefits.
c) Political and administrative benefits:
   i. improved information bases on which to take political and executive decisions;
   ii. other political benefits from undertaking research.
d) Health sector benefits:
   i. cost reduction in the delivery of existing services;
   ii. qualitative improvements in the process of service delivery;
   iii. increased effectiveness of services e.g. increased health;
   iv. equity, e.g. improved allocation of resources at an area level, better targeting and accessibility;
   v. revenues gained from intellectual property rights.
e) Broader economic benefits:
   i. wider economic benefits from commercial exploitation of innovations arising from R&D;
   ii. economic benefits from a healthy workforce and reduction in working days lost.

Source: Buxton *et al.* (1999), *Assessing the benefits from North Thames Research and Development.* HERG Research Report No. 25. HERG, Brunel University, Middlesex.

Figure 1.2: Outline input–output model for assessing the payback



Source: Buxton *et al.* (1999), *Assessing the benefits from North Thames Research and Development.* HERG Research Report No. 24. HERG, Brunel University, Middlesex.

outputs (Stage IV), such as clinical guidelines, and then applied to every day practice (Stage V). Therefore, in the language of the 'payback' model, publications (peer reviewed or otherwise) are only a primary output; they are a long way removed from achieving biomedical research's unifying mission of improving health and only a part of the knowledge spectrum. The challenge is to develop methodologies that fit the research objectives or payback categories listed in Figure 1.2. In the concluding part of this report we explore this issue further. It is raised now to highlight to the reader the need to use the data presented in this report in context. That is, it measures one objective – knowledge creation – using one methodology – bibliometrics.

Mapping the NHS landscape

The purpose of this research project was to 'map' research outputs for a single performer of research – the National Health Service in England – and then to describe the topography of that landscape. The work builds on a previous report – *Mapping the Landscape*[15] – that benchmarked all research outputs in the UK. As with that report,

Box D - The Wellcome Trust's Corporate Plan

The Wellcome Trust is an independent research-funding charity, established under the will of Sir Henry Wellcome in 1936. It is funded from a private endowment, which is managed with long-term stability and growth in mind.

Its mission is to foster and promote research with the aim of improving human and animal health. Its work covers four areas:

Knowledge base:	improving our understanding of human and animal biology in health and disease, and of the past and present role of medicine in society. • Supporting basic, applied and strategically important research in biomedical science • Researching the societal impact of biomedical science – past, present and future
Resources:	providing exceptional researchers with the infrastructural and career support they need to fulfil their potential. • Human resources: meeting training and career deveopment needs of researchers • Physical resources: building suitable conditions for research
Translation:	ensuring maximum health benefits are gained from biomedical research. • Promoting patient-oriented research and health services research • Advancing the dissemination and exploration of the results of Trust-funded research
Public engagement:	raising awareness of the medical, ethical and social implications of biomedical science. • Stimulating an informed dialogue to raise awareness and understanding of biomedical science, its achievments, applications and implications

the data presented describe patterns of research papers published in the peer-reviewed serial literature.

The research described in this report was supported by the Research and Development Directorate of the London Regional Office of the National Health Service Executive and the Wellcome Trust. The objectives of the project were:

1. to provide an information source for policy makers;
2. to demonstrate the usefulness of biliometric indicators in R&D evaluation;
3. to develop a standard set of indicators for future evaluations of research outputs; and
4. to support decision making in funding allocations.

By publishing this report we hope to fulfil objectives 1, 2 and 3. All those involved in the project see it as an interactive and iterative process and as such we hope the data presented will stimulate further discussion and research questions.

We have used a classical structure to this report. Chapter 2 describes the bibliometric methodologies we developed and utilized. It explains how we have created an NHS research outputs dataset and then describes how it can be 'mined' using a number of standard tools. Chapter 3 – the results section – is limited to single and bi-variate analysis of NHS research. Six types of analysis are presented – the number of papers published per year, by region etc.; the level of collaboration between researchers, funders, regions and countries; an analysis of the funding of supporting research in the NHS; a description of the type of research (i.e. whether basic or clinical) in the NHS; analysis by 24 different 'subfields', or clinical specialities; and estimates of the impact of that research. The fourth chapter brings together these findings, by identifying the policy questions raised from the analysis and developing some initial thoughts for further investigation. Given the large volume of data, we have made an effort to focus our analyses (for example we only look at two of the 24 subfields) but we have provided extensive tabulations in the Appendix.

2 Measuring NHS research outputs

In order to achieve the goals set out in the original project specification, a dataset of NHS research outputs was defined using peer-reviewed literature in England for the years 1990–97. This information was collated from the Research Outputs Database (ROD), which contains all biomedical research papers from the United Kingdom covering the timescale of the study. Funding acknowledgements, an address filter and a comprehensive list of NHS postcodes and addresses were combined to create an NHS dataset.

The development of ROD

In the early 1990s, the Wellcome Trust wanted to determine what had been achieved with its support and to investigate the effectiveness of different funding mechanisms. To do this, it needed details of papers published as a result of its support. However, the acquisition of the relevant data presented a problem as attempts to obtain lists directly from grantholders proved unreliable and incomplete.

An alternative approach was tried in which a large sample of papers was examined in libraries and their acknowledgements reviewed in order to identify papers supported by the Trust. As a result of a pilot study, a decision was made to design a full-scale ROD that would capture all UK biomedical papers in the peer-reviewed serial literature. Primarily this was intended to assist the Trust in its research management role. Since it also included data of value to other funding bodies it was envisaged that it would be made available to a 'club' of interested organizations, one of which was the NHS[c]. The scope of the database was designed to include all the scientific areas of interest to the Trust, including clinical and veterinary medicine, basic cell biology and genetics, and some of the social sciences such as psychology and nursing.

The methodology whereby UK biomedical papers are identified and downloaded from the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) is described in detail in the Annex. Briefly, all papers (articles, notes and reviews) with at least one UK address in the biomedical and relevant social science journals that are indexed on the SCI and SSCI are included, as are those with a biomedical keyword in other journals.

Data derived from ROD were published in 1998 in a report benchmarking UK biomedical outputs, *Mapping the Landscape: National Biomedical Research Outputs, 1988–1995* [15]. It is the intention to use this report as a model for the current study, focusing on all research outputs from NHS institutions in England.

The development of the NHS research outputs dataset

There are several well-defined bibliometric techniques[20,21,22,23] that can be used to describe research outputs. *Mapping the Landscape* developed some of these techniques, which have been utilized to create an NHS research outputs dataset. Initial steering committee meetings proposed that the dataset should cover the period from 1990 until 1997, with regular updates for new publications to be added at a later date. It was also decided to look only at research carried out by the NHS in England. Therefore, for the purpose of comparison, research outputs in England as a whole were used instead of the UK.

[c] The NHS ROD membership is paid for and managed by the R&D Directorate of the London Regional Office of the NHSE.

Two major issues needed to be addressed in using ROD as the primary source of data to define NHS research outputs. First was the vexed question of defining NHS outputs given the complexity of extricating the health services systems from the university system. Second, it had been shown that coverage of health service research journals in UK bibliometric databases is inadequate.

Defining NHS research outputs

In order to create a dataset of NHS research outputs, a way had to be found of defining NHS publications contained in ROD. This was done in three ways. First, an address filter was applied directly to ROD. The address field was searched for the letter strings HOSP, INFIRM and NHS. Second, ROD was cross-referenced, using postcodes, with a database adapted from the NHS Organization Codes Service (OCS) dataset (see Box E for a description of the OCS data). Finally, any paper which received explicit funding acknowledgements from the NHS was also added to the dataset. Twenty-four NHS codes were used, representing funding by the Department of Health, the NHS Executive (NHSE) and regional offices of the NHSE (formerly Regional Health Authorities[d]), shown in Table 2.1 (p. 16). These methods provided three sets of overlapping data: papers with an NHS address; papers with an NHS postcode; and papers with an explicit NHS-funding acknowledgement.

The address filter relies on address words that denote a clinical setting, common to the large majority of NHS sites (hospitals, infirmaries, etc.). This filter also acts as an auxiliary to the postcode filter, as the OCS database may not include details of all postcodes within a large hospital trust site. The address filter allows us to pick up NHS sites with secondary or departmental postcodes that are not covered by the OCS. Similarly, the OCS postcodes not only validate records collected by the address filter but they also identify NHS sites regardless of the existence of address keywords. This provides a greater level of recall for records that do not conform to typical address structures either because of their name, links to a parent organization, or editorial formatting in journals. The funding filter takes into account the fact

Box E - Organization Codes Service[28]

The Organization Codes Service (OCS) is managed by the Codes Development and Allocation Section of the Department of Health and provides nationally agreed reference data on all organizations in the NHS, and some non-NHS organizations that supply services to the NHS.

The service maintains a dataset of all NHS organizations and allocates a unique code to each. This is used for a number of functions including:

- Reporting – information produced by individual organizations can be uniquely identified and data on resources and finances may be aggregated in useful ways such as by NHS region;
- Patient administration – by allowing identification and verification of the patient's referral source, registered GP and health authority of residence;
- Commissioning and managing service agreements – by identifying both the service provider and commissioner.

The information produced by the OCS includes:

- Authoritative national lists for all NHS organiztions;
- A change history for each of these organizations to allow changes in name, location or mergers to be traced over time;
- Details of geographic areas covered by these organizations, including postcodes.

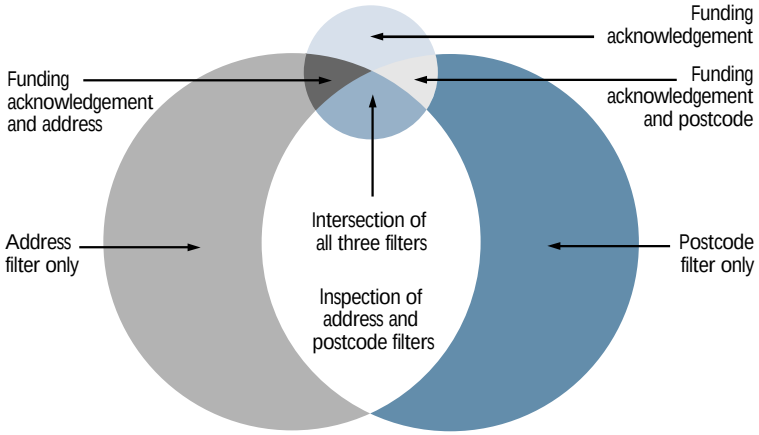
Using this information, a comprehensive list of postcodes for NHS organizations in England was created and used as one of the means of identifying NHS papers. This data also allowed each paper to be linked to the corresponding NHS region of England.

d In this report we use year 2000 boundaries of the regional offices of the NHSE and back-project these over the time period of analysis. Hence the London region includes data from 1990 which then was known as North West Thames, North East Thames, South West Thames, and South East Thames and included parts of the now Eastern and South Eastern Regions.

Table 2.1: NHS funding bodies

Code	Regional Health Authorities or NHSE regional offices
OXR	Oxford Region
EAR	East Anglia Region
XAO	Anglia & Oxford NHS Executive
NWT	North West Thames Regional Health Authority
NET	North East Thames Regional Health Authority
XNT	North Thames NHS Executive
MYR	Mersey Regional Health Authority
NWR	North Western Regional Health Authority
XNW	North West NHS Executive
NOR	Northern Regional Health Authority
YKR	Yorkshire Regional Health Authority
XNY	Northern & Yorkshire NHS Executive
SWR	South Western Regional Health Authority
WXR	Wessex Regional Health Authority
XSW	South and West NHS Executive
SET	South East Thames Regional Health Authority
SWT	South West Thames Regional Health Authority
XST	South Thames NHS Executive
TRR	Trent Regional Health Authority
XTR	Trent NHS Executive
WMR	West Midlands Regional Health Authority
XWM	West Midlands NHS Executive
XNH	NHSE generic code
DOH	DOH generic code

Fig 2.1: Schematic representation illustrating the construction of the NHS dataset



that some NHS-funded research may not be on an NHS site (and therefore cannot be recognized through either address keywords or NHS postcode) but if they explicitly acknowledge NHS-funding support then any outputs will be added to the dataset[e].

Using the overlapping filters a dataset of 108 850 unique NHS papers in England between 1990 and 1997 was identified (represented by Figure 2.1).

One difficulty with this method is that in practice the health service system is embedded in the university system, and vice versa. Specifically, during steering committee sessions, fears were raised that papers from academic sites would not be captured and their output under-represented within the NHS. This arises from the perception that clinicians in academic institutions may use their university addresses on papers. Other than stressing editorial accuracy and consistency in the way NHS research is attributed there is little that can be

e It should be noted that since April 1998 NHS providers in receipt of NHS funds have been expected, by contract, to acknowledge the NHS R&D funding stream.

Table 2.2: Postcode coverage of three groups of NHS sites

Trust type	No. of postcodes	No. in ROD	No. in NHS dataset	Dataset coverage of postcodes
University Hospital Trust A	21	20	20	95%
University Hospital Trust B	27	20	20	74%
Community Health Services Trust	56	16	16	29%

Table 2.3: List of additional HSR journals included in ROD

Journal title	Added to ROD	Number of papers[a]
Audit Trends	●	122
British Journal of Health Care Management	●	319
Health Director	○	Not peer reviewed
Health Services Journal	○	Not peer reviewed
Health Services Management Research	●	59
Journal of Evaluation in Clinical Practice	●	56
Journal of Health Services Research and Policy	●	44
Journal of Management in Medicine	●	38
Journal of Mental Health Policy and Economics	○	Began in 1998
Nurse Researcher	●	81
Nursing Standard	●	973
Quality Connection	○	Not peer reviewed
Quality of Life in Childhood Asthma	○	Not found

[a] that is articles, notes or review with a UK address.

● = *Yes*

○ = *No*

done to assure complete recall without compromising the precision of records within the dataset. To this end several sensitivity analyses were undertaken to see just what was being captured or missed by the filters used to create the dataset. This analysis concluded that, in London the vast majority (i.e. 20 out of 24 – 83%) of 'medical academic sites' of the University of London (i.e. not directly funded by the NHS) were included in the NHS research outputs dataset.

A further analysis assessed the recall and precision of the techniques used to define NHS research outputs. The postcodes from two acute hospital trusts and one community health services trust (all designated University Hospitals but where the latter contained a number of small clinics) were compared with ROD and the NHS datasets. The three groups of postcodes and their coverage on the datasets are detailed in Table 2.2. Whilst there was very good coverage of postcodes for the University Hospital Trusts, for the Community Health Services Trust there was much lower coverage by ROD. This raises the question of whether these sites are research-active in the sense that they produce research papers in peer-reviewed journals (and would therefore be included in the

SCI/SSCI and ROD) or whether there is a tendency systematically to under-represent community-based research.

Defining health services research

In a recent paper[24] Black and Davies pointed out that UK bibliographic databases, including ROD, underestimated the output of health services researchers. This is in part due to the lack of coverage of health services research (HSR) journals in ROD and other databases. Black and Davies argue that, although the 'poor cousin' of basic and clinical research, HSR is becoming a rival in terms of funding, scientific quality and political importance. Any database that concentrates on clinical and basic research journals is therefore missing out on a third 'vital requirement' of healthcare research. However, the wide range of journals in which HSR is published makes it difficult to monitor both the quantity and quality of HSR research.

In response to this analysis, an attempt was made to increase ROD's coverage of HSR journals[25]. Out of 264 HSR journals identified by respondents to Black and Davies' request for lists of original research articles, only 138 were in ROD (41%). However, of the remaining 126 journals not in ROD, 13 contained 50% of the missing papers identified by the survey respondents. These 13 journals are listed in Table 2.3 (p. 17). Five of the journals were excluded from ROD for various reasons. One journal could not be located in any library. Another journal began in 1998, which is outside the remit of this project but will be included in future updates of the dataset. Three of the journals were not peer reviewed and so were not added to ROD. These five journals alone accounted for 30% of the missing papers.The remaining 20% of papers, in the other eight journals, were collected from libraries and inputted into ROD if they were articles, notes, or reviews with UK addresses. According to standard procedures for ROD records, any funding information was also noted. Eventually, 1692 papers were collected, less than 1% of the current total on ROD.

Counting publications

When assessing the number of publications by different units (e.g. NHS region, funding body etc.), two different methods can be used. In some studies a unit's contribution is recorded as a fraction (for example, a publication bearing addresses from say, London and North West regions would score 0.5 each) but in other studies – including this one – integer counting is used, whereby each region scores 1.0. The difference in the two methods is that if counts of publications are fractionated, then individual unit percentages sum to 100% and the subsequent proportions attributable are lower than with integer counting.

Identifying funding sources

All the papers in the dataset were looked up in libraries to determine their funding sources. For extramural funding this was taken from the formal acknowledgement section, following detailed guidelines (see Annex). Intramural funding determined from addresses was also included in this analysis: this is particularly important for Government and Research Council labs, industrial companies and charity-funded labs. The funding bodies were individually identified from a thesaurus and additionally classified into three main funding sectors: Government; private-non-profit (PNP); and industry.

We defined Government funding as the research councils (e.g. the Medical Research Council), Government departments (e.g. the Department of Health), and local or regional authorities (e.g. the Scottish Executive). The PNP funding included collecting charities (e.g. Cancer Research Campaign), endowed or single source charities/foundations (e.g. the Wellcome Trust), hospital trustees (i.e. funds association with a particular hospital such as St. James' University Hospital Special Trustees), other not-for-profit organizations like MERLIN (Medical Emergency Relief International), and other mixed sources of academic funds (e.g. CT Taylor Studentship

Fund in Cambridge). In addition to assessing the PNP sector as a whole, we also looked at Wellcome Trust outputs arising from within an NHS setting.

The industry sector was defined as pharmaceutical (e.g. SmithKline Beecham) and non-pharmaceutical (e.g. Channel Four Television) companies and their subsidiaries, as well as biotechnology companies (e.g. Oxford Biomedica). We did not analyse veterinary practices and those 1.2% of unclassified funding acknowledgements.

Over one-third of papers (greater for those arising from the NHS) do not have funding acknowledgements and the implications of this are discussed later. That said, it should be noted that the number of papers without acknowledgements is declining[15], and it has been shown that seven out of eight papers actually acknowledge extramural support that should do so[26]. It should be stressed that the lack of a funding acknowledgement does not imply that the research is unfunded – the main sources of funding for this research will be the NHS and to a lesser degree the Higher Education Funding Councils.

Subfield definition

The research outputs identified for the NHS can be characterized by biomedical subfield. Such analysis is important, as it has been shown that different fields of research have different publication patterns[20].

The process used in defining subfields is given in the Annex. Table 2.4 shows the available subfields. Five of these subfields have been specifically developed for this project. In total, 25 subfields were to be applied, however, the filter for health services research proved exceptionally difficult to define and is as yet unfinished (and thus excluded from this report). This was unfortunate given the recent importance attributed to HSR and it is intended that the filter will be finally defined and added to future updates of the NHS dataset.

Of the current list, 11 subfields were used either because National Service Frameworks in the area are published or because specific NHS advisory groups ('Topic Working Groups') to the Central Research and Development Committee (CRDC) recently reviewed research needs in that field[27]. A further 14 were chosen by the steering committee. Stroke, mental health, asthma, rehabilitation and public health were all developed specifically for this study at the request of the steering committee. In this report we concentrate on two contrasting subfields (oncology and mental health) to illustrate the utility of subfield specific bibliometric analysis. However, in the Appendix we provide the complete data for all 24 subfields.

Table 2.4: List of 24 biomedical subfields used in study

Anaesthetics	Gerontology	Oncology
Arthritis and rheumatism	Haematology	Paediatrics
Asthma	Intensive care	Primary healthcare
Cardiology	Mental health	Public health
Clinical trials	Neonatology	Rehabilitation
Diabetes	Neurosciences	Respiratory medicine
Gastroenterology	Nursing research	Stroke
Genetics	Obstetrics and gynaecology	Surgery

Classifying research

A further tool used was a journal classification system developed and updated by CHI Research Inc., which is based on expert opinion and journal-to-journal citations, and has become a standard tool in bibliometric analyses[21]. Journals are allocated into four hierarchical levels in which each level is more likely to cite papers in journals at the same level or the level below it and vice versa (Table 2.5). Hence, only 4% of papers in level 1 'clinical observation' journals (e.g. *BMJ*) will cite papers in level 4 'basic' journals (e.g. *Nature*), compared to 8% for level 2 'clinical mix' journals (e.g. *New England Journal of Medicine*), and 21% for level 3 'clinical investigation' journals (e.g. *Immunology*). By looking at the journals in which papers are published, it is possible to characterize the research on a clinical to basic continuum. It should be noted that this analysis is rather crude as it allocates all papers within a journal to one level, despite a strong likelihood that there is variation in the type of research published in a given journal.

Measuring impact

As noted in the introduction, there are a number of ways in which research impacts on healthcare. One way is the transfer of knowledge from one user to another via publication in peer-reviewed journals. A proxy for the number of times a paper is read would be the number of times it is cited by other researchers. Hence citation analysis provides a useful tool for measuring the impact of research. In this study we use five-year journal impact factors; that is a measure of expected number of citations a paper would receive if it was published in a given journal over a five-year period. For example, the five-year journal impact factor of the *BMJ* is 16 – this means that a paper published in the *BMJ* in 1994 might be expected to receive 16 citations between 1994 and 1998.

The major drawback of journal impact factors is that they range from 0 to over 200. However, it has been shown that scientific administrators and medical researchers differentiate the impact of publications by a factor of only about four[22,23]. Therefore in this study, each journal has been assigned a weight (W) indicating the potential impact of a paper from a journal, with W=4 being high potential impact (the top 10% of journals) and W=1 being low potential impact (the bottom 40% of journals)[15].

This is probably best illustrated with reference to Figure 2.2. In this schematic diagram, the y-axis is the five-year journal impact factor, and the x-axis is the number of journals (sorted in descending order of their journal impact factor). In this example, we are representing oncology research for papers published in England between 1990–97. The top 10% of journals all have a five-year impact factor greater than 29.2 (and include, for example, *Nature* and *Cancer Research*). These journals are allocated a weighting value of 4. The second group of journals – which

Table 2.5: Definition of research levels

Research level	Type	Example
1	Clinical observation	*BMJ*
2	Clinical mix	*New England Journal of Medicine*
3	Clinical investigation	*Immunology*
4	Basic research	*Nature*
N/A	Yet to be classified/difficult to classify	–

Source: Narin *et al.* (1976) 'Structure of the Biomedical Literature', *Journal of the American Society for Information Science*, Jan–Feb, 25–45.

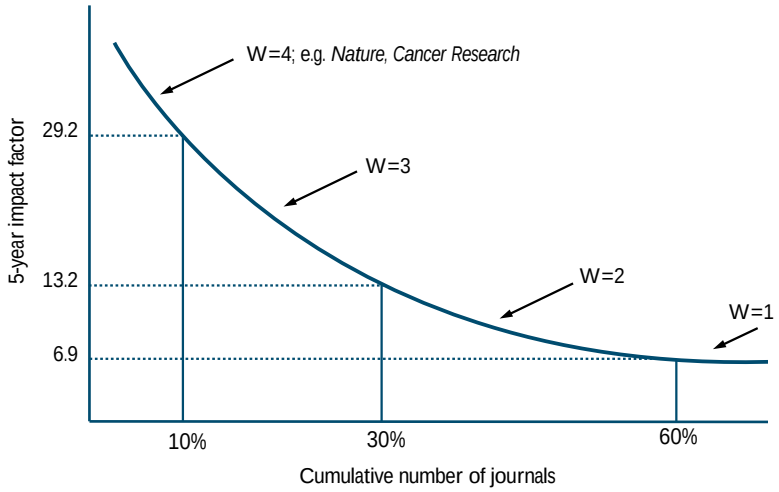
account for 20% of the journals that publish oncology papers – have five-year journal impact factors between 13.2 and 29.1. These journals are given a W-value of 3. This process is repeated for the next 30% of W2 journals whose impact factors lie between 6.9 and 13.1, and the final 40% of W1 journals which all have a five-year impact factor less than 6.9.

As different areas of research use different journals, the citation boundaries for each of the W-values is calculated for each subfield, on the basis of the journals used by that subfield. This in effect means that all the W-values are subfield specific, thus controlling for different publication patterns between different disciplines.

Summary

In this chapter we have discussed the tools that we use to describe scientific publication patterns in the NHS. In the next chapter we begin to map NHS research outputs by looking at the quantity of publications, the level of collaboration, sources of funding, the type of research (using research levels) and the impact of research for two subfields, oncology and mental health.

Fig 2.2: Schematic representation illustrating how W-values were calculated for each subfield



3 Results – An analysis of scientific publications in the NHS

In one sense, the challenge set by this project was developing a systematic methodology for capturing all NHS research outputs. The dataset we have defined includes all research papers that are (a) on the Wellcome Trust's Research Outputs Database (ROD) and (b) either acknowledge the NHS for funding support and/or describe research that occurred on NHS premises and thus is supported by the health service. Therefore, the only plausible weakness to our methodology is if (a) ROD has inadequate coverage for NHS research (and this is the reason why we added Health Services Research) and (b) if authors with joint (or honorary) positions between the NHS and a university/medical school are inappropriately excluding their NHS affiliation on research papers by not declaring NHS R&D support. It is worth pointing out that HSR papers only accounted for 1% of research outputs, and secondly the sensitivity analysis performed suggested that 83% of University of London medical academic sites are included in the dataset.

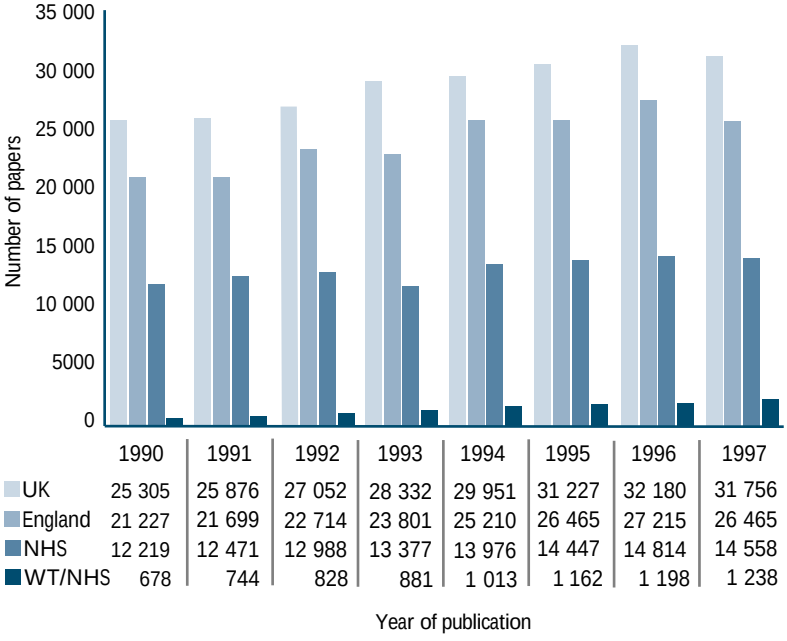
In this chapter we describe the NHS research landscape by assessing: the number of papers published a year by region etc.; the level of collaboration between researchers, funders, regions, countries; an analysis of the funding of supporting research in the NHS; a description of the level of research (i.e. whether basic or clinical) in the NHS; and an analysis of two contrasting subfields (oncology and mental health), including estimates of the impact of the research. (We also provide all the data for all 24 subfields in the Appendix). Throughout the chapter we compare the research outputs for the NHS (1990–97) with those of England (1990–97)[f]. In the analyses of the subfields we focus on outputs in the London region (1990–97) and those acknowledging the Wellcome Trust as a funder; these are compared with both the NHS and England[g]. It should be noted that these sets are not mutually exclusive – the NHS dataset is a subset of the English one, and the London region and the Wellcome Trust a subset of the NHS (papers acknowledging the Wellcome Trust as a funder are referred to as Wellcome Trust/NHS or WT/NHS from here on). Hence, any differences between the sets would be even more exaggerated if they were, or could be, separated.

Producing research – the number of publications

On average, the NHS in England supports over 13 500 research publications a year. Figure 3.1 shows the number of papers published per year in the UK, England, the NHS, and the Wellcome Trust/NHS. In 1997, the NHS accounted for 55% of English outputs, although this had declined from 58% in 1990. The average annual percentage growth of NHS outputs was 2.96%, compared to 3.87% in England[h], and 9.67% for Wellcome Trust/NHS outputs.

Using the data provided by the OCS (see Box E, p. 15), NHS regional codes were allocated to every NHS postcode and NHS address in the dataset. This enabled us to map the output of research publications by region, as shown in Figure 3.2.

Fig 3.1: Number of research publications in the UK, England, the NHS and the Wellcome Trust/NHS



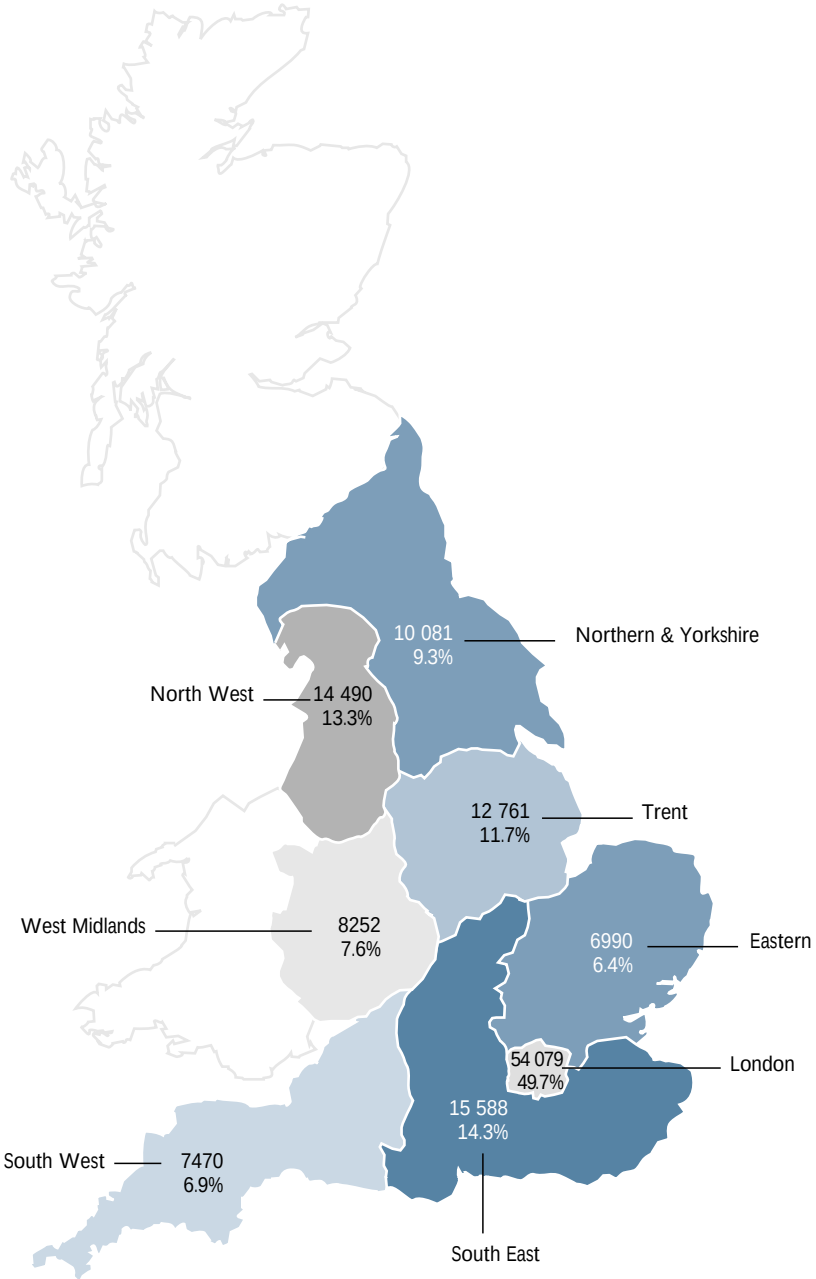
	1990	1991	1992	1993	1994	1995	1996	1997
UK	25 305	25 876	27 052	28 332	29 951	31 227	32 180	31 756
England	21 227	21 699	22 714	23 801	25 210	26 465	27 215	26 465
NHS	12 219	12 471	12 988	13 377	13 976	14 447	14 814	14 558
WT/NHS	678	744	828	881	1 013	1 162	1 198	1 238

f These data are taken from the Research Outputs Database.

g We have concentrated on the London region – the sponsors of the project.

h It should be noted that both ROD and the NHS research outputs dataset are derived from the CD-ROM version of the SCI which has expanded in recent years to cover more journals. Thus some of the increase in publications will be an artifact of increased coverage, and this may impact one subfield more than another.

Fig 3.2: Map of England, showing output of NHS papers by region (1990–97)



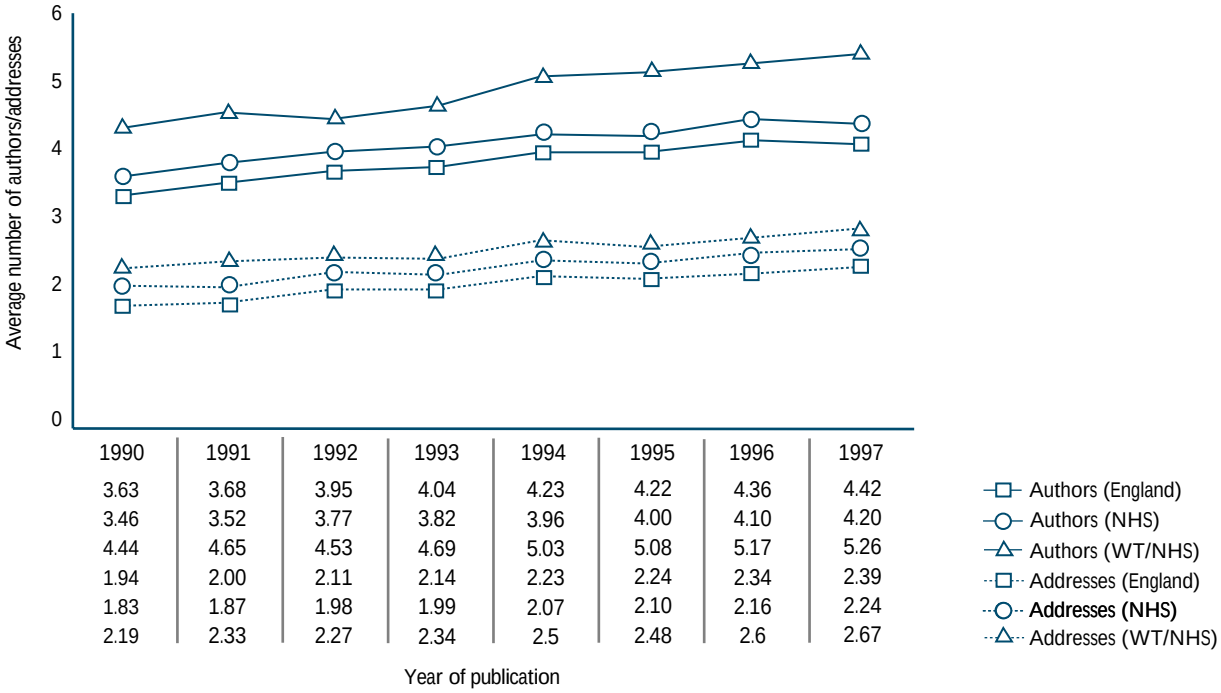
As can be seen in this map, the London region accounts for a half of all research outputs. The next largest region, in terms of output, is the South East (14%), followed by the North West (13%), Trent (12%), Northern and Yorkshire (9%), West Midlands (8%), South West (7%) and Eastern (6%). The regional distribution of Wellcome Trust-acknowledged papers in the NHS follows a similar distribution with the London region at 44%, followed by the South East (19%), North West (10%), Trent (8%), Eastern (7%), West Midlands (4%), South West (4%) and Northern and Yorkshire (4%).

Working in partnership

Collaboration or partnership is widely seen as a 'good thing'. It has been a central theme of science policy for the last ten years. In fact, there is evidence to support this policy – scientific research papers with more authors, addresses and funding bodies are, other things being equal, more likely to be published in high-impact journals than single-author, single-funded publications[20].

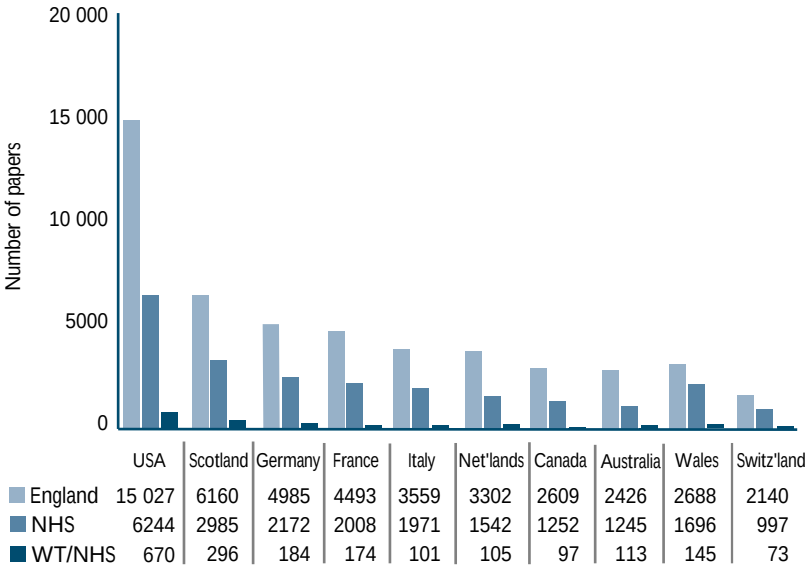
There are a number of different types of partnerships – there are those collaborations between researchers (which themselves could be interdisciplinary, interinstitutional, or international) and those collaborations between funders (whether formally via schemes such as the Joint Infrastructure Fund[29], the NHS and qualifying partners for Support for Science NHS future funding[i], or informally though multiple acknowledgements on papers). The level of collaboration through some of these types of partnership is assessed below.

Fig 3.3: Average number of authors and addresses for English, NHS, and Wellcome Trust/NHS papers (1990–97)



i See Box G (p. 39) for details of new NHS R&D funding.

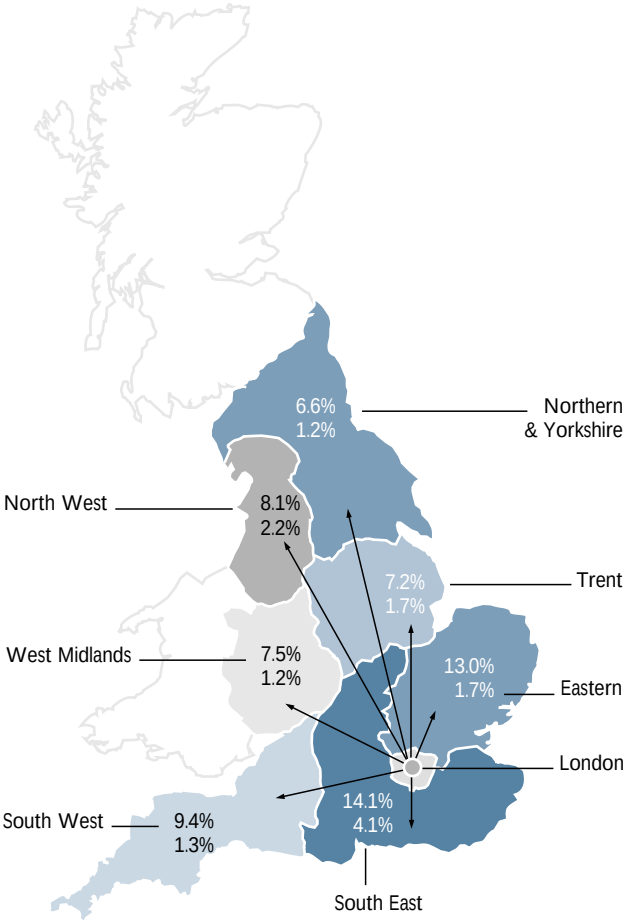
Fig 3.4: International co-authorship on English, NHS, and Wellcome Trust/NHS papers (1990–97)



	USA	Scotland	Germany	France	Italy	Net'lands	Canada	Australia	Wales	Switz'land
England	15 027	6160	4985	4493	3559	3302	2609	2426	2688	2140
NHS	6244	2985	2172	2008	1971	1542	1252	1245	1696	997
WT/NHS	670	296	184	174	101	105	97	113	145	73

Country of co-authorship with NHS

Fig 3.5: Map of England, showing collaboration between the London region and other NHS regions



Top % = proportion of regional papers
Bottom % = proportion of London papers

The average number of authors and addresses per paper is shown in Figure 3.3. These data, which proxy research collaborations between researchers and institutions, indicate an increased tendency to collaborate between 1990 and 1997. Figure 3.3 demonstrates that, on average, NHS papers have more authors and more addresses than other papers in England, whilst Wellcome Trust/NHS outputs have a greater number of authors and addresses than either the NHS as a whole or England.

International addresses can also be used as an indicator of collaboration. Those countries co-authoring with NHS papers are shown in Figure 3.4. Around 6% of NHS papers have been co-authored with colleagues from the USA. Papers co-authored with colleagues from the USA, Scotland, Germany and France account for the majority of international papers. The level of international collaboration in the NHS is less than it is for England as a whole.

Collaboration on papers between the London region and the remaining seven regions was also examined. Figure 3.5 displays the proportion of papers in each region that have a London address (top percentage). The percentage below is the proportion of London papers that are collaborative with the other regions. In other words, 14.1% of South East papers are jointly published with a London region address, whilst 4.1% of London papers have a South East address. The interesting thing to note from this map is how London is co-authoring more interregional research with the other regions, and that this is greater in the geographical surrounding regions than those further afield.

Another form of collaboration is between funding partners. A paper may acknowledge a number of funding sources as researchers – or groups of researchers – may have won a number of competitive grants from a number of different sources. Figure 3.6 (p. 26) shows the number of papers with a given number of explicit funding acknowledgements. There are two points to note from this figure. First, the proportion of 'unacknowledged' papers is considerably greater (i.e. by more than 10 percentage

points) for the NHS than for England. This does not imply that these papers are 'unfunded', but suggests that either the authors are not acknowledging direct funding support, or the support is via 'soft' money, i.e. funding which is not awarded through a competitive grant application. As previous research has shown that seven out of eight papers correctly acknowledge funding support[26], then it would seem appropriate to assume that the majority of the 'unacknowledged' papers are indeed those arising from 'soft' research funds. Within the NHS such research is often known as 'own account' research[j]. That is, research conceived by clinical staff, often pre-protocol, which is funded through the NHS R&D Levy but not specifically applied for outside the host institution through a competitive peer-review process (see Box C, p. 11). Wellcome Trust papers are identified in this analysis by funding body acknowledgement; the number of papers that did not acknowledge Trust support when in receipt of funding is not known.

The second point to note related to Figure 3.6 is that it has been shown in other studies that multiple funding is associated with high-impact journals[20]. That is, the 28% of papers that have two or more funding body acknowledgements are more likely to be published in journals such as *Nature* or *Science*, than those papers with no or only one acknowledgement. This empirical observation has a sound basis – the more times a project goes through a competitive peer-reviewed process the greater its quality is likely to be. From a research policy perspective, this would suggest that 'own account' research is of lower impact; this is a hypothesis that is explored in detail below and in the following chapter.

Funding support

By assessing the pattern of funding body acknowledgements stated at the end of a paper, we can 'link' research inputs (i.e. funding or

Fig 3.6: Number of English, NHS, and Wellcome Trust/NHS papers (1990–97) with a given number of acknowledged funding bodies

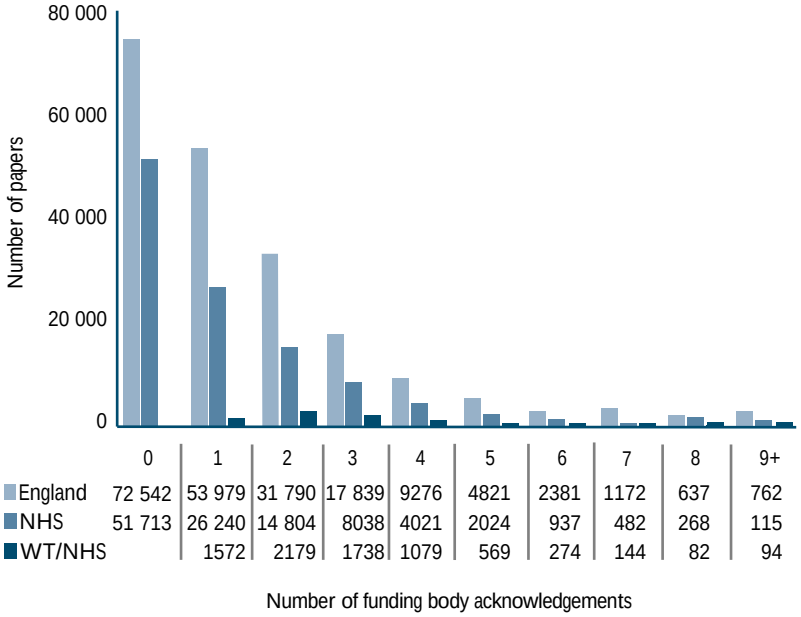
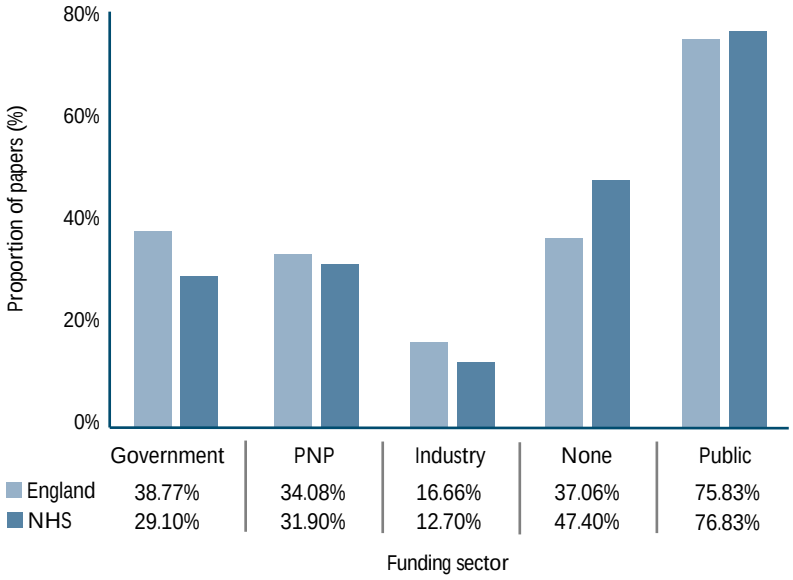


Fig 3.7: Proportion of papers acknowledging funding from a sector – English and NHS papers (1990–97)



j We make the assumption that papers without funding acknowledgement result from 'own account' funds. However, we are aware that other funding sources may also contribute to funding this research, e.g. Higher Education Funding Council allocations.

Table 3.1: Number of NHS papers acknowledging main sectors and subsectors

Year	1990	1991	1992	1993	1994	1995	1996	1997	Total	AAPG
Gov	3490	3641	3805	4014	4059	4287	4216	4173	31 685	2.84%
PNP	3442	3722	4031	4483	4792	4842	4913	4509	34 734	4.75%
WT	678	744	828	881	1013	1162	1198	1238	7742	9.67%
Industry	1417	1508	1514	1766	1821	1920	1957	1938	13 841	5.18%
None	6091	6029	6265	6030	6398	6692	7002	7129	51 636	2.54%
Public	9581	9670	10 070	10 044	10 457	10 979	11 218	11 302	83 321	2.65%
All NHS	12 219	12 471	12 988	13 377	13 976	14 447	14 814	14 558	108 850	2.96%

AAPG = Average Annual Percentage Growth

Stage I in the payback model; Figure 1.2, p. 12) with outputs (i.e. publication or Stage III in the payback model). In the analysis presented here we focus on three main sectors: Government; private-not-for-profit (PNP) including the Wellcome Trust; and industry, although all these sectors are also supported by the NHS. We also assume that those papers without acknowledgements are 'own account' research and therefore funded from the public purse. Hence we combine the Government sector with unacknowledged papers to create a category for all publicly funded research outputs.

Table 3.1 illustrates the number of papers in the three main funding sectors, and selected subgroups. Between 1990 and 1997, the UK Government contributed to 29% (i.e. 31 685/108 850) of all NHS biomedical research funding, the private-non-profit sector 32% (i.e. 34 734/108 850) and the industrial sector 13% (i.e. 13 841/108 850). The combined public sector accounted for 76% (i.e. 83 321/108 850) of all outputs. During the period 1990–97, Government funding, as a proportion of all funding, declined, whilst the private-non-profit sector and industry increased their relative share of research outputs. The rise of the PNP sector is largely due to the increased funding of the Wellcome Trust and its subsequent doubling of NHS research output over the period of analysis. The increased support for research sponsored by industry is noteworthy, no doubt reflecting the 5% annual increase in extramural R&D expenditure of the pharmaceutical industry over the same period[k].

A comparison between the patterns of funding acknowledgements in the NHS and for England as a whole is shown in Figure 3.7. The figures add up to more than 100% because it is possible for more than one sector to fund each paper. Explicitly acknowledged support from the Government sector, private-non-profit and industry is lower in the NHS than for England, whilst the reverse is true for the unacknowledged papers. The combined 'public' group is nearly identical for both the NHS and England and accounts for three-quarters of all publications.

Research levels

Research policy makers often debate the balance between basic and clinical research. On one hand, the serendipitous nature of science and the need to understand fundamental biological processes makes a compelling case for supporting basic research. On the other hand, and as noted in the introduction, the objective of biomedical research is ultimately to improve health, and thus most biomedical research strategies include support for applied – or clinical – research. In practice, most research

k This is calculated from Table 4.4 of the *Science Engineering and Technology Statistics 1999* (reference 2).

funders have a portfolio of programmes that cover both basic and applied research. One way to describe a research portfolio is to consider the research published in a given journal and then categorize that journal by the predominance of papers in it. Thus if most of the papers in a journal are found to be of a clinical nature that journal would be categorized as clinical. As explained in Chapter 2 (p. 20), CHI Research Inc. has developed a method for classifying papers by their journal type into four research levels: clinical observation (RL=1); clinical mix (RL=2); clinical investigation (RL=3); and basic (RL=4). Figure 3.8 compares the research levels of NHS papers and the Wellcome Trust/NHS to that for England. Unsurprisingly, the NHS produces proportionately more clinical observation (RL=1) papers than England as a whole (i.e. 26% for the NHS versus 17% for England and 8% for the Wellcome Trust/NHS). Conversely, the NHS produces less basic research (16%) than either England (29%) or the Wellcome Trust/NHS (40%). Perhaps the most interesting point arising from the analysis of research levels is how they have changed in the eight-year period of analysis (Table 3.2). Over this period, research in the NHS has increased by around 3%, in terms of output, annually. Basic research in the NHS increased by 5%, which is in part due to the increase in the Wellcome Trust/NHS outputs which increased year on year by 13%. NHS clinical research is relatively stable over this period, growing at a rate less than that for all NHS publications. At all research levels the Wellcome Trust/NHS outputs had increased at a faster rate annually than NHS outputs.

Subfields

Table 3.3 shows the number of papers in the 24 selected subfields, their annual average percentage growth, and their proportion of all NHS outputs. There are, of course, overlaps between subfields. For example, paediatrics will 'share' some papers with oncology. The largest subfield in Table 3.3 is surgery (14%) followed by oncology (12%) and cardiology (12%). The smallest subfield is stroke (1%), followed by asthma (1%) and intensive care (2%). The fastest growing subfields are nursing research, stroke and genetics. Analysis of research level in the different subfields reveals that those with the highest percentage of basic research are genetics (33%), neuroscience (26%) and diabetes (15%), whilst mental health (52%), stroke (52%) and intensive care (51%) are the most clinical subfields.

The impact of research

As explained in the previous chapter (p. 20), to estimate the potential influence of a paper,

Table 3.2: Distribution of research levels of NHS and Wellcome Trust/NHS papers, 1990–97

Year		1990	1991	1992	1993	1994	1995	1996	1997	Total	AAPG
Clin. obs.	NHS	3307	3425	3430	3576	3735	3570	378	3613	28 442	1.54%
(RL = 1)	WT/NHS	52	52	56	67	93	91	95	84	590	10.20%
Clin. mix	NHS	4217	4099	4385	4305	4511	4665	4360	4474	35 016	1.15%
(RL = 2)	WT/NHS	166	189	197	210	212	251	252	245	1722	6.00%
Clin. inv.	NHS	2531	2672	2831	2865	2956	2964	3102	2990	22 911	2.51%
(RL=3)	WT/NHS	232	216	251	269	316	309	346	338	2277	7.11%
Basic	NHS	1813	1884	1901	2070	2124	2376	2588	2453	17 209	5.38%
(RL = 4)	WT/NHS	224	284	320	331	383	495	486	542	3065	13.08%
Not	NHS	351	391	441	561	650	872	978	1028	5272	18.55%
classified	WT/NHS	4	3	4	4	9	16	19	29	88	39.67%
Total	NHS	12 219	12 471	12 988	13 377	13 976	14 447	14 814	14 558	108 850	2.96%
	WT/NHS	678	744	828	881	1013	1162	1198	1238	7742	9.67%

RL 1 = clinical observation; RL 2 = clinical mix; RL 3 = clinical investigation; and RL 4 = basic
AAPG = Average Annual Percentage Growth

Fig 3.8: Research level of English, NHS, and Wellcome Trust/NHS papers (1990–97)

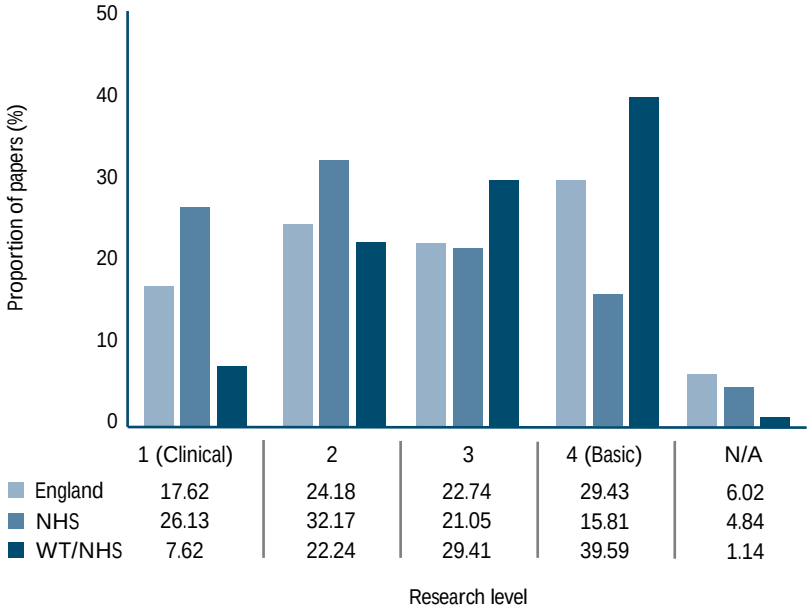


Table 3.3: Proportion of biomedical papers in 24 selected subfields, 1990–97

Subfield name	N outputs	% of NHS	AAPG
Anaesthetics	4271	3.9	1.04
Arthritis and rheumatism	4869	4.5	0.66
Asthma	1354	1.2	3.61
Cardiology	12 479	11.5	1.88
Clinical trials	2489	2.3	7.44
Diabetes	2294	2.1	1.06
Gastroenterology	9504	8.7	-0.66
Genetics	8454	7.8	8.86
Gerontology	4691	4.3	8.53
Haematology	7832	7.2	1.79
Intensive care	1615	1.5	2.19
Mental health	5311	4.9	6.20
Neonatology	2576	2.4	2.20
Neurosciences	12 296	11.3	3.68
Nursing research	1953	1.8	15.94
Obstetrics and gynaecology	7506	6.9	3.08
Oncology	13 500	12.4	2.41
Paediatrics	11 724	10.8	3.42
Primary healthcare	10 185	9.3	5.78
Public health	2022	1.9	8.63
Rehabilitation	2451	2.2	7.64
Respiratory medicine	6727	6.2	1.60
Stroke	878	0.8	9.37
Surgery	15 311	14.0	0.63
Total	152 292	–	–

AAPG = Average Annual Percentage Growth

five-year journal impact factors are mapped onto a four-point scale of weights (or W-values), with W=4 being high-impact papers (i.e. within the top-rated 10% of journals) and W=1 being low impact (i.e. the bottom 40% of journals). This method means that the impact of a paper is partly determined by the subfield within which it falls. For example, and as illustrated in Table 3.4 (p. 30), for a paper to be classified as W=4 in oncology, its journal impact factor would need to exceed 29 citations over a five-year period. In mental health research, on the other hand, a W=4 journal would only need a five-year impact factor of 15 citations. It should be noted that the values presented in Table 3.4 are for all English papers and therefore are used to act as benchmark to compare outputs, by subfield, for the NHS and its regions.

Below, we focus on two contrasting subfields – oncology and mental health. We look at outputs for England, the NHS, the Wellcome Trust/NHS and the London region, and profile the growth of outputs, collaboration, funding, and type and impact of research. The information presented for these two subfields is included for all 24 subfields in the Appendix, but without commentary.

Table 3.4: Distribution of five-year impact factors for English outputs, determining impact categories, W, for 24 subfields

Subfield	W2	W3	W4
Anaesthetics	5.27	9.58	15.45
Arthritis and rheumatism	7.19	12.26	22.71
Asthma	8.34	14.14	21.28
Cardiology	7.19	11.71	21.65
Clinical trials	7.62	11.82	19.94
Diabetes	7.70	13.82	28.79
Gastroenterology	6.65	11.49	19.25
Genetics	10.94	17.89	40.26
Gerontology	6.96	11.21	16.56
Haematology	7.83	14.63	30.91
Intensive care	4.52	9.53	14.58
Mental health	6.66	10.57	15.67
Neonatology	6.34	11.26	16.77
Neurosciences	7.72	12.64	22.23
Nursing research	4.08	7.41	13.77
Obstetrics and gynaecology	6.83	10.86	15.63
Oncology	6.87	13.18	29.19
Paediatrics	5.69	11.15	23.01
Primary healthcare	6.35	11.06	19.56
Public health	6.48	8.87	16.47
Rehabilitation	4.42	9.58	16.82
Respiratory medicine	7.02	11.59	16.43
Stroke	5.53	10.31	15.97
Surgery	4.69	9.12	15.16

Oncology research

Table 3.5 profiles oncology research in England, the NHS, the Wellcome Trust/NHS and the London region of the NHS. A number of observations can be made from this profile. First, oncology research is a well-established subfield. It accounts for 12% (Table 3.3, p. 29) of all NHS publications. Between 1990 and 1997, 18 805 papers were published in England, 72% (i.e. 13 500/18 805) of these were from the NHS. This is considerably higher than the expected 56% (Figure 3.1, p. 22) for all NHS publications in England. The London region produced 6584 papers over the eight-year period, making up 49% (i.e. 6854/13 500) of all NHS oncology papers, although it is growing at a slower rate (2.4%) than for all NHS papers (3.3%). Only 2% (287/18 805) of NHS oncology papers acknowledge the Wellcome Trust. This is not surprising given that the Trust will consider proposals for funding cancer research only where the research could have broader relevance to the understanding of biological processes or of other diseases[l].

The second observation is that collaboration – as proxied by the number of authors on a paper – is positively associated with impact. This is a recurrent theme in bibliometric analyses and supports the notion that funding large, possibly multinational and multidisciplinary research teams is more effective in producing high-impact research than funding lone scientists. This, however, does not mean that such research is (cost) efficient; large-scale collaborations are more expensive than single scientist-led projects. The challenge for analysts is to develop methodologies that can begin to differentiate between the effectiveness (i.e. impact) of research and its efficiency.

The W-values were based on the distribution of five-year journal impact factors for all English oncology papers. The reason that 11.9% (i.e. 2244/18 805) of English oncology papers are classified as being of high impact (i.e., W=4) is because the *Journal of Biological Chemistry* spanned the 10th percentile and the citation boundary was lowered to include all papers published in this journal. The 11.9% figure, however, acts as a benchmark for both the NHS (8.8% = 1190/13 500), London (10.3% = 677/6584) and the Wellcome Trust/NHS (18.5% = 53/287). In other words, in comparison to all English oncology outputs, the NHS and the

l The Wellcome Trust policy on funding cancer research can be found at: www.wellcome.ac.uk/en/1/biopolcan.html

Table 3.5: Profile of oncology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	6256	5977	4328	2244	18 805
		AAPG	~	~	~	~	3.04%
The average annual percentage growth – AAPG – is calculated for 1990–97	NHS	N	4855	4602	2852	1190	13 500
		AAPG	~	~	~	~	2.41%
	WT/NHS	N	42	116	76	53	287
		AAPG	~	~	~	~	4.30%
	London	N	2130	2377	1400	677	6584
		AAPG	~	~	~	~	1.19%
Mean (and standard error) number of authors per paper	England	Mean	3.83	4.75	5.23	7.12	4.88
		SE	0.05	0.04	0.05	0.26	0.04
	NHS	Mean	3.89	4.91	5.51	8.34	5.00
		SE	0.06	0.05	0.06	0.47	0.05
	WT/NHS	Mean	4.83	4.81	5.57	6.60	5.34
		SE	0.43	0.22	0.28	0.75	0.19
	London	Mean	4.00	5.24	5.66	8.93	5.33
		SE	0.09	0.08	0.09	0.68	0.08
Number of papers by research level	England	1 (Clinical)	2002	716	274	8	3000
		2	1922	2498	1874	417	6711
(848 papers for England, 574 papers for the NHS and 249 papers for London did not have a research level and were excluded from this analysis)		3	1141	1994	1428	923	5486
		4 (Basic)	406	742	718	894	2760
	NHS	1 (Clinical)	1828	654	234	5	2721
		2	1594	2138	1513	346	5591
		3	702	1466	821	549	3538
		4 (Basic)	196	328	263	290	1077
	WT/NHS	1 (Clinical)	5	4	4	0	13
		2	12	33	16	5	66
		3	15	48	29	24	116
		4 (Basic)	8	31	27	24	90
	London	1 (Clinical)	764	287	127	5	1138
		2	699	1110	756	215	2770
		3	347	815	354	279	1795
		4 (Basic)	84	170	156	178	588
Research funder	England	Government	1064	1522	1613	1079	5278
		PNP	1875	3050	2928	1805	9658
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		Industry	536	780	604	379	2299
		None	3598	2066	737	169	6570
		Public	4662	3588	2350	1248	11 848
	NHS	Government	611	952	870	509	2942
		PNP	1302	2287	1922	949	6460
		Industry	265	478	336	184	1263
		None	3147	1823	598	125	5693
		Public	3758	2775	1468	634	8635
	London	Government	250	489	373	298	1410
		PNP	607	1254	967	533	3361
		Industry	122	261	156	106	645
		None	1360	883	303	79	2625
		Public	1610	1372	676	377	4035

London region of the NHS produce fewer high-impact publications, where as those funded by the Wellcome Trust are of greater impact. This observation, however, needs to be treated with caution, as impact is confounded by the research level of a journal of publication. Other things being equal, basic research is of greater impact than clinical research. This is not to say that basic research is 'better' than clinical research, but it does emphasize two points. First, citation analysis may be an inappropriate tool for measuring clinical research (and this is discussed in chapter 4) and, second, if bibliometric techniques are used, it is essential that the research level of a journal is controlled for in any analysis.

Accordingly, Table 3.5 (p. 31) presents cross tabulations of impact (W-values) by research level, for the four units of analysis – England, the NHS, the Wellcome Trust and the London region of the NHS. The first point to note is that the correlation between impact and research level is shown clearly in these data. In England, a third of 1% (i.e. 8/3000) of high-impact (W4) papers are clinical observation (RL=1), compared to 32% (i.e. 894/2760) of high-impact basic (RL=4) papers. The proportion of high-impact (W4) papers by the four research levels, for England, the NHS, London and the Wellcome Trust/NHS, is plotted in Figure 3.9. The differences between the four sets of data are marginal, although the London region has a higher proportion of high-impact journals across all four research levels than for the NHS as a whole.

A second confounding factor in assessing impact is funding. It has been shown that there is a correlation between the number of funding body acknowledgements on a paper and the impact of that paper[20]. Most importantly, in the current context, papers without a funding acknowledgement are of lower impact than those with one. This observation is validated in Table 3.5. For English papers, over half of the unacknowledged papers (i.e. 54.8% = 3598/6750) are low impact (W1) compared to 2.6% (i.e. 169/6570) for high-impact (W4) publications. The proportion of unacknowledged low-impact papers for the NHS (55.3% = 3147/5693) and London is similar (51.8% = 1360/2625) to England as a whole (54.8%).

For those papers with one or more acknowledgements, the PNP sector dominates oncology funding. Perhaps not unsurprisingly, given the cancer research charities in the UK, around a half (6460/13 500 = 48%) of all NHS oncology papers acknowledge the PNP sector. For the high-impact (W4) papers, PNP is acknowledged on around 80% (i.e. 949/1190) of NHS papers, compared to 43% (i.e. 509/1190) for Government, and 15% (i.e. 184/1190) for industry. This pattern is similar for all English papers and for the London region.

Mental health research

In contrast to oncology, mental health research is a small but fast-growing subfield. It accounts for around 5% of publications in England, the NHS, London and the Wellcome Trust/NHS, but is growing at around 7% a year in England and 11% for the Wellcome Trust. This would mean that the number of mental health research publications would double in a decade. Yet, despite the low base and high growth rate, the associations described for oncology are further validated in Table 3.6.

Fig 3.9: Research level of high-impact (W4) oncology papers for England, the NHS, London, and the Wellcome Trust/NHS (1990–97)

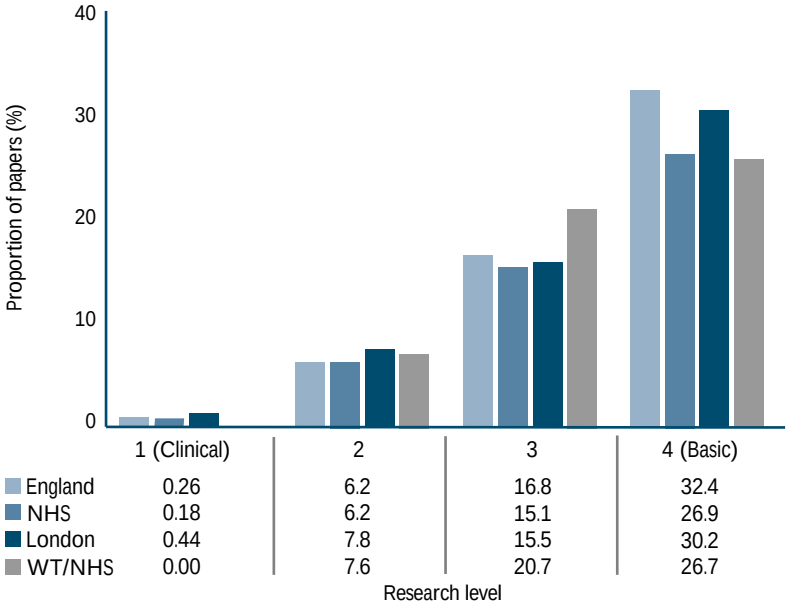


Table 3.6: Profile of mental health research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	3167	1723	2440	531	7861
		AAPG	~	~	~	~	7.39%
	NHS	N	2061	1177	1777	296	5311
		AAPG	~	~	~	~	6.20%
	WT/NHS	N	63	142	169	61	435
		AAPG	~	~	~	~	11.30%
	London	N	888	621	1010	170	2689
		AAPG	~	~	~	~	6.69%
Mean (and standard error) number of authors per paper	England	Mean	2.60	3.96	3.65	4.93	3.40
		SE	0.033	0.104	0.0610	0.196	0.036
	NHS	Mean	2.68	4.01	3.68	5.29	3.48
		SE	0.042	0.135	0.067	0.294	0.045
	WT/NHS	Mean	3.71	5.52	5.01	5.74	5.09
		SE	0.30	0.83	0.24	0.44	0.30
	London	Mean	2.80	4.67	3.93	6.15	3.90
		SE	0.071	0.243	0.090	0.486	0.079
Number of papers by research level *(1443 papers for England, 847 papers for the NHS and 356 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	1201	569	1784	176	3730
		2	351	730	325	119	1525
		3	115	181	189	89	574
		4 (Basic)	189	149	108	143	589
	NHS	1 (Clinical)	886	420	1354	98	2758
		2	241	534	252	94	1121
		3	61	84	90	39	274
		4 (Basic)	94	89	65	63	311
	WT/NHS	1 (Clinical)	29	45	116	22	212
		2	5	65	15	11	96
		3	3	14	20	5	42
		4 (Basic)	11	12	17	23	63
	London	1 (Clinical)	389	218	755	61	1423
		2	104	294	166	59	623
		3	27	38	45	12	122
		4 (Basic)	42	51	36	36	165
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	556	573	831	277	2237
		PNP	394	484	597	213	1688
		Industry	215	211	299	134	859
		None	1099	1165	134	32	2430
		Public	1655	1738	965	309	4667
	NHS	Government	329	385	562	137	1413
		PNP	240	334	436	127	1137
		Industry	123	111	173	58	465
		None	792	897	108	24	1821
		Public	1121	1282	670	161	3234
	London	Government	150	199	309	79	737
		PNP	140	205	274	81	700
		Industry	54	56	96	25	231
		None	319	481	57	17	874
		Public	469	680	366	96	1611

For example, high-impact papers are associated with more authors, basic research and explicitly acknowledged funding.

In contrast to oncology, mental health research is far more clinical. For example, 52% (i.e. 2758/5311; Table 3.6, p. 33) of NHS mental health papers are published in clinical observation (i.e. RL=1) journals compared to 20% (i.e. 2721/13500; Table 3.5, p. 31) of oncology papers. Within the NHS clinical observation (RL=1) group there are proportionately more high-impact mental health papers (i.e. 3.5% = 98/2758 for mental health research versus 0.2% = 5/2721 for oncology research; a statistically significant difference at $p < 0.05$). Conversely, there is less high-impact basic (RL=4) research in the NHS in mental health than in oncology (i.e. 20.3% = 36/311 for mental health research versus 26.9% = 290/1077 for oncology research; a statistically significant difference at $p < 0.05$).

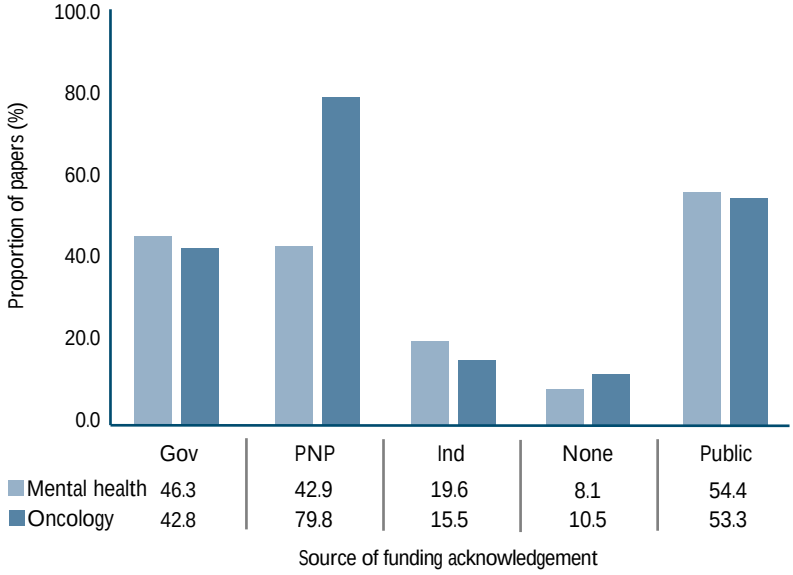
Another contrast with oncology is the funding profile. For the high-impact (W4) papers, Figure 3.10 illustrates the funding body acknowledgements for oncology and mental health research. As noted previously, oncology research is exceptional in its support from the cancer research charities. That apart, support from Government and industry is similar between the two subfields.

Summary

In this chapter we have illustrated the information that can be derived from a research outputs dataset. We have demonstrated how it is possible to analyse scientific publications using a number of different techniques. Most importantly, we have demonstrated the complexity of the data and how one needs to control for various confounding variables. In doing so, we hope we have demonstrated the use of bibliometric analysis as a source of information for supporting R&D management.

In the next chapter, we assess the potential limitations of our analysis and discuss some of the main R&D policy issues arising from the study. We also highlight some of the research questions arising from this work and explain how the project will be developed.

Fig 3.10: Proportion of high-impact (W4) NHS papers, by funding source for mental health and oncology research



Policy implications for R&D management

4

Research in the NHS is big business. Over half of all biomedical research papers published in England are supported, one way or another, by the National Health Service. Between 1990 and 1997, the NHS would have invested around £2.5 billion in research and development[m]. Somewhere between two-thirds and four-fifths of this investment has been used as the 'third leg' in a 'triple support system' to fund the indirect costs of externally sponsored non-commercial research[n]. The size of this inward investment is hard to estimate, but could be in the region of £150 m per year[o]. This would make the combined (non-commercial) expenditure on R&D in the NHS in excess of £400 m per year over the period of analysis; an expenditure equivalent to the R&D budgets of major household names such as Zeneca (£653 m), Shell (£403 m) and British Aerospace (£301 m).[24]

For these commercial organizations the return on R&D investment is measured in increased sales, profit and ultimately in share price. For non-commercial organizations such as the NHS, research councils, and medical research charities, the task of measuring payback is much harder as there is no agreed metric such as monetary value[p]. The payback model (Figures 1.1 and 1.2, p. 12) provides a framework whereby it is possible to disaggregate the research process and begin to measure different payback categories and different stages in research and development. In this study, we have comprehensively measured the return on knowledge creation. The question is whether new knowledge (as recorded in the peer-reviewed literature) has any impact on 'health gain', and if so by how much?

In this chapter we expand on this research question, by examining whether bibliometrics is an appropriate tool to assess clinical research. We then draw out three major policy issues that, we believe, arise from this study. In conclusion we describe how this project will be managed and developed over the coming years.

Using bibliometrics to assess clinical research

At the outset of this study, we were aware of the view that bibliometrics is an inappropriate tool to assess clinical research. This, in part, reflected general concerns about bibliometric analysis but also was a special plea for clinical research. As we emphasized in the introduction, we unreservedly accept that bibliometrics has

m This estimate is based on a combined Budget 1 and 2 expenditure of £410 m in 1996/7, deflated by 5% per year for the preceding eight years.

n This is the recently adopted language used in the Department of Health report, *Research and Development for a First Class Service* (reference 19).

o This is hard to estimate but 37% of Culyer projects in 1995/6 recorded some non-commercial external funding.

p Although, in theory at least, instruments such as quality-adjusted life years could be used.

limitations and that it is one part of a research evaluator's toolkit (see Box B, p. 10). Thus, the data we have presented in this report should not be used in isolation from other supporting evidence. That said, we hold the strong conviction that bibliometric analysis provides a useful, quantifiable, evidence base for R&D strategists and managers in the NHS and elsewhere.

We also have some sympathy with the argument that clinical research is a 'special case' inasmuch as the objective of clinical research is to improve healthcare and is not, necessarily, about knowledge creation (as is the case for basic research). However, in our opinion, this concern arises from the misplaced assumption that clinical researchers will be compared directly with those basic scientists publishing in highly cited journals such as *Nature* or *Science*. In this study we have controlled for this by, firstly, only evaluating research that has occurred in a clinical setting (i.e. the NHS) and, secondly, by using the research level classification developed by CHI Research Inc. (although we accept that this is a rather crude tool and one that could be refined in subsequent research).

A second issue is that high-impact research may not be best measured by citation analysis. For example, an article in, say, (the non peer-reviewed) *Nursing Times* may have a greater clinical impact than a paper published in, say, (the peer-reviewed) *Clinical Genetics*. Likewise, research that informs systematic reviews, national clinical guidelines etc. (at Stage IV Secondary Output in the payback model; Figure 1.2, p. 12) may have a greater clinical impact than a paper published in *Nature*. Previously, the Wellcome Trust has undertaken some work to 'link' funding with publications and their citation on clinical guidelines (see Box F), but this only goes some way in developing a clinically-relevant impact factor. We see this as an important area for future bibliometric research. One possible protocol would be to identify (via survey or previous research) what type of publication (whether a paper, systematic review or clinical guideline etc.) has the greatest impact on clinical practice and see by how many degrees the original research (published in the peer-reviewed literature) is 'removed' from that publication. Journals that are more likely to be cited in more clinically relevant publications (e.g. a clinical guideline) could receive a greater weight than other journals. This weight could then be scaled depending on how 'close' (in terms of generations of citations) the original research was to clinically-relevant publications. Obviously such a system would

Box F - Measuring citations on clinical guidelines

Papers cited in clinical guidelines may prove to be a useful alternative for measuring impact. A recent study investigated the use of this indicator and, among other things, concluded that:

- The median age of papers cited in clinical guidelines is eight years;
- Most papers are published by authors living in either the USA (36%) or the UK (25%); and
- Clinical guidelines do not cite basic research.

From a policy viewpoint this study raised two important issues. First was the finding that UK clinical guidelines disproportionately cite research papers in the UK – 25% of citations are from the UK, whereas only 10% of all biomedical papers are from the UK. The study finds no evidence of publication bias and therefore concluded that preferential citing of UK papers may provide good evidence for supporting a local science base. If so, then the central policy question is does a strong science base lead to improved clinical practice?

A second policy relevant finding was that clinical guidelines do not cite basic research. By tracing the research process through four preceding generations of citations, the authors conclude that it takes about 17 years for basic research to feed into clinical practice. Furthermore, the proportion of basic (i.e. RL=4) research papers increased from 0.2% to 8% over the four generations of citation, whereas around a quarter of biomedical research in the UK is basic.

need validating but, if workable, could provide a method to evaluate clinical research.

By highlighting these issues, we do not wish to undermine the importance of the findings we present in this report, but to illustrate the difficulties faced by researchers in undertaking studies such as this. Indeed, despite these limitations, we would encourage other investigators to spend some time thinking about the way research is managed. In a period when researchers are demanding that clinicians practice evidence-based medicine, it is only appropriate and correct that researchers audit and evaluate the research outputs and outcomes of their own investigations.

Policy implications and research agenda

Given the quantity of data presented in this project, it is not possible to draw out every policy implication from the study. Indeed, it is likely that there will be specific issues relevant to different subfields and for this reason we have published all the data in the Appendix. In this section we have decided to focus on three issues which we believe to have generic relevance to R&D managers in the NHS and elsewhere. They are: the characteristics of high-impact research; the role of basic research in supporting clinical advance; and the effectiveness and efficiency of partnerships.

Supporting high-impact research

The analysis we have presented confirms previous observations that high-impact (W4) research is associated with multi-authored multi-funded papers[20]. Naturally, such an observation could be confounded by other inputs (for example, the research level of a paper, the increase in funding and authorship etc.) and multivariate analysis will be the subject of future research[q]. As noted earlier, the association between multiple funding and impact is plausible. The more times that research proposals have been through a peer-review funding process, the more likely that the subsequent research is of high quality and thus published in high-impact research journals.

From a policy perspective this suggests that the NHS should continue to develop systems to ensure that all research it funds (via whatever mechanism) is quality assured through peer (or other forms of) review. This would mean that 'own account' research – those 47% of publications without a funding acknowledgement but, presumably, initiated and paid for by the NHS – should be discouraged. Indeed, following a review of the NHS R&D Levy, the NHS recently published a new framework for managing R&D (see Box G, p. 39). This document states that 'R&D in the NHS...will normally involve appropriate external peer review' (paragraph 2.17) although funds will be provided 'to recognize the costs of preparing protocols to submit for external funding [and] for pilot work' (paragraph 2.35).

These two, potentially conflicting, statements reflect a common problem in R&D policy. Whilst peer review has been shown (here and elsewhere) to be associated with high-quality research, some of the most important developments in medical research in the last 50 years have been funded from 'soft' (i.e. non-peer reviewed) sources such as 'own account' research. Anecdotal examples include[31] the introduction of *in vitro* fertilization, the identification of B-lymphocytes, and the development of radioimmunoassays. In the case of *in vitro* fertilization, requests for research funding by Steptoe were repeatedly turned down, forcing him to fund the research personally[32]. Despite this inauspicious start, in 1996 over 5000 test tube babies were born in the UK[33, 34].

Thus the issue is one of balance – on one hand the NHS, and other funders, should be supporting first class research, but on the other hand they do not want to be suppressing high-risk innovative research which could provide payback with a paradigm-changing outcome. From bibliometric evidence, we are not in a position to say what that balance should be. To inform this debate we need

q Previous multivariate analysis (reference 20) confirms that the association between impact, authorship and funding still holds, even when other factors have been controlled for.

a better understanding of what happens to research that, at the margin, is turned down by peer-review funding panels. If some of these projects were subsequently supported from NHS own account funds, it would be possible to compare the output and outcome of those 'soft-' and 'hard-' funded projects which, in terms of quality, are broadly similar inasmuch as they were on the borderline for funding.

Support for basic research in the NHS

One of the most interesting observations in this report is that one in six NHS publications are in basic science journals. Moreover, the proportion of research classified as basic increased at an average annual rate of 5% over the eight-year period of analysis (although, as already noted, there was a decline in basic research outputs in 1996 and 1997).

That said, it is worth noting that 83% (i.e. 14 302/(2907+14 302) in Table 4.1) of the basic research in the NHS is externally supported (i.e. has a funding body acknowledgement) and the vast majority of this funding is therefore outside the strategic control of NHS R&D. The new NHS Support for Science funding stream (see Box G) will continue to meet the costs of supporting R&D in the NHS and thus by implication will continue to underpin basic research in the NHS.

By raising this point we are not arguing that the NHS should not be supporting basic research, but we are suggesting that there needs to be a greater understanding of how basic research actually supports the NHS in achieving its mission. The relationship between basic research, and how it supports clinical research, has often been debated. A recent study of clinical guidelines (described in Box F, p. 36) concluded that, after four generations of citation, only 8% of research underpinning clinical guidelines (and thus a healthcare intervention) is basic (i.e. RL=4)[5]. This observation, however, is at odds with Comroe and Dripps' seminal study which concluded that 40% of all research articles judged to be essential for later clinical advance were not clinically oriented at the time of the study[35]. However, to further confuse the debate, the validity of the Comroe and Dripps' study has been questioned on the premise that the methodology is not repeatable[36]. In other words, the relationship between basic research and clinical advance is not clear, and there is an urgent need to develop our understanding in this area if R&D managers are going to be able to make informed, evidence-based, decisions on the type of research to be supported.

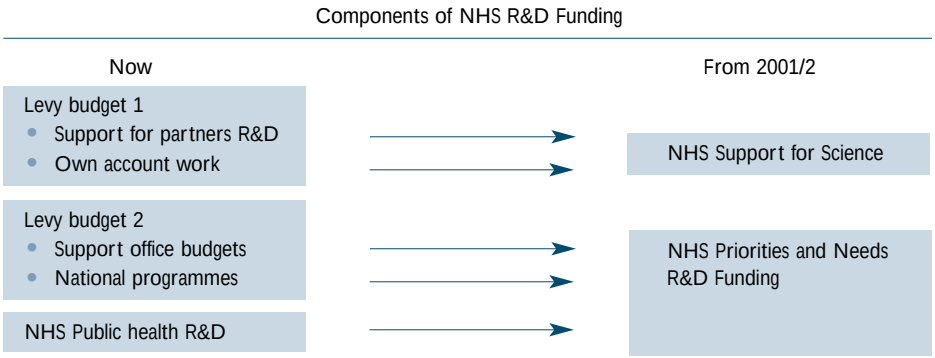
Table 4.1: Research level of unacknowledged papers

Research level	Acknowledged papers	Unacknowledged papers
Clinical observation (RL = 1)	8225	20 217
Clinical mix (RL = 2)	17 334	17 682
Clinical investigation (RL=3)	15 780	7131
Basic (RL = 4)	14 302	2907
Not classified	1602	3670
Total	57 243	51 607

Box G - Research and Development for a First Class Service

On 30 March 2000, the Parliamentary Under Secretary of State for Health announced a new statement of policy and principles and a development programme to carry through reforms of NHS R&D. These are set out in *Research and Development for a First Class Service: R&D funding in the new NHS.* This document replaces The Strategic Framework for the use of the NHS R&D Levy (1997).

From April 2001, NHS R&D funding will be organized into two funding streams: NHS Support for Science; and NHS Priorities and Needs R&D Funding. The diagram shows how the current components of NHS R&D funding will relate to the new systems.



NHS Priorities and Needs R&D Funding will support research that is needed to underpin modernization and quality improvements in the health service. It will address:

- the implementation of NHS priorities;
- the programme of National Service Framework and National Performance Assessment Framework;
- the work of the National Institute for Clinical Excellence; and
- the needs of the NHS in implementing Government policy.

NHS Support for Science will be available to NHS providers to meet costs they incur in supporting R&D in the NHS under the direction and quality assurance of an eligible R&D funding partner (such as the MRC and medical research charities) and NHS Priorities and Needs R&D Funding.

Funding will be separated into NHS Support for Science and NHS Priorities and Needs R&D Funding from 2001/2. As the new funding systems are introduced, a quality framework of research governance for NHS R&D will be developed to improve leadership and systems to deliver results and performance management. This will include arrangements for reviewing the outputs, outcomes and value for money of research.

The effectiveness and efficiency of partnership

As we have repeated many times in this report, collaborative research is associated with high-impact research publications. Collaboration and especially multiple funding requires clear and transparent lines of accountability. With such mechanisms in place, it would seem entirely appropriate that the NHS and others promote and foster collaboration – be that by bringing together individual scientists or funding agencies. However, in doing so we should make a distinction between the effectiveness and efficiency of partnerships. Effectiveness could be measured as the number of high-impact publications, whilst efficiency could be the cost per paper or citation of high-impact publications. This is perhaps best illustrated with reference to Figure 3.2 (p. 23). In this diagram the London region is obviously the most effective region –

it produces more research than any other region. However, London accounts for 70% of the NHS R&D budget and thus, in terms of (cost) efficiency (Table 4.2) it has the highest estimated cost per paper. However, this type of input:output ratio has some inherent flaws. First, is the time lag between input and output (one that is solved by comparing inputs at time *t* with outputs at time *t* plus 2–3 years). The second is the issue of attribution. For example, a publication may have a number of authors, from different NHS regions supported by different funding agencies. In this, not untypical example, how does one attribute the inputs and outputs to calculate cost-efficiency ratios? This is perhaps best illustrated with reference to Table 4.2, where the North West has a higher cost efficiency (as measured by the cost of a paper published in 1997 from the amount estimated to have been invested by the NHS in 1995) than London. Part of the reason is that the North West's NHS R&D budget is small (estimated £23.7 m in 1995) but nearly one-in-ten of its papers are indirectly supported by London through collaboration (Figure 3.5, p. 25). Conversely, London's NHS R&D budget is over ten times greater (estimated £275 m in 1995), but only one-in-fifty of its papers are co-authored with the North West. In other words, the investment from London to the North West is four times greater than in the opposite direction, making it very difficult to attribute the financial inputs to published papers. An associated problem is that because the medical schools in London have traditionally been less associated with 'broader' universities there is less chance in London than elsewhere of biomedical papers from non-NHS parts of the university being included as part of the NHS output. This may lead in some cases to the number of papers from regions outside London being somewhat inflated.

These examples illustrate the difficulties in developing meaningful cost-efficiency indicators for R&D (and we have made no attempt to include funding external to the NHS). The way public domain research in the UK is organized means that there are multiple inputs from a pluralistic funding sector which contribute to the production of knowledge through peer-reviewed publications. Given the immense complexity of the system we would caution against the use of cost-efficiency indicators. Further research on the link between input and output is clearly needed, although perfect hypothecation of one by the other will always be difficult, if only because the timescale is always out of synchrony. The extent to which the existing

Table 4.2: Illustrative example of the effectiveness and efficiency of research by NHSE region

Region	Estimated R&D (£ m) expenditure (1995)[a, b]	Research outputs (1997)	Cost (£) per paper
Northern & Yorkshire	18.6	1267	14 680
Trent	21.2	1689	12 551
West Midlands	10.9	1038	10 500
North West	22.7	1711	13 267
Eastern	7.0	942	7430
London	275.0	6145	44 751
South East	15.0	1995	7518
South West	18.7	966	19 358

[a] Prior to 1996, R&D expenditure in the NHS was not known. Following the Culyer report, during 1996 NHS Trusts were asked to declare their R&D costs for the 1995/96 financial year. This in effect established Budget 1 of the Levy (see Box C). Budget 2 was established from the returns provided by the regions and HQ giving spend on activity supporting R&D funded by the NHSE. In this example we have deflated the combined Budget 1 and 2 by 5% to estimate NHS R&D expenditure for 1995.

[b] In January 1999 the NHS regions were reorganized, thus the figures for Eastern, London and the South East are estimated based on the deflated figures for Anglia and Oxford, North Thames and South Thames.

ratios should cautiously inform current decision making, or should be regarded purely as 'work in progress', is a matter of judgement.

Future development of the NHS research outputs dataset

This research project began in February 1999 as a collaboration between the Wellcome Trust's Unit for Policy Research in Science and Medicine (PRISM) and the London Regional Office of the NHSE. As part of this project, the London Regional Office of the NHSE paid for an 'NHS fellow' (Michael Yare) to work within PRISM to benchmark NHS research outputs, using ROD data and the expertise of staff in the Unit.

In October 1999, PRISM was refocused and renamed as the Wellcome Trust's Policy Unit. As part of this process it was decided to outsource ROD. Following a competitive tendering process, City University's Department for Informatics won a contract to take over the maintenance and development of ROD. At the same time it was decided to transfer the NHS fellow to the Health Economics Research Group at Brunel University (the developers of the payback model). HERG have now taken over this project (although collaborative links will be maintained with the Wellcome Trust) and thus any suggestions for future research should be addressed to them[r].

r Professor Martin Buxton, Health Economics Research Group, Brunel University, Uxbridge UB8 3PH.

Annex: Methodology

Methodology

Research papers considered The ROD contains three types of record (limited to articles, notes and reviews with a UK address):

- papers that have been checked for funding (status A);
- papers that have not yet been checked (status C);
- papers that have been deleted, usually because they did not have a UK address (status D).

Only status A papers are used for funding-related analyses whereas for global counts all status A and C papers are counted.

Research Level A Research Level (RL) value can be determined for each journal. It is a number from clinical observation = 1 to basic research = 4 which characterizes the majority of the papers in a journal by their research type, based on expert opinion and journal-to-journal citation patterns. Values for many journals have been determined by CHI Research Inc., and this categorization system is becoming an industry standard for the classification of research journals.

Potential impact of research (W) For each paper a W value has been calculated to indicate the level of average citation impact of the journal in which it was published. For any given group of papers the W values were calculated as follows:

- First, all the journals in a group were listed in descending order of frequency of use;
- Second, a 'core set' of journals was identified, which accounted for about 85% of the total number of papers;
- Third, the core set of journals was listed in descending order of five-year impact factor, determined as the mean number of citations from 1994–98 to papers published in 1994;
- Fourth, the top 10% of these journals were assigned a weighting, W, of 4; the next 20% W=3; the next 30% W=2 and the bottom 40% W=1.

Subfield definition The first step is to identify papers with addresses containing relevant keywords (i.e. from specialist departments) which are likely to be mostly within the subfield and to derive from these a list of specialist journals. A sample of papers from all of these journals, and ones from the named departments, are then processed to list all the title words used and place them in descending order of frequency of use. These words are scanned by experts in the field and a proportion retained as being indicative of a paper relevant to that subfield. The performance of the filter is then checked by printing out sets of papers (titles and journal names) to check for their relevance to the subfield, and to provide data with which the filter may be calibrated. Two methods of calibration are used, one based on the relative numbers of papers in specialist and general journals, and another based on the relative numbers of papers retrieved and not retrieved from specialist departments. The two methods are independent and afford a check on the system. The filter calibration factor is an estimate of the number of papers actually present in a subfield compared with the number identified by the filter.

Methodological caveats

Filters It was apparent during filter development that some were much better than others, i.e. they had both better recall and better precision. These were the filters for papers associated with particular parts of the human body, e.g. gastroenterology. None of the figures in this report have been adjusted by the calibration factors but the true absolute number of biomedical publications in any given subfield may be estimated by multiplying by the calibration factor (which is available from the authors on request).

SCI/SSCI The Research Outputs Database (ROD) is based on data available within ISI's (Institute for Scientific Information) Science and Social Sciences Citation Indeces (SCI/SSCI) with the addition of further post-code checks and funding information. This leaves ROD open to the same criticisms as these indices. This is not the case for subfield filters that are developed independently of ISI (Institute for Scientific Information).

One major concern is the journal coverage of the Science Citation Index. The database has been based on the CD-ROM version of the SCI until 2000 but has expanded in more recent years to cover more journals. This creates a moving target when attempting to indicate research trends and may impact on one subfield more than another. The only way to overcome this problem is always to consider changes in output in any given subfield at the national level as a proportion of world papers. In this way any changes are standardized for the changing base and should remain relatively comparable from one country to the next.

Another problem is the 'bias' towards international journals which precludes much research of any one country that may be in local national journals in the language of origin. The SCI has a tendency to cover journals of higher renown in the English language causing biases in any international comparisons, and this tendency is even more pronounced in the SSCI. As this report concentrates on national trends of the NHS, albeit in an increasingly global climate, and research that is predominantly in the English language, these problems may be less important here but are still worth noting.

Within the UK we may talk about increases or decreases in the output of a funding sector or in a given subfield but these must be considered in relation to overall movements from year to year in UK biomedicine as a whole. The biomedical filter used to develop the ROD is country specific, i.e. it uses UK address keywords. It is not therefore fully appropriate to use for the identification of biomedical papers from other countries or from the SCI as a whole. Thus although we have shown that publications increased between 1990 and 1997, it is not clear what has happened to the true level of world biomedical publications (as defined here) in that time, although it appears to have increased steadily, by about 3% per year, based on the application of the filter to the SCI alone.

The Research Outputs Database

Paper identification The bibliographic records for inclusion in the ROD are selected from the Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI) CD-ROMs under a licence agreement with ISI in Philadelphia. These databases are not only multidisciplinary and give coverage of all the scientific areas of interest, but they also contain all the authors' names and all the addresses in a standardized format. The ROD is intended to cover all UK papers in the scientific areas of interest to the Trust and the ROD members.

In order to select relevant papers from journals other than those classed as biomedical, and in particular important multidisciplinary journals such as *Nature* and *Science*, an additional keyword filter is used to search the address field of all UK papers. These words are of two types, specific (such as GLAXO or MRC) and generic (such as the contractions CANC – cancer, or BIOCHEM – biochemistry, used by the compilers of the SCI). The biomedical filter is checked and refined prior to the start of each campaign to ensure a comprehensive search of the CD-ROMs.

Database architecture A relational data model was chosen for implementation of the database that provides data integrity and allows flexible data analysis through the mapping of relationships between parameters. The relational database management system Oracle 7 was selected, running on a Hewlett-Packard UNIX machine.

Recording funding information Once the paper data are loaded into the database, the funding details are manually noted by inspection of the original sources. Recorders (history graduates) are supplied with workbooks each listing approximately 1000 papers and a thesaurus of funding bodies with three-letter (trigraph) codes, see below. The journals covered in the workbooks may be found in several libraries, and the workbooks list the journals and their shelf references for ease of location. The libraries mainly used are:

- The Science Reference Library (SRL), part of the British Library (in two parts);
- The library of the Royal Society of Medicine (RSM);
- The library of the British Medical Association (BMA);

- The libraries of University College, London (UCL) and its constituent medical schools.

Six types of funding are recorded in the workbooks, as follows:

- Intramural support (from the addresses on the paper);
- Extramural;
- Personal (e.g. fellowship or studentship);
- Travel;
- Equipment;
- In-kind (often a gift of a pharmaceutical drug).

Funding body thesaurus The funding body thesaurus database, developed within the Wellcome Trust using MS Access, currently lists approximately 9500 different bodies funding biomedical research from many different countries, of which some 3640 are from the UK. Each is assigned a unique three-letter code in addition to its country code (two-digit ISO code) and organizational category. Currently the categories in use are as follows:

- BT Biotechnology company
- CH Charity, collecting from the public
- FO Foundation, endowed or with a single source (e.g. a company)
- GA Government agency (not controlled by ministers)
- GD Government department
- HT Hospital trustees (funds associated with a particular hospital)
- IN Industry (non-pharmaceutical)
- IP Industry (pharmaceutical)
- LA Local or regional authority
- NP Not-for-profit (including some charities not primarily supporting research)
- MI Mixed (collecting charity and endoment; mainly academic own funds)
- SN Subsidiary industrial organization (non-pharmaceutical)
- SP Subsidiary industrial organization (pharmaceutical)
- VP Veterinary practice
- XX Unidentified

New or unrecognized funding bodies found by the recorders are temporarily assigned a numerical code and the details noted in the workbooks for investigation within the Trust. Some are found to have existing codes, some are assigned new codes and some are not sources of funding and therefore ignored.

New funding bodies are investigated using available information sources to determine their country and their category, and whether they are in fact the same as an organization previously listed. Some funding bodies are acknowledged with their names in English and some in other languages; some with their full names and some with only their initials. In the past, books and other readily available directories were consulted but currently the Internet (through the use of many search engines and online databases) is proving to be an excellent source of new funding body information. It is particularly valuable for organizations identified only by their initials or acronyms. When they are found, the addresses of the relevant web pages are recorded for future reference.

Inevitably, there are many organizations with but a single paper in the ROD acknowledging their support. This creates a very long tail of funding bodies which occupies space in the thesaurus and makes it needlessly long. To simplify the problem, a system of 'generic' codes, which include numeric as well as alphabetic characters, has been adopted for the grouping of minor funding bodies in the larger countries (other than the UK). Thus 'X12' designates a US foundation and 'X4B' a Swedish biotech company.

Data entry process Once the workbooks holding the indexed acknowledgements are returned to the Trust, all queries resolved and new funding body codes assigned, the funding acknowledgements are entered into the database. This is done separately by two

different data entry clerks and procedurally cross-checked. Any inconsistencies are resolved and corrections are made.

Postcode correction and addition All UK postcodes are checked for consistency and are corrected where necessary. If a postcode is missing from a paper and no address with the correct postcode exists on other papers in the ROD, then it is determined by reference to a postcode CD-ROM compiled by the Post Office, or other references such as The Hospitals and Health Services Year Book. If the address cannot be identified precisely by postcode (e.g. UNIV-OXFORD), a 'dummy' postcode is entered. The area code (the first one or two letters) is entered if it is obvious, followed by dummy values: this allows the paper to be assigned to the correct geographical area for mapping purposes.

Quality assurance A photocopy of the address and acknowledgement sections of every 100th paper is made by the recorders. The funding bodies recorded in the workbook are checked against the photocopies within the Trust and any errors are noted and fed back to the recorders to resolve any misunderstanding or lack of clarity in the guidelines.

ROD club membership Access to detailed data in the ROD is through a club membership scheme. It is open to all organizations funding or carrying out research in the UK or Ireland. Membership is currently in four classes with annual subscriptions based on either biomedical research expenditure (for funding bodies) or external income (for research performers) in the UK and Ireland. It provides a wide variety of benefits, including:

- An annual cumulative list of papers supported or published by the funding organization;
- Attendance at or representation on the ROD Club Members' Committee to influence the development of the database;
- Invitations to seminars on research outputs;
- Complimentary copies of research reports and publications;
- Consultancy time to help with analysis and interpretation (with an initial free allowance).

Appendix: Subfield analysis

Table A1: Profile of anaesthetics research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	1511	2690	738	522	5461
		AAPG	~	~	~	~	0.31%
	NHS	N	1072	2372	479	348	4271
		AAPG	~	~	~	~	1.04%
	WT/NHS	N	29	50	43	26	148
		AAPG	~	~	~	~	11.71%
	London	N	455	831	246	182	1714
		AAPG	~	~	~	~	-3.05%
Mean (and standard error) number of authors per paper	England	Mean	2.91	3.35	4.58	4.08	3.48
		SE	0.051	0.036	0.383	0.147	0.059
	NHS	Mean	2.93	3.33	5.06	4.28	3.51
		SE	0.060	0.036	0.585	0.1875	0.073
	WT/NHS	Mean	3.79	3.84	4.23	4.42	4.05
		SE	0.221	0.181	0.347	1.445	0.151
	London	Mean	3.07	3.60	4.74	4.38	3.72
		SE	0.102	0.064	0.294	0.248	0.066
Number of papers by research level *(136 papers for England, 101 papers for the NHS and 29 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	565	1220	183	119	2087
		2	435	1167	159	90	1851
		3	222	145	311	222	900
		4 (Basic)	203	112	82	90	487
	NHS	1 (Clinical)	517	1153	171	108	1949
		2	301	1051	129	77	1558
		3	119	87	148	129	483
		4 (Basic)	74	44	29	33	180
	WT/NHS	1 (Clinical)	1	12	6	1	20
		2	7	19	4	5	35
		3	8	6	29	10	53
		4 (Basic)	13	11	4	10	38
	London	1 (Clinical)	199	404	85	45	733
		2	129	349	60	50	588
		3	61	34	78	60	233
		4 (Basic)	51	31	23	26	131
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	235	296	221	178	930
		PNP	298	358	225	179	1060
		Industry	221	505	270	151	1147
		None	925	1758	228	170	3081
		Public	1160	2054	449	348	4011
	NHS	Government	99	228	110	100	537
		PNP	164	291	142	108	705
		Industry	108	377	137	75	697
		None	772	1640	196	145	2753
		Public	871	1868	306	245	3290
	London	Government	44	97	55	45	241
		PNP	97	118	92	62	369
		Industry	42	140	79	53	314
		None	309	535	79	65	988
		Public	353	632	134	110	1229

Table A2: Profile of arthritis and rheumatism research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *(The average annual percentage growth – AAPG – is calculated for 1990–97)*	England	N	2220	2913	1130	394	6657
		AAPG	~	~	~	~	2.55%
	NHS	N	1646	2257	743	223	4869
		AAPG	~	~	~	~	0.66%
	WT/NHS	N	60	120	65	42	287
		AAPG	~	~	~	~	1.98%
	London	N	745	1096	419	154	2414
		AAPG	~	~	~	~	-2.76%
Mean (and standard error) number of authors per paper	England	Mean	3.63	4.38	5.13	5.98	4.37
		SE	0.051	0.067	0.135	0.148	0.043
	NHS	Mean	3.64	4.45	5.07	6.14	4.37
		SE	0.060	0.070	0.134	0.194	0.046
	WT/NHS	Mean	4.65	4.70	5.17	5.93	4.98
		SE	0.242	0.223	0.235	0.474	0.139
	London	Mean	4.00	4.88	5.61	6.09	4.84
		SE	0.111	0.108	0.205	0.236	0.073
Number of papers by research level *(379 papers for England, 310 papers for the NHS and 113 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	442	791	110	0	1343
		2	839	1452	295	63	2649
		3	358	504	499	248	1609
		4 (Basic)	216	153	225	83	677
	NHS	1 (Clinical)	384	658	91	0	1133
		2	644	1159	224	48	2075
		3	203	341	308	131	983
		4 (Basic)	111	93	120	44	368
	WT/NHS	1 (Clinical)	8	23	4	0	35
		2	22	51	7	7	87
		3	14	33	40	29	116
		4 (Basic)	14	13	14	6	47
	London	1 (Clinical)	160	273	36	0	469
		2	316	549	148	32	1045
		3	97	205	167	98	567
		4 (Basic)	62	66	68	24	220
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	401	739	410	223	1773
		PNP	723	1391	669	311	3094
		Industry	255	446	249	129	1079
		None	1187	1069	253	33	2542
		Public	2566	3645	1581	696	8488
	NHS	Government	251	540	248	115	1154
		PNP	455	1004	422	168	2049
		Industry	132	307	129	66	634
		None	1013	931	201	24	2169
		Public	1264	1471	449	139	3323
	London	Government	139	311	161	84	695
		PNP	240	551	249	118	1158
		Industry	61	176	79	47	363
		None	420	365	99	14	898
		Public	559	676	260	98	1593

Table A3: Profile of asthma research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	907	524	325	174	1930
		AAPG	~	~	~	~	5.91%
	NHS	N	641	349	239	125	1354
		AAPG	~	~	~	~	3.61%
	WT/NHS	N	13	24	19	18	74
		AAPG	~	~	~	~	5.56%
	London	N	271	172	113	70	626
		AAPG	~	~	~	~	0.11%
Mean (and standard error) number of authors per paper	England	Mean	3.49	4.26	5.37	5.12	4.17
		SE	0.116	0.186	0.298	0.388	0.066
	NHS	Mean	3.59	4.44	5.38	5.06	4.27
		SE	0.142	0.238	0.348	0.453	0.080
	WT/NHS	Mean	4.92	4.58	6.37	7.00	5.6
		SE	0.625	0.380	0.593	0.780	0.311
	London	Mean	3.60	4.83	5.82	5.01	4.50
		SE	0.262	0.302	0.477	0.965	0.141
Number of papers by research level *(45 papers for England, 23 papers for the NHS and 7 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	483	6	66	0	555
		2	192	187	206	127	712
		3	158	305	14	39	516
		4 (Basic)	31	26	37	8	102
	NHS	1 (Clinical)	389	6	59	0	454
		2	141	136	153	103	533
		3	75	195	3	18	291
		4 (Basic)	14	12	23	4	53
	WT/NHS	1 (Clinical)	6	0	2	0	8
		2	4	12	8	12	36
		3	2	11	2	3	18
		4 (Basic)	1	1	7	3	12
	London	1 (Clinical)	162	5	21	0	188
		2	63	53	78	61	255
		3	32	107	2	8	149
		4 (Basic)	7	7	12	1	27
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	127	115	140	75	457
		PNP	190	144	135	84	553
		Industry	281	222	127	71	701
		None	436	178	78	38	730
		Public	563	293	218	113	1187
	NHS	Government	92	82	100	46	320
		PNP	140	100	102	68	410
		Industry	146	115	77	48	386
		None	345	139	64	25	573
		Public	437	221	164	71	893
	London	Government	39	44	56	24	163
		PNP	76	58	55	39	228
		Industry	70	60	42	31	203
		None	134	62	17	15	228
		Public	173	106	73	39	391

Table A4: Profile of cardiology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	6517	5279	3688	1436	16 920
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	2.40%
	NHS	N	4978	4118	2376	1007	12 479
		AAPG	~	~	~	~	1.88%
	WT/NHS	N	123	237	226	110	696
		AAPG	~	~	~	~	5.63%
	London	N	2482	2300	1381	714	6877
		AAPG	~	~	~	~	0.39%
Mean (and standard error) number of authors per paper	England	Mean	3.61	4.37	4.60	6.88	4.38
		SE	0.052	0.059	0.085	0.344	0.071
	NHS	Mean	3.65	4.49	4.86	7.45	4.5
		SE	0.064	0.068	0.126	0.480	0.058
	WT/NHS	Mean	4.19	4.66	4.78	5.64	4.77
		SE	0.184	0.155	0.152	0.246	0.090
	London	Mean	3.80	4.83	5.20	7.59	4.87
		SE	0.642	0.115	0.208	0.532	0.170
Number of papers by research level	England	1 (Clinical)	1781	1693	718	9	4201
(960 papers for England, 609 papers for the NHS and 357 papers for London did not have a research level and were excluded from this analysis)		2	1976	1635	341	793	4745
		3	1109	1375	1878	383	4745
		4 (Basic)	708	564	746	251	2269
	NHS	1 (Clinical)	1637	1562	622	8	3829
		2	1692	1403	294	677	4066
		3	738	893	1176	236	3043
		4 (Basic)	315	251	280	86	932
	WT/NHS	1 (Clinical)	13	28	27	0	68
		2	29	43	17	32	121
		3	39	101	125	53	318
		4 (Basic)	42	65	57	25	189
	London	1 (Clinical)	734	833	346	4	1917
		2	836	785	169	505	2295
		3	355	484	677	150	1666
		4 (Basic)	209	192	186	55	642
Research funder	England	Government	1052	1086	1292	607	4037
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	1714	1952	1888	916	6470
		Industry	801	897	906	357	2961
		None	3798	2371	949	272	7390
		Public	4850	3457	2241	879	11 427
	NHS	Government	622	737	741	378	2478
		PNP	1079	1441	1135	609	4264
		Industry	475	569	462	231	1737
		None	3307	2069	772	237	6385
		Public	3929	2806	1513	615	8863
	London	Government	325	427	428	261	1441
		PNP	660	900	716	426	2702
		Industry	250	351	297	171	1069
		None	1558	1058	414	169	3199
		Public	1883	1485	842	430	4640

Table A5: Profile of clinical trials research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	1283	817	727	317	3144
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	8.75%
	NHS	N	943	691	593	262	2489
		AAPG	~	~	~	~	7.44%
	WT/NHS	N	16	21	34	14	85
		AAPG	~	~	~	~	25.58%
	London	N	360	318	292	171	1141
		AAPG	~	~	~	~	9.18%
Mean (and standard error) number of authors per paper	England	Mean	5.46	6.60	7.28	17.67	7.47
		SE	0.308	0.292	0.481	1.903	0.287
	NHS	Mean	5.79	6.69	7.34	18.23	7.78
		SE	0.407	0.335	0.558	2.380	0.346
	WT/NHS	Mean	6.25	10.86	5.91	10.64	7.98
		SE	0.727	5.410	0.579	2.495	1.420
	London	Mean	7.13	8.10	7.19	20.96	9.54
		SE	0.732	0.660	0.580	3.241	0.607
Number of papers by research level	England	1 (Clinical)	456	186	347	17	1006
(198 papers for England, 144 papers for the NHS and 48 papers for London did not have a research level and were excluded from this analysis)		2	470	443	254	266	1433
		3	154	163	112	29	458
		4 (Basic)	22	17	5	5	49
	NHS	1 (Clinical)	359	174	284	11	828
		2	345	375	216	225	1161
		3	97	135	86	22	340
		4 (Basic)	7	3	2	4	16
	WT/NHS	1 (Clinical)	3	0	21	2	26
		2	8	13	8	11	40
		3	3	5	5	0	13
		4 (Basic)	2	2	0	1	5
	London	1 (Clinical)	137	65	140	7	349
		2	131	181	119	148	579
		3	45	68	31	14	158
		4 (Basic)	2	1	2	2	7
Research funder	England	Government	282	203	279	142	906
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	267	270	307	158	1002
		Industry	393	290	200	142	1025
		None	549	250	162	35	996
		Public	831	453	441	177	1902
	NHS	Government	173	158	213	106	650
		PNP	192	237	258	130	817
		Industry	251	237	170	110	768
		None	161	95	60	23	339
		Public	334	253	273	129	989
	London	Government	56	65	100	67	288
		PNP	80	112	128	84	404
		Industry	113	133	86	76	408
		None	161	95	60	23	339
		Public	217	160	160	90	627

Table A6: Profile of diabetes research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	1236	860	808	358	3262
		AAPG	~	~	~	~	3.01%
The average annual percentage growth – AAPG – is calculated for 1990–97	NHS	N	883	609	552	250	2294
		AAPG	~	~	~	~	1.06%
	WT/NHS	N	53	86	98	78	315
		AAPG	~	~	~	~	1.58%
	London	N	361	289	238	98	986
		AAPG	~	~	~	~	-0.46%
Mean (and standard error) number of authors per paper	England	Mean	4.09	4.93	5.67	6.67	5.02
		SE	0.185	0.238	0.340	0.338	0.133
	NHS	Mean	4.29	5.15	6.32	6.73	5.31
		SE	0.251	0.315	0.490	0.414	0.181
	WT/NHS	Mean	4.51	4.51	6.29	8.01	5.93
		SE	0.331	0.184	0.385	0.719	0.240
	London	Mean	5.19	6.06	7.93	6.91	6.32
		SE	0.589	0.648	1.104	0.840	0.403
Number of papers by research level	England	1 (Clinical)	178	153	93	2	426
		2	290	211	25	60	586
(169 papers for England, 110 papers for the NHS and 34 papers for London did not have a research level and were excluded from this analysis)		3	427	337	420	197	1381
		4 (Basic)	177	157	267	99	700
	NHS	1 (Clinical)	148	126	78	2	354
		2	245	177	19	52	493
		3	308	228	327	139	1002
		4 (Basic)	76	77	125	57	335
	WT/NHS	1 (Clinical)	5	13	5	0	23
		2	17	11	3	12	43
		3	19	37	49	37	142
		4 (Basic)	10	25	41	29	105
	London	1 (Clinical)	56	66	31	2	155
		2	107	104	12	28	251
		3	135	94	164	59	452
		4 (Basic)	30	24	31	9	94
Research funder	England	Government	334	335	419	218	1306
		PNP	426	435	493	270	1624
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		Industry	231	222	210	110	773
		None	575	241	169	40	1025
		Public	909	576	588	258	2331
	NHS	Government	207	228	277	152	864
		PNP	279	293	340	187	1099
		Industry	147	142	145	77	511
		None	453	192	120	27	792
		Public	660	420	397	179	1656
	London	Government	84	99	108	51	342
		PNP	123	146	155	72	496
		Industry	66	53	59	29	207
		None	180	87	48	11	326
		Public	264	186	156	62	668

Table A7: Profile of gastroenterology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	5093	4348	3424	1360	14 225
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	0.08%
	NHS	N	3311	3098	2263	832	9504
		AAPG	~	~	~	~	-0.66%
	WT/NHS	N	115	154	165	113	447
		AAPG	~	~	~	~	-3.95%
	London	N	1524	1500	1172	556	4752
		AAPG	~	~	~	~	-2.42%
Mean (and standard error) number of authors per paper	England	Mean	3.59	4.34	4.77	6.30	4.39
		SE	0.030	0.044	0.054	0.131	0.026
	NHS	Mean	3.57	4.40	4.91	6.48	4.44
		SE	0.038	0.055	0.070	0.190	0.034
	WT/NHS	Mean	4.11	4.90	5.25	5.99	5.07
		SE	0.185	0.166	0.275	0.283	0.134
	London	Mean	3.74	4.79	5.19	6.94	4.83
		SE	0.063	0.091	0.082	0.251	0.052
Number of papers by research level	England	1 (Clinical)	1535	1205	261	12	3013
(568 papers for England, 293 papers for the NHS and 146 papers for London did not have a research level and were excluded from this analysis)		2	1445	1813	1551	800	5609
		3	1029	859	934	286	3108
		4 (Basic)	561	435	673	258	1927
	NHS	1 (Clinical)	1289	1031	218	8	2546
		2	979	1444	1261	595	4279
		3	542	456	521	145	1664
		4 (Basic)	221	156	261	84	722
	WT/NHS	1 (Clinical)	10	24	3	1	38
		2	42	73	72	73	260
		3	35	35	47	22	139
		4 (Basic)	28	22	43	17	110
	London	1 (Clinical)	560	453	107	6	1126
		2	480	734	675	426	2315
		3	247	237	279	85	848
		4 (Basic)	103	64	111	39	317
Research funder	England	Government	1174	1204	1203	650	4231
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	1075	1218	1367	716	4376
		Industry	674	733	683	307	2397
		None	2877	2021	1142	275	6315
		Public	4051	3225	2345	925	10 546
	NHS	Government	533	699	622	344	2198
		PNP	593	804	839	410	2646
		Industry	271	427	359	178	1235
		None	2239	1656	939	214	5048
		Public	2772	2355	1561	558	7246
	London	Government	214	298	309	198	1019
		PNP	326	482	481	267	1556
		Industry	100	190	167	133	590
		None	1028	780	467	158	2433
		Public	1242	1078	776	356	3452

Table A8: Profile of genetics research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	8236	4372	3377	1656	17 641
		AAPG	~	~	~	~	7.89%
The average annual percentage growth – AAPG – is calculated for 1990–97	NHS	N	4300	1980	1617	557	8454
		AAPG	~	~	~	~	8.86%
	WT/NHS	N	412	297	339	156	1204
		AAPG	~	~	~	~	18.54%
	London	N	1951	984	837	270	4042
		AAPG	~	~	~	~	6.36%
Mean (and standard error) number of authors per paper	England	Mean	4.49	5.15	6.00	6.75	5.17
		SE	0.043	0.055	0.081	0.252	0.038
	NHS	Mean	4.82	5.68	6.98	9.29	5.75
		SE	0.066	0.095	0.127	0.553	0.061
	WT/NHS	Mean	5.69	5.99	7.16	10.95	6.86
		SE	0.315	0.193	0.225	1.056	0.197
	London	Mean	5.29	5.99	7.58	8.04	6.13
		SE	0.124	0.162	0.203	0.380	0.088
Number of papers by research level	England	1 (Clinical)	585	131	8	0	724
		2	2318	495	228	131	3172
(613 papers for England, 255 papers for the NHS and 97 papers for London did not have a research level and were excluded from this analysis)		3	1652	1140	1165	65	4022
		4 (Basic)	3105	2592	1953	1460	9110
	NHS	1 (Clinical)	482	94	6	0	582
		2	1792	371	185	108	2456
		3	886	719	731	32	2368
		4 (Basic)	901	791	684	417	2793
	WT/NHS	1 (Clinical)	13	12	3	0	28
		2	167	35	24	24	250
		3	94	90	157	6	347
		4 (Basic)	133	160	154	126	573
	London	1 (Clinical)	273	63	6	0	342
		2	869	198	137	64	1268
		3	416	376	385	14	1191
		4 (Basic)	303	345	304	192	1144
Research funder	England	Government	4124	2892	2286	1211	10 513
		PNP	3583	2547	2369	1188	9687
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		Industry	918	615	464	257	2254
		None	2190	436	217	96	2939
		Public	6314	3328	2503	1307	13 452
	NHS	Government	1700	1132	996	387	4215
		PNP	1906	1240	1219	441	4806
		Industry	339	215	200	96	850
		None	1504	281	133	42	1960
		Public	3204	1413	1129	429	6175
	London	Government	731	560	517	195	2003
		PNP	964	662	645	214	2485
		Industry	141	115	104	46	406
		None	659	131	66	14	870
		Public	1390	691	583	209	2873

Table A9: Profile of gerontology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	3277	1336	983	512	6108
		AAPG	~	~	~	~	7.85%
	NHS	N	2596	1022	721	352	4691
		AAPG	~	~	~	~	8.53%
	WT/NHS	N	66	68	65	56	258
		AAPG	~	~	~	~	7.92%
	London	N	972	474	328	227	2001
		AAPG	~	~	~	~	6.74%
Mean (and standard error) number of authors per paper	England	Mean	3.33	4.55	4.58	6.82	4.11
		SE	0.079	0.150	0.154	0.687	0.084
	NHS	Mean	3.45	4.68	4.69	7.35	4.22
		SE	0.097	0.166	0.199	0.964	0.104
	WT/NHS	Mean	3.89	5.04	5.23	7.36	5.30
		SE	0.234	0.350	0.311	0.718	0.221
	London	Mean	3.91	4.98	5.27	6.40	4.68
		SE	0.243	0.296	0.384	0.352	0.157
Number of papers by research level *(650 papers for England, 417 papers for the NHS and 128 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	1602	265	4721	13	2352
		2	739	505	134	248	1626
		3	219	318	197	107	841
		4 (Basic)	152	184	163	140	639
	NHS	1 (Clinical)	1415	229	387	10	2041
		2	586	433	113	208	1340
		3	132	208	132	67	539
		4 (Basic)	93	115	81	65	354
	WT/NHS	1 (Clinical)	28	8	26	0	62
		2	18	30	4	23	75
		3	3	16	15	15	49
		4 (Basic)	14	11	19	18	62
	London	1 (Clinical)	516	105	176	4	801
		2	241	211	51	144	647
		3	60	88	55	35	238
		4 (Basic)	38	61	46	42	187
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	616	478	395	278	1767
		PNP	617	498	407	288	1810
		Industry	328	230	154	122	834
		None	2072	485	322	99	2978
		Public	2688	963	717	377	4745
	NHS	Government	443	342	266	183	1234
		PNP	441	369	292	198	1300
		Industry	225	167	92	71	555
		None	1740	400	258	77	2475
		Public	2183	742	524	260	3709
	London	Government	165	146	116	124	551
		PNP	217	191	160	137	705
		Industry	97	88	48	39	272
		None	622	184	100	45	951
		Public	787	330	216	169	1502

Table A10: Profile of haematology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	4323	3866	1802	1136	11 127
		AAPG	~	~	~	~	2.35%
The average annual percentage growth – AAPG – is calculated for 1990–97	NHS	N	3134	2931	1087	680	7832
		AAPG	~	~	~	~	1.79%
	WT/NHS	N	97	186	122	98	503
		AAPG	~	~	~	~	3.43%
	London	N	1334	1595	563	371	3863
		AAPG	~	~	~	~	0.94%
Mean (and standard error) number of authors per paper	England	Mean	3.86	4.87	5.40	7.04	4.81
		SE	0.038	0.047	0.136	0.195	0.038
	NHS	Mean	3.93	5.05	5.68	7.83	5.43
		SE	0.042	0.056	0.212	0.306	0.050
	WT/NHS	Mean	4.54	5.10	5.46	6.43	5.34
		SE	0.196	0.193	0.232	0.248	0.113
	London	Mean	4.13	5.40	6.31	8.71	4.95
		SE	0.064	0.081	0.391	0.403	0.083
Number of papers by research level	England	1 (Clinical)	663	287	172	8	1130
		2	1686	1120	269	225	3300
(403 papers for England, 286 papers for the NHS and 132 papers for London did not have a research level and were excluded from this analysis)		3	1229	2083	813	601	4726
		4 (Basic)	352	371	543	302	1568
	NHS	1 (Clinical)	600	271	149	6	1026
		2	1371	893	220	184	2668
		3	726	1604	532	384	3246
		4 (Basic)	154	162	184	106	606
	WT/NHS	1 (Clinical)	6	14	4	0	24
		2	30	39	6	10	85
		3	40	102	71	62	275
		4 (Basic)	17	31	41	26	115
	London	1 (Clinical)	232	141	76	6	455
		2	585	495	123	104	1307
		3	329	888	261	213	1691
		4 (Basic)	57	71	102	48	278
Research funder	England	Government	1100	1267	904	684	3955
		PNP	1180	1782	1068	851	4881
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		Industry	544	629	400	229	1802
		None	2152	1246	287	74	3759
		Public	3252	2513	1191	758	7714
	NHS	Government	600	839	467	367	2273
		PNP	797	1327	606	491	3221
		Industry	272	410	198	123	1003
		None	1835	1080	242	61	3218
		Public	2435	1919	709	428	5491
	London	Government	243	444	249	199	1135
		PNP	371	760	310	271	1712
		Industry	128	235	103	75	541
		None	774	571	129	37	1511
		Public	1017	1015	378	236	2646

Table A11: Profile of intensive care research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	473	849	323	210	1855
		AAPG	~	~	~	~	2.22%
	NHS	N	406	752	282	175	1615
		AAPG	~	~	~	~	2.19%
	WT/NHS	N	5	26	15	10	56
		AAPG	~	~	~	~	6.02%
	London	N	164	304	174	113	755
		AAPG	~	~	~	~	-1.19%
Mean (and standard error) number of authors per paper	England	Mean	3.01	3.66	5.93	6.37	4.23
		SE	0.062	0.092	1.020	1.880	0.215
	NHS	Mean	3.07	3.64	6.17	6.62	4.23
		SE	0.064	0.087	1.235	2.762	0.244
	WT/NHS	Mean	4.80	4.23	5.40	4.70	4.68
		SE	0.969	0.393	0.748	0.650	0.306
	London	Mean	3.09	3.96	5.34	8.39	4.79
		SE	0.101	0.121	0.567	3.770	0.372
Number of papers by research level *(72 papers for England, 53 papers for the NHS and 24 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	243	424	142	68	877
		2	117	270	92	101	580
		3	34	92	77	28	231
		4 (Basic)	9	61	12	13	95
	NHS	1 (Clinical)	235	396	130	59	820
		2	90	246	88	86	510
		3	24	77	58	21	180
		4 (Basic)	6	31	6	9	52
	WT/NHS	1 (Clinical)	2	4	2	1	9
		2	2	10	7	5	24
		3	0	3	5	2	10
		4 (Basic)	1	9	1	2	13
	London	1 (Clinical)	88	170	67	22	347
		2	40	78	61	74	253
		3	8	29	41	10	88
		4 (Basic)	5	26	5	7	43
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	57	122	83	51	313
		PNP	72	176	95	69	412
		Industry	35	107	75	25	242
		None	344	534	150	96	1124
		Public	401	656	233	147	1437
	NHS	Government	42	101	63	39	245
		PNP	49	142	83	55	329
		Industry	23	88	59	18	188
		None	318	492	142	87	1039
		Public	360	593	205	126	1284
	London	Government	12	52	40	23	127
		PNP	21	80	57	41	199
		Industry	9	32	41	15	97
		None	133	181	81	49	444
		Public	145	233	121	72	571

Table A12: Profile of neonatology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	1365	1337	577	345	3624
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	3.04%
	NHS	N	984	1009	359	224	2576
		AAPG	~	~	~	~	2.20%
	WT/NHS	N	40	79	41	50	210
		AAPG	~	~	~	~	18.71%
	London	N	504	459	221	149	1333
		AAPG	~	~	~	~	3.06%
Mean (and standard error) number of authors per paper	England	Mean	3.66	4.14	4.12	6.42	4.20
		SE	0.112	0.103	0.093	0.850	0.102
	NHS	Mean	3.75	4.19	4.17	7.29	4.30
		SE	0.146	0.120	0.103	1.287	0.136
	WT/NHS	Mean	4.03	5.47	4.32	4.74	4.80
		SE	0.285	0.342	0.299	0.341	0.175
	London	Mean	3.77	4.70	4.26	6.75	4.52
		SE	0.230	0.240	0.135	0.977	0.166
Number of papers by research level	England	1 (Clinical)	296	182	157	4	639
(211 papers for England, 88 papers for the NHS and 44 papers for London did not have a research level and were excluded from this analysis)		2	533	728	67	115	1443
		3	172	230	216	73	691
		4 (Basic)	161	191	135	153	640
	NHS	1 (Clinical)	269	162	127	4	562
		2	447	636	53	101	1237
		3	109	120	134	43	406
		4 (Basic)	74	89	44	76	283
	WT/NHS	1 (Clinical)	7	4	11	1	23
		2	9	23	6	13	51
		3	9	28	12	11	60
		4 (Basic)	15	23	12	25	75
	London	1 (Clinical)	119	79	72	4	274
		2	234	240	34	67	575
		3	58	69	85	24	236
		4 (Basic)	51	69	30	54	204
Research funder	England	Government	411	469	245	180	1305
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	503	594	299	210	1606
		Industry	116	205	128	81	530
		None	596	469	123	43	1231
		Public	1007	938	368	223	2536
	NHS	Government	252	305	130	106	793
		PNP	332	421	178	137	1068
		Industry	67	133	68	54	322
		None	499	410	97	33	1039
		Public	751	715	227	139	1832
	London	Government	115	131	68	64	378
		PNP	189	242	122	96	649
		Industry	43	60	42	40	185
		None	249	155	55	20	479
		Public	364	286	123	84	857

Table A13: Profile of neurosciences research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	8613	7244	5283	2236	23 376
		AAPG	~	~	~	~	3.64%
	NHS	N	5065	3845	2254	1132	12 296
		AAPG	~	~	~	~	3.68%
	WT/NHS	N	294	581	452	293	1620
		AAPG	~	~	~	~	11.27%
	London	N	2426	2196	1315	832	6769
		AAPG	~	~	~	~	3.09%
Mean (and standard error) number of authors per paper	England	Mean	3.30	3.82	4.05	4.86	3.80
		SE	0.023	0.034	0.045	0.098	0.018
	NHS	Mean	3.50	4.16	4.41	5.52	4.08
		SE	0.031	0.051	0.069	0.156	0.029
	WT/NHS	Mean	4.14	4.41	4.35	5.54	4.55
		SE	0.142	0.099	0.108	0.180	0.064
	London	Mean	3.74	4.45	4.65	5.71	4.42
		SE	0.049	0.079	0.096	0.202	0.045
Number of papers by research level *(2024 papers for England, 923 papers for the NHS and 462 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	1721	469	509	22	2721
		2	1967	1698	381	682	4728
		3	1049	1662	1476	294	4481
		4 (Basic)	2020	3288	2885	1229	9422
	NHS	1 (Clinical)	1479	390	436	12	2317
		2	1468	1421	310	584	3783
		3	512	784	624	134	2054
		4 (Basic)	756	1196	868	399	3219
	WT/NHS	1 (Clinical)	39	44	31	4	118
		2	72	119	26	115	332
		3	47	154	107	33	341
		4 (Basic)	130	255	287	139	811
	London	1 (Clinical)	646	217	211	5	1079
		2	678	857	222	456	2213
		3	252	415	327	75	1069
		4 (Basic)	415	689	548	294	1946
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	2707	3491	2934	1455	10 587
		PNP	2488	3094	2572	1396	9550
		Industry	1067	1475	1336	429	4307
		None	4031	1748	803	286	6868
		Public	6738	5239	3737	1741	17 455
	NHS	Government	1244	1554	1071	685	4554
		PNP	1369	1684	1109	737	4899
		Industry	479	653	480	174	1786
		None	2806	1183	505	168	4662
		Public	4050	2737	1576	853	9216
	London	Government	632	811	604	512	2559
		PNP	829	1062	741	573	3205
		Industry	222	339	267	115	943
		None	1230	677	252	105	2264
		Public	1862	1488	856	617	4823

Table A14: Profile of nursing research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	441	362	441	238	1482
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	17.18%
	NHS	N	308	287	356	197	1148
		AAPG	~	~	~	~	15.94%
	WT/NHS	N	2	3	8	5	19
		AAPG	~	~	~	~	13.18%
	London	N	280	148	160	101	689
		AAPG	~	~	~	~	12.75%
Mean (and standard error) number of authors per paper	England	Mean	2.02	3.17	4.59	4.74	2.85
		SE	0.072	0.110	0.580	0.451	0.144
	NHS	Mean	2.19	3.38	4.79	4.94	3.19
		SE	0.093	0.130	0.713	0.528	0.194
	WT/NHS	Mean	3.67	5.67	5.75	4.60	5.11
		SE	0.882	2.186	1.291	1.825	0.507
	London	Mean	2.62	3.45	4.36	5.32	3.61
		SE	0.126	0.190	0.215	0.764	0.144
Number of papers by research level	England	1 (Clinical)	197	236	234	167	834
(1388 papers for England, 777 papers for the NHS and 177 papers for London did not have a research level and were excluded from this analysis)		2	207	102	146	59	514
		3	30	19	55	11	115
		4 (Basic)	7	5	6	1	19
	NHS	1 (Clinical)	161	191	187	138	677
		2	122	78	121	50	371
		3	22	15	47	9	93
		4 (Basic)	3	3	1	0	7
	WT/NHS	1 (Clinical)	0	2	3	2	7
		2	0	0	4	3	7
		3	1	1	1	0	3
		4 (Basic)	0	0	0	0	0
	London	1 (Clinical)	64	83	78	61	286
		2	40	36	56	35	167
		3	10	10	24	3	47
		4 (Basic)	0	0	0	0	0
Research funder	England	Government	213	113	123	99	548
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	186	59	102	89	436
		Industry	40	29	56	41	166
		None	1346	289	226	96	1957
		Public	1559	402	349	195	2505
	NHS	Government	173	88	91	77	429
		PNP	110	41	85	76	312
		Industry	26	21	37	29	113
		None	769	212	189	81	401
		Public	942	300	280	158	830
	London	Government	46	36	38	36	156
		PNP	44	20	39	45	148
		Industry	12	10	20	18	60
		None	196	92	80	33	401
		Public	242	128	118	69	557

Table A15: Profile of obstetrics and gynaecology research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	3867	3674	1962	1048	10 551
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	3.10%
	NHS	N	2769	2663	1439	635	7506
		AAPG	~	~	~	~	3.08%
	WT/NHS	N	81	164	94	74	413
		AAPG	~	~	~	~	9.31%
	London	N	1176	1280	791	337	3584
		AAPG	~	~	~	~	2.73%
Mean (and standard error) number of authors per paper	England	Mean	3.53	3.97	4.61	6.46	4.19
		SE	0.065	0.038	0.084	0.430	0.054
	NHS	Mean	3.62	4.11	4.80	6.94	4.31
		SE	0.085	0.041	0.106	0.642	0.069
	WT/NHS	Mean	3.93	4.11	4.37	5.86	4.45
		SE	0.210	0.142	0.213	0.398	0.115
	London	Mean	3.82	4.25	5.09	7.54	4.62
		SE	0.067	0.060	0.178	1.069	0.114
Number of papers by research level	England	1 (Clinical)	1208	253	435	14	1910
(407 papers for England, 245 papers for the NHS and 105 papers for London did not have a research level and were excluded from this analysis)		2	1407	2020	862	247	4536
		3	539	1011	417	446	2413
		4 (Basic)	324	385	244	332	1285
	NHS	1 (Clinical)	1056	216	365	12	1649
		2	1037	1776	731	201	3745
		3	292	540	234	300	1366
		4 (Basic)	148	128	108	117	501
	WT/NHS	1 (Clinical)	15	6	15	3	39
		2	32	55	22	16	125
		3	12	79	36	36	163
		4 (Basic)	18	24	21	19	82
	London	1 (Clinical)	464	114	202	9	789
		2	405	840	409	124	1778
		3	138	250	119	134	641
		4 (Basic)	65	76	61	69	271
Research funder	England	Government	1002	1235	733	553	3523
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	1059	1359	942	645	4005
		Industry	394	463	307	204	1368
		None	2030	1470	577	168	4245
		Public	3032	2705	1310	721	7768
	NHS	Government	204	271	216	134	825
		PNP	709	963	666	382	2720
		Industry	215	279	202	116	812
		None	1674	1254	495	129	3552
		Public	1878	1525	711	263	4377
	London	Government	204	271	216	134	825
		PNP	355	505	368	200	1428
		Industry	108	135	117	64	424
		None	667	576	284	76	1603
		Public	871	847	500	210	2428

Table A16: Profile of paediatrics research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	6032	6096	2879	1091	16 098
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	4.71%
	NHS	N	4359	4724	1953	688	11 724
		AAPG	~	~	~	~	3.42%
	WT/NHS	N	94	286	239	135	754
		AAPG	~	~	~	~	19.05%
	London	N	1820	2026	995	405	5246
		AAPG	~	~	~	~	2.01%
Mean (and standard error) number of authors per paper	England	Mean	3.37	4.31	5.26	8.05	4.40
		SE	0.036	0.050	0.086	0.204	0.033
	NHS	Mean	3.48	4.33	5.45	7.99	4.43
		SE	0.043	0.052	0.095	0.222	0.035
	WT/NHS	Mean	4.62	6.17	6.12	8.43	6.37
		SE	0.247	0.433	0.244	0.517	0.209
	London	Mean	3.74	4.81	5.87	7.87	4.90
		SE	0.085	0.101	0.147	0.254	0.062
Number of papers by research level	England	1 (Clinical)	1697	937	827	4	3465
(1470 papers for England, 727 papers for the NHS and 291 papers for London did not have a research level and were excluded from this analysis)		2	2271	3671	686	377	7005
		3	513	946	706	398	2563
		4 (Basic)	249	417	618	311	1595
	NHS	1 (Clinical)	1462	776	584	2	2824
		2	1788	3079	541	302	5710
		3	320	619	502	242	1683
		4 (Basic)	119	203	316	142	780
	WT/NHS	1 (Clinical)	14	23	29	0	66
		2	40	157	58	53	308
		3	11	58	63	44	176
		4 (Basic)	24	46	88	38	196
	London	1 (Clinical)	522	361	257	1	1141
		2	813	1213	284	189	2499
		3	152	323	270	139	884
		4 (Basic)	65	111	179	76	431
Research funder	England	Government	1274	1799	1325	730	5128
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	1373	2299	1534	817	6023
		Industry	340	738	374	207	1659
		None	3727	2646	732	96	7201
		Public	5001	4445	2057	826	12 329
	NHS	Government	731	1170	798	421	3120
		PNP	914	1680	1010	500	4104
		Industry	206	504	246	124	1080
		None	2915	2289	577	78	5859
		Public	3646	3459	1375	499	8979
	London	Government	297	483	373	238	1391
		PNP	484	821	531	301	2137
		Industry	111	246	136	78	571
		None	1145	899	305	47	2396
		Public	1442	1382	678	285	3787

Table A17: Profile of primary healthcare research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	5209	4005	2770	721	12 705
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	6.66%
	NHS	N	4040	3327	2245	573	10 185
		AAPG	~	~	~	~	5.78%
	WT/NHS	N	62	140	118	62	382
		AAPG	~	~	~	~	6.80%
	London	N	1655	1613	1153	381	4802
		AAPG	~	~	~	~	4.28%
Mean (and standard error) number of authors per paper	England	Mean	3.52	4.62	5.12	7.92	4.49
		SE	0.070	0.080	0.138	0.466	0.056
	NHS	Mean	3.68	4.63	5.27	8.20	4.62
		SE	0.087	0.086	0.161	0.577	0.067
	WT/NHS	Mean	4.95	5.21	5.76	7.10	5.64
		SE	0.314	0.200	0.249	0.358	0.136
	London	Mean	4.03	5.20	5.72	8.73	5.23
		SE	0.130	0.165	0.197	0.797	0.109
Number of papers by research level	England	1 (Clinical)	1900	1501	1254	14	4669
(1441 papers for England, 956 papers for the NHS and 366 papers for London did not have a research level and were excluded from this analysis)		2	1320	1704	780	423	4227
		3	525	595	589	219	1928
		4 (Basic)	97	159	120	64	440
	NHS	1 (Clinical)	1587	1245	1012	9	3853
		2	1050	1477	662	349	3538
		3	429	491	478	173	1571
		4 (Basic)	66	87	73	41	267
	WT/NHS	1 (Clinical)	18	34	38	1	91
		2	21	57	33	23	134
		3	11	37	29	25	102
		4 (Basic)	4	11	18	13	46
	London	1 (Clinical)	619	569	465	8	1661
		2	437	721	364	258	1780
		3	211	269	279	93	852
		4 (Basic)	38	43	40	22	143
Research funder	England	Government	925	1097	914	344	3280
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	887	1360	1008	449	3704
		Industry	495	626	407	182	1710
		None	3305	1672	1041	110	6128
		Public	4230	2769	1955	454	9408
	NHS	Government	689	891	744	258	2582
		PNP	650	1103	803	342	2898
		Industry	340	474	305	134	1253
		None	2639	1449	876	95	5059
		Public	3328	2340	1620	353	7641
	London	Government	274	426	401	169	1270
		PNP	325	573	440	219	1557
		Industry	145	230	165	87	627
		None	1045	674	412	68	2199
		Public	1319	1100	813	237	3469

Table A18: Profile of public healthcare research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	1194	995	636	257	3082
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	10.89%
	NHS	N	802	617	458	145	2022
		AAPG	~	~	~	~	8.63%
	WT/NHS	N	16	28	26	20	90
		AAPG	~	~	~	~	14.13%
	London	N	285	242	207	81	815
		AAPG	~	~	~	~	8.76%
Mean (and standard error) number of authors per paper	England	Mean	3.25	3.91	4.84	9.74	4.35
		SE	0.076	0.120	0.195	1.284	0.129
	NHS	Mean	3.22	4.03	5.05	8.81	4.29
		SE	0.064	0.108	0.243	1.824	0.152
	WT/NHS	Mean	5.00	4.82	5.27	6.80	5.42
		SE	0.492	0.468	0.456	0.823	0.289
	London	Mean	3.39	4.24	5.38	6.85	4.51
		SE	0.130	0.183	0.309	0.589	0.127
Number of papers by research level	England	1 (Clinical)	355	630	324	4	1313
(561 papers for England, 371 papers for the NHS and 95 papers for London did not have a research level and were excluded from this analysis)		2	203	190	193	200	786
		3	50	162	103	42	357
		4 (Basic)	40	5	13	7	65
	NHS	1 (Clinical)	263	410	242	2	917
		2	134	145	144	109	532
		3	25	58	66	24	173
		4 (Basic)	16	2	4	7	29
	WT/NHS	1 (Clinical)	4	21	19	1	45
		2	6	7	2	14	29
		3	0	0	4	1	5
		4 (Basic)	3	0	1	4	8
	London	1 (Clinical)	127	155	110	2	384
		2	49	63	62	63	237
		3	13	24	33	12	82
		4 (Basic)	4	0	2	1	7
Research funder	England	Government	425	510	294	167	1396
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		PNP	232	287	287	159	965
		Industry	81	83	80	47	291
		None	601	318	177	30	1126
		Public	1026	828	471	197	2522
	NHS	Government	301	334	212	90	937
		PNP	139	193	214	86	632
		Industry	51	47	63	23	184
		None	391	180	116	16	703
		Public	692	514	328	106	1640
	London	Government	88	114	97	48	347
		PNP	67	85	101	45	298
		Industry	17	17	41	13	88
		None	148	87	49	12	296
		Public	236	201	146	60	643

Table A19: Profile of rehabilitation research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	1641	1223	827	277	3968
		AAPG	~	~	~	~	8.82%
	NHS	N	946	772	547	186	2451
		AAPG	~	~	~	~	7.64%
	WT/NHS	N	6	31	48	41	126
		AAPG	~	~	~	~	18.20%
	London	N	306	270	244	115	935
		AAPG	~	~	~	~	1.69%
Mean (and standard error) number of authors per paper	England	Mean	2.49	3.44	3.72	5.62	3.29
		SE	0.041	0.065	0.086	0.429	0.046
	NHS	Mean	2.74	3.68	3.91	6.35	3.60
		SE	0.060	0.088	0.117	0.614	0.068
	WT/NHS	Mean	5.67	4.00	5.06	7.24	5.54
		SE	1.054	0.325	0.320	0.704	0.296
	London	Mean	2.95	3.90	4.05	6.45	3.98
		SE	0.138	0.132	0.131	0.957	0.142
Number of papers by research level *(1291 papers for England, 602 papers for the NHS and 178 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	286	264	285	5	840
		2	305	401	176	117	999
		3	50	255	143	54	502
		4 (Basic)	27	121	165	95	408
	NHS	1 (Clinical)	234	203	229	3	669
		2	197	299	146	99	741
		3	31	133	72	35	271
		4 (Basic)	11	39	71	47	168
	WT/NHS	1 (Clinical)	2	4	17	0	23
		2	1	6	10	13	30
		3	0	11	9	7	27
		4 (Basic)	2	7	11	21	41
	London	1 (Clinical)	92	62	98	3	255
		2	57	106	69	66	298
		3	15	53	28	18	114
		4 (Basic)	4	17	42	27	90
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	326	418	353	154	1251
		PNP	232	342	298	156	1028
		Industry	65	124	76	44	309
		None	1120	528	287	55	1990
		Public	1446	946	640	209	3241
	NHS	Government	164	222	191	95	672
		PNP	122	225	196	113	656
		Industry	34	70	42	28	174
		None	678	367	225	39	1309
		Public	842	589	416	134	1981
	London	Government	45	63	76	52	236
		PNP	46	95	111	70	322
		Industry	11	26	22	14	73
		None	223	127	92	25	467
		Public	268	190	168	77	703

Table A20: Profile of respiratory medicine research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	3590	3075	1444	1106	9215
The average annual percentage growth – AAPG – is calculated for 1990–97		AAPG	~	~	~	~	1.94%
	NHS	N	2633	2408	933	753	6727
		AAPG	~	~	~	~	1.60%
	WT/NHS	N	81	116	89	94	380
		AAPG	~	~	~	~	9.04%
	London	N	1195	1136	463	460	3254
		AAPG	~	~	~	~	0.55%
Mean (and standard error) number of authors per paper	England	Mean	3.56	4.14	4.72	5.69	4.20
		SE	0.042	0.049	0.099	0.131	0.033
	NHS	Mean	3.52	4.24	4.78	5.81	4.49
		SE	0.043	0.058	0.121	0.161	0.044
	WT/NHS	Mean	4.69	5.02	5.06	5.88	5.17
		SE	0.253	0.260	0.250	0.350	0.143
	London	Mean	3.53	4.63	5.18	5.84	4.49
		SE	0.064	0.104	0.221	0.227	0.064
Number of papers by research level	England	1 (Clinical)	1299	1284	197	8	2788
(326 papers for England, 172 papers for the NHS and 81 papers for London did not have a research level and were excluded from this analysis)		2	1124	605	617	642	2988
		3	511	947	398	195	2051
		4 (Basic)	339	236	228	259	1062
	NHS	1 (Clinical)	1155	1126	170	6	2457
		2	891	487	471	487	2336
		3	255	671	190	105	1221
		4 (Basic)	165	123	99	154	541
	WT/NHS	1 (Clinical)	11	24	6	0	41
		2	24	22	34	36	116
		3	14	50	24	15	103
		4 (Basic)	32	20	25	43	120
	London	1 (Clinical)	522	511	93	3	1129
		2	410	197	224	310	1141
		3	94	355	99	59	607
		4 (Basic)	90	73	46	87	296
Research Funder	England	Government	820	735	619	527	2701
(The public category is the sum of government and none. The figures can add up to more than 100% because of multiple funding)		PNP	943	942	572	600	3057
		Industry	511	584	356	309	1760
		None	1899	1437	392	210	3938
		Public	2719	2172	1011	737	6639
	NHS	Government	436	514	360	330	1640
		PNP	607	698	363	418	2086
		Industry	263	366	184	191	1004
		None	1652	1264	316	158	3390
		Public	2088	1778	676	488	5030
	London	Government	203	272	176	190	841
		PNP	304	402	195	253	1154
		Industry	128	186	100	129	543
		None	735	535	146	101	1517
		Public	938	807	322	291	2358

Table A21: Profile of stroke research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications *The average annual percentage growth – AAPG – is calculated for 1990–97*	England	N	390	266	192	221	1069
		AAPG	~	~	~	~	9.71%
	NHS	N	335	221	154	168	878
		AAPG	~	~	~	~	9.37%
	WT/NHS	N	4	9	11	17	41
		AAPG	~	~	~	~	3.74%
	London	N	123	97	51	86	357
		AAPG	~	~	~	~	7.93%
Mean (and standard error) number of authors per paper	England	Mean	3.45	3.82	4.84	6.79	4.51
		SE	0.095	0.123	0.673	1.285	0.301
	NHS	Mean	3.48	3.90	4.95	7.14	4.73
		SE	0.104	0.138	0.811	1.671	0.260
	WT/NHS	Mean	4.25	3.89	4.18	5.65	4.73
		SE	1.377	0.611	0.585	0.606	0.359
	London	Mean	3.92	3.98	6.51	5.57	4.57
		SE	0.219	0.190	2.404	0.777	0.565
Number of papers by research level *(66 papers for England, 48 papers for the NHS and 18 papers for London did not have a research level and were excluded from this analysis)*	England	1 (Clinical)	221	82	67	130	500
		2	85	114	70	42	311
		3	13	43	34	19	109
		4 (Basic)	12	23	18	30	83
	NHS	1 (Clinical)	205	77	62	108	452
		2	79	104	67	37	287
		3	5	25	15	9	54
		4 (Basic)	4	12	7	14	37
	WT/NHS	1 (Clinical)	2	4	6	4	16
		2	2	3	2	5	12
		3	0	0	0	3	3
		4 (Basic)	0	2	3	5	10
	London	1 (Clinical)	63	36	22	57	178
		2	37	47	19	17	120
		3	3	8	6	3	20
		4 (Basic)	3	6	3	9	21
Research funder *(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)*	England	Government	52	47	55	84	238
		PNP	67	78	72	114	331
		Industry	22	36	30	49	137
		None	280	141	86	52	559
		Public	332	188	141	136	797
	NHS	Government	38	39	43	66	186
		PNP	48	57	60	95	260
		Industry	16	22	15	22	75
		None	256	134	77	43	510
		Public	294	173	120	109	696
	London	Government	16	17	13	33	79
		PNP	25	27	22	50	124
		Industry	10	5	6	13	34
		None	87	62	26	20	195
		Public	103	79	39	53	274

Table A22: Profile of surgery research

			JOURNAL IMPACT				
			W1 (LOW)	W2	W3	W4 (HIGH)	Total
Number of publications	England	N	7830	3745	4016	2038	17 629
		AAPG	~	~	~	~	1.25%
The average annual percentage growth – AAPG – is calculated for 1990–97	NHS	N	6941	3233	3546	1591	15 311
		AAPG	~	~	~	~	0.63%
	WT/NHS	N	50	92	138	133	413
		AAPG	~	~	~	~	9.53%
	London	N	2669	1413	1603	810	6495
		AAPG	~	~	~	~	-1.01%
Mean (and standard error) number of authors per paper	England	Mean	3.40	4.32	4.75	6.42	4.30
		SE	0.025	0.088	0.60	0.246	0.040
	NHS	Mean	3.42	4.32	4.77	6.57	4.30
		SE	0.026	0.098	0.065	0.311	0.045
	WT/NHS	Mean	4.60	6.11	5.30	7.41	6.08
		SE	0.216	1.252	0.170	0.536	0.336
	London	Mean	3.59	4.62	4.98	7.62	4.72
		SE	0.049	0.118	0.109	0.594	0.089
Number of papers by research level	England	1 (Clinical)	4046	1379	2031	380	7836
		2	1586	1366	843	703	4498
(1393 papers for England, 1240 papers for the NHS and 430 papers for London did not have a research level and were excluded from this analysis)		3	789	620	897	522	2828
		4 (Basic)	160	246	236	432	1074
	NHS	1 (Clinical)	3768	1255	1929	351	7303
		2	1303	1227	771	619	3920
		3	654	476	699	411	2240
		4 (Basic)	98	160	140	210	608
	WT/NHS	1 (Clinical)	7	20	26	8	61
		2	13	24	34	23	94
		3	24	32	59	45	160
		4 (Basic)	6	16	19	57	98
	London	1 (Clinical)	1463	535	818	155	2971
		2	524	529	373	362	1788
		3	240	227	318	167	952
		4 (Basic)	47	89	92	126	354
Research funder	England	Government	728	642	818	741	2929
		PNP	1055	975	1238	1121	4389
(The public category is the sum of Government and none. The figures can add up to more than 100% because of multiple funding)		Industry	405	346	429	303	1483
		None	6044	2244	2205	628	11 121
		Public	6772	2886	3023	1369	14 050
	NHS	Government	555	458	640	480	2133
		PNP	786	737	981	807	3311
		Industry	309	262	348	215	1134
		None	5593	2087	2090	572	10 342
		Public	6148	2545	2730	1052	12 475
	London	Government	213	216	272	238	939
		PNP	362	409	513	434	1718
		Industry	142	132	165	121	560
		None	2089	827	886	272	4074
		Public	2302	1043	1158	510	5013

References

1 Office of Science and Technology (1999) *The Forward Look 1999*. The Stationery Office.

2 Office of Science and Technology (1999) *Science, Engineering and Technology Statistics 1999*. The Stationery Office.

3 Funding First (2000) *Exceptional Returns: The Economic Value of America's Investment in Medical Research*. (www.fundingfirst.org).

4 Grant J (1999) 'Evaluating the outcomes of bio medical research on healthcare', *Research Evaluation*, 8: 33–38.

5 Grant J, Cottrell R, Cluzeau F and Fawcett G (2000) 'Evaluating the "payback" on biomedical research from papers cited in clinical guidelines: applied bibliometric study', *BMJ*, 320: 1107–1111.

6 National Science Board (1996) *Science and Engineering Indicators – 1996*. Washington DC, US Government Printing Office.

7 See www.hefce.ac.uk

8 Seglen P O (1997) 'Why the impact factor of journals should not be used for evaluating research', *BMJ*, 314: 497.

9 Martin B (1996) 'The use of multiple indicators in the assessment of basic research', *Scientometrics*, 36: 343–362.

10 Committee on Science, Engineering and Public Policy (1999) *Evaluating Federal Research Programs Research and Government Performance and Results Act*. National Academy Press, Washington DC.

11 Buxton M and Hanney S (1996) 'How can pay back from health services research be assessed?' *Journal of Health Services Research and Policy*, 1: 35–43.

12 Buxton M and Hanney S (1997) *Assessing pay back from Department of Health Research and Development*. Second Report. Main report. Brunel University HERG, Research Report No. 25, Vol 1.

13 Buxton M, Hanney S, Packwood T, Roberts S and Youll P (1999) *Assessing the benefits from North Thames Research and Development*. Brunel University HERG, Research Report No.5.

14 NHSE (1997) *Strategic Framework for the use of the NHS R&D Levy*. NHSE, January 1997.

15 Dawson G, Lucocq B, Cottrell R and Lewison G (1998) *Mapping the landscape: National biomedical research outputs 1988–95*. The Wellcome Trust, London.

16 *Economist* (2000) 'The Health Effect', 3 June 2000.

17 Department of Health (1991) *Research for Health*. Department of Health, September 1991.

18 HMSO (1994) *Supporting Research and Development in the NHS (Culyer Report)*. HMSO, September, 1994.

19 Department of Health (2000) *Research and Development for a First Class Service*. Department of Health, March 2000.

20 Lewison G and Dawson G (1998) 'The effect of funding on the outputs of biomedical research', *Scientometrics*, 41: 17–27.

21 Narin F, Pinski G and Gee H H (1976) 'Structure of the Biomedical Literature', *Journal of the American Society for Information Science*, Jan–Feb: 25–45.

22 Lewison G (1998) 'New bibliometric techniques for the evaluation of medical schools', *Scientometrics*, 41: 5–16.

23 Lewison G (1996) 'The definition of biomedical research subfields with title keywords and application to the analysis of research outputs', *Research Evaluation*, 6: 25–36.

24 Black N and Davies S (1999) 'Where do UK health services researchers publish their findings?' *Journal of the Royal Society of Medicine*, 92: 129–131.

25 Grant J and Lewison G (1999) 'Where is UK health services research published?', (letter) *Journal of the Royal Society of Medicine*, 92: 35.

26 Lewison G, Dawson G and Anderson J (1995) 'The behaviour of biomedical authors in acknowl edging their funding sources', *Proceedings of the Fifth International Conference of the International Society for Scientometrics and Informetrics*, 255–264. Learned Information Inc., Medford NJ.

27 See www.doh.gov.uk/research/documents/listof publications.htm

28 Organization Codes Service Handbook v2.2, Department of Health, London, March 1999.

29 See www.wellcome.ac.uk

30 DTI (1999) *The UK R&D Scoreboard, 1998*. Department of Trade and Industry, London.

31 Horrobin D F (1990) 'The philosophical basis of peer review and the suppression of innovation', *JAMA*, 2623: 1438–1441.

32 Steptoe P (1985) 'Historical aspects of the ethics of *in vitro* fertilization', *Annals of the New York Academy of Sciences*, 442: 573–576.

33 Human Fertilization and Embryology Authority (1998) *Seventh Annual Report and Accounts*. HEFA London.

34 Grant J and Allen E (1999) 'Evaluating high risk research: an assessment of the Wellcome Trust's Sir Henry Wellcome Commemorative Awards for Innovative Research', *Research Evaluation*, 8: 201–204.

35 Comroe J and Dripps R (1976) 'Scientific basis for the support of biomedical science', *Science*, 192: 105–111.

36 Mason B and Grant J (2000) *Factors that lead to advances in neonatal intensive care – Comroe and Dripps revisited*. Proceedings of S&T 2000, Leiden, May 24–27.

37 Grant J and Lewison G (1997) 'Government funding of Research and Development', *Science*, 278: 878–880.

ISBN 1 84129 035 1

Design and production: The Wellcome Trust Publishing Department
First published 2001.

The Wellcome Trust is a registered charity, no. 210183
Trustee: The Wellcome Trust Limited
Registered in England, no. 2711000
Registered office: 183 Euston Road, London NW1 2BE

TR16-2212/1500/03/-2001/MC

Putting NHS Research on the Map
April 2001

All correspondence:

Jonathan Grant
Policy Unit
The Wellcome Trust
210 Euston Road
London NW1 2BE, UK
Tel: +44 (0)20 7611 8448
Fax: +44 (0)20 7611 8742
E-mail: j.grant@wellcome.ac.uk

Further copies of this report are available from:

The Marketing Department
The Wellcome Trust
183 Euston Road
London NW1 2BE, UK
Tel: +44 (0)20 7611 8651
Fax: +44 (0)20 7611 8416
E-mail: marketing@wellcome.ac.uk
Web: www.wellcome.ac.uk