EPSRC

Engineering and Physical Sciences Research Council

EPSRC Portfolio Day

Cardiovascular Disease

The Guoman Cumberland Hotel, London

24 February 2010

Findings and Observations of the Independent Panel

Contents

Chair's Introduction

This EPSRC Portfolio Day, devoted to Cardiovascular Disease, brought together 53 researchers from the United Kingdom, 12 staff from the EPSRC and an independent invited panel. The aim was to inform the EPSRC of research currently taking place in this area, within and outside the EPSRC current portfolio, to identify future opportunities and to facilitate networking between attendees.

Cardiovascular disease is a broad topic, and the focus of this meeting was on contributions in the Engineering and Physical Sciences (EPS) that fall under the EPSRC remit, which range from medical devices, imaging, modelling to drug discovery and nanotechnology. Attendees were also asked to consider, if appropriate, whether there were natural cross-funding agency opportunities that the EPSRC might investigate and training needs specific to this research area.

Rather than split up attendees into their respective sub disciplines, attendees were divided into five groups, each convened by a member of the invited panel.

Each group conducted firstly an analysis of research area strengths and then research area weaknesses. Issues related to translation of basic research to the clinic as well as technology transfer was then considered, and finally training/skills needs in the field. Following each of the four group discussion sessions, the Convenor of each group presented their findings to a plenary session where the Chair invited comments from all participants. This report summarises the findings of the meeting and provides data and opinion to inform the wider research community, funders and Government. As on the day, each of the four topics is dealt with separately. This has been done to maximise its value as a source of information, further enhanced by the provision of appendices. The report concludes with one element of synthesis – the key messages of the day.

I think all will agree that the day was interesting in a number of respects. It is the first time this particular UK community has met, and this in itself I know a number of attendees found useful. It also showed what a diverse range of exciting research is currently going on in the UK, be it currently there is a relatively small community working in this area.

I would like to close this introduction by thanking all who participated in the Cardiovascular Disease Day in London – the researchers for their active participation in the sessions, the EPSRC staff for efficiently running the meeting and supporting the Panel, and the other panel members for their effective convening and contributions to writing this report: Professor Rhodri Williams, Professor David Newby, Professor Peter Weinberg and Professor Andrew Lewis. It was a very interesting and productive day which is hopefully reflected by the insight provided by this report.

Professor Alison Noble FREng

Chair

1. Introduction

On the 24 February 2010, the Engineering and Physical Sciences Research Council (EPSRC) held a Portfolio Day in London to look at research related to the area of Cardiovascular Disease. The attendees on the day were selected by submitting Expressions of Interest to attend the event.

A list of attendees is shown in Appendix 1.

This report gives details of the Portfolio Day and the panel observations (Sections 1-3). Section 4 presents the key findings of the day and the panel's recommendations to the community, research funders and the EPSRC.

1.1 Portfolio Day Objectives

The objectives for the Portfolio Day were:

- To bring together research communities in the area of cardiovascular disease to allow networking opportunities and to promote dialogue and a constructive relationship with the Engineering and Physical Sciences Research Council (EPSRC).
- To gather and exchange views, on the health of the discipline in the UK.
- To explore upcoming opportunities for the research area and to learn of the key issues affecting the community.
- To provide baseline information, and achieve a consistent view of the research landscape, in order to inform portfolio management and future opportunities for the community and EPSRC.

1.2 Independent Review Panel

The Panel assembled for the Portfolio Day comprised the following:

Chair:

Professor Alison Noble – University of Oxford

Members:

Professor Rhodri Williams – Swansea University

Professor David Newby – University of Edinburgh

Professor Peter Weinberg – Imperial College London

Professor Andrew Lewis – Biocompatibles Ltd.

1.3 Agenda

A copy of the agenda is shown in Appendix 2.

The day started with EPSRC introducing programmes within EPSRC that provided funding relevant to this day. The Chair, Alison Noble, highlighted her and the panel's expectations for the day.

The attendees were split into five groups as indicated in Appendix 3. The five groups, and the panel member leading each group, were as follows:

- **EPSRC Group 1 – Professor Alison Noble (Chair)**
- **EPSRC Group 2 – Professor Andrew Lewis**
- **EPSRC Group 3 – Professor David Newby**
- **EPSRC Group 4 – Professor Peter Weinberg**
- **EPSRC Group 5 – Professor Rhodri Williams**

Each of the five groups was led by a member of the panel and the groups discussed strengths, weaknesses, gaps and opportunities in the morning session before feeding in the plenary session their top 5 discussion points from each of their areas. The summaries of findings are described in Section 2.

In the afternoon breakout sessions (in the same groups) there was a discussion of translation and training issues related to their research areas. The findings from these discussions are presented for each of the groups in Section 3.

The key messages from all discussions are highlighted in Section 4 with the panel's conclusions following in Section 5.

1.4 Panel Information

The Panel used the day's discussions, and the following data sources to prepare their session reports:

Appendix 4: Data on the EPSRC Portfolio relevant to this area

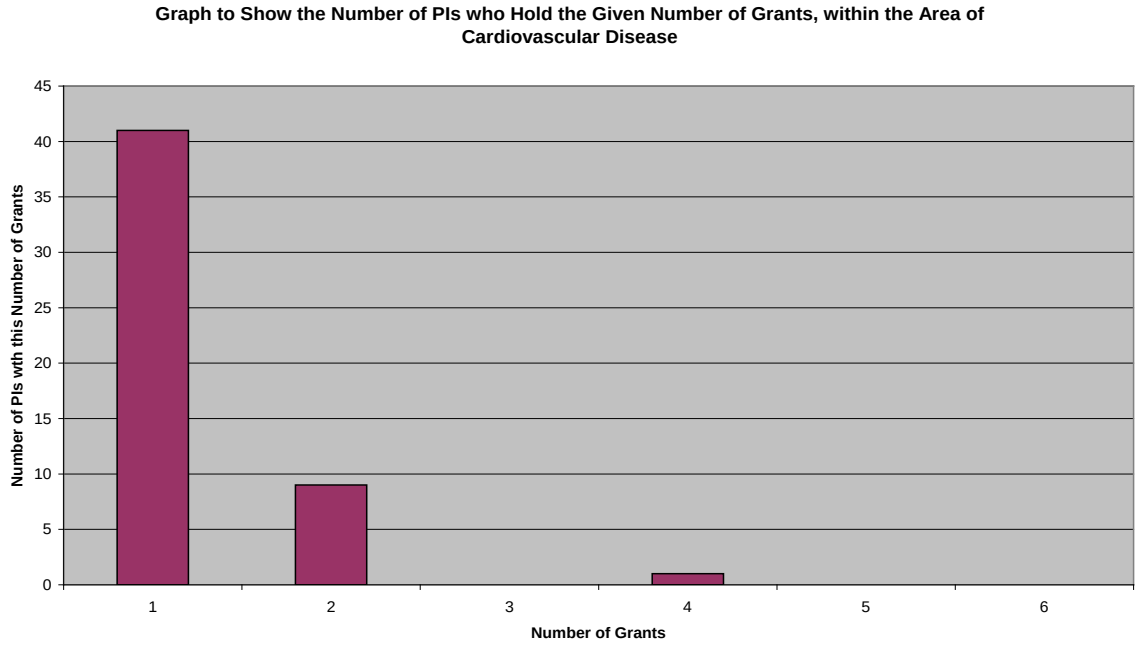
Appendix 5: Bristol Online Survey of opinion from the attendees

Appendix 6: Bibliometric data based on journals picked by the Cardiovascular Disease panel

2. Morning Session Discussions – Strengths, Gaps, Weaknesses and Opportunities

All five groups used the list of grant titles shown in Appendix 4. This list was produced by looking at all the grant titles in the Healthcare Portfolio and selecting those of particular relevance to Cardiovascular Disease. This was done manually as, unlike other areas of the portfolio, grants are not coded to 'Cardiovascular' when processed by EPSRC.

Overall Portfolio Graph



Overall, in the portfolio there are 61 Grants from 56 different Principal Investigators (PIs) at 23 different institutes. The grants in the portfolio are worth a value of £14,617,376 million.

2.1 Group 1 - Convenor: Professor Alison Noble

2.1.1 Strengths

Modelling

There is a critical mass of people working in the area and conducting high quality research on topics such as electrical excitability and blood flow.

The UK publishes very competitively in this area on a global scale, although globally the clinical impact of the research conducted is relatively low.

Population data

There is strong and possibly unique data in this area from longitudinal studies and cohorts eg GP database and Generation Scotland; EPSRC funded research could make use of this data.

Device development

This is a traditional area of UK strength. Examples of devices being developed include stents, pacemakers and monitors and electronics such as telemedicine systems and home monitoring. The UK strength in this area is measured in terms of the clinical impact.

Imaging

Cardiac Magnetic Resonance Imaging (MRI) is a relatively large and internationally leading area due in part to the level of prior investment in equipment for MR research. Image analysis is a comparatively smaller area, although it is one in which the UK is also world leading. The UK strength in imaging is measured in terms of clinical impact.

Three key areas reflected globally

Strength in the areas of modelling, device development and imaging is not unique to the UK as these strengths are reflected globally. Research in these areas is therefore extremely competitive.

2.1.2 Weaknesses and Gaps

Multimodality imaging

Most clinical areas use multi-modality imaging (particularly neurology and oncology) but there has not been the same take up in cardiology, in part because 3D multi-modality imaging (MRI, Computed Tomography Angiography, echocardiography) has not been available in many large hospitals until recently. MRI can be expensive, so there may be cost-effective opportunities to use multi-modality solutions in management of patients with cardiac conditions.

Research over the life span

There is a lack of research focussing on cardiovascular conditions and health in the early years and continuing to monitor cardiovascular health over the entire life span.

Industry

The industry base in the cardiovascular area is weak in the UK making it extremely hard for academics to find UK-based industrial partners willing to work

with them on the pull through of their research from proven concept to commercial product.

Drug discovery and development

It is currently very difficult to get industrial partners to collaborate with academics on early stage drug discovery. Industrial partners are primarily interested in the concepts when they have been validated, as early stage drug discovery is considered too high risk. This creates a significant gap which needs to be addressed in the UK to ensure that academics have sufficient support to pull through their research from the understanding of the fundamental biology and identifying the biological targets to validating the concept; this would bring the research to a point at which industry is more likely to take up the research. More recently the UK has suffered from an additional challenge to drug discovery and development as pharmaceutical companies previously based in the UK are increasingly moving abroad.

2.1.3 Opportunities

Multidisciplinary groups

Although these groups are in the best position to bring basic research through to products or into the clinic, there are currently only small pockets of these groups working in the UK. There is the opportunity therefore to promote multidisciplinary research teams and training in areas such as modelling.

Novel therapeutics approach

There is the opportunity to more strongly support the underpinning technology for novel therapeutics in the engineering and physical sciences area. This includes increased long term support of therapeutics from the early discovery through to delivery and increased support for regenerative medicine and stem cells work in particular.

Community based management of disease

Through building on the UK's existing strengths in areas such as device development and by working with the NHS there is an opportunity to utilise current computer systems to work towards a more community based method of managing disease that delivers patient-centric care. This includes the opportunity for the development of biosensors, intelligent feedback systems and remote-monitoring technologies for this purpose and also for smart systems to guide medical decision making and the interpretation of data. Success in this area would also provide the UK with the opportunity to export the technologies to overseas markets.

Working with the NHS

There is a considerable opportunity to work more closely with the NHS for example, by forming collaborative groups with both engineers and clinicians to work on mutually important issues such as personalised medicine.

EPSRC collaborations

Due to the poor UK industry base in the area of cardiovascular disease there is a need to look for other ways to stimulate the translation of basic research in to the clinic and other ways to maximise the potential of proven concepts. There is an opportunity here for the EPSRC to collaborate with organisations such as the

National Institute for Health Research (NIHR) and NHS Innovations to help to fill this gap.

Demographic changes

As we face the challenges arising from an ageing population, in both the UK and globally, there is a definite opportunity to tackle these challenges by rapidly expanding our research base in this area and becoming world leaders in this field. Expenditure in healthcare costs will continue to rise in this area unless significant research is conducted tackling the challenges arising from an ageing population.

Use of imaging as a therapy

We can now apply our UK strength in imaging to increased exploration of the use of imaging in therapies.

Modelling

Although we publish very competitively in this area compared to the rest of the world, the clinical impact of the research is not as strong as other areas in which we are globally competitive, such as imaging. There is an opportunity therefore to improve upon our translation of strong basic research in to products and into the clinic. It is not clear whether the right skills to translate the research are currently present in this area and so, as mentioned above, it seems that multidisciplinary teams may hold the key to more successful translation. One barrier to translation within this area is a lack of interest among some basic scientists to take research through to products and into the clinic, especially when they may have to publish in less esteemed journals as a result. There may be a need to train a new type of researcher to do this.

2.2 Group 2 - Convenor: Professor Andrew Lewis

2.2.1 Strengths

Strong underpinning research base

The fundamental research base in this area is well supported in the UK with multiple funding opportunities; this results in the UK being very good at conducting strong research in underpinning areas such as cellular imaging. For example, an EPSRC-funded project looking into the development of a Scanning Ion Conductance Microscope (SICM) has now resulted in a spin out company and the instrument was featured in the publication Science.

Imaging and modelling

Imaging and modelling are widely considered to be research strengths in the UK and this is reflected by the level of EPSRC investment in these areas. Internationally, the UK does very well in terms of the number of patents granted in the areas of imaging and modelling. It was felt that it is easier for academics to engage in research in imaging and modelling because clinical trials are not always necessary; this has resulted in a critical mass of people working in these areas which could go some way to account for our strength in these fields. Although modelling can be considered as a UK strength, it was considered that we are internationally competitive, but not internationally leading in this area.

'Healthy Aims' EU funding

The 'Healthy Aims' EU Framework VI project is a so far successful funding initiative set up with 26 partners, including 6 SMEs, to develop a range of medical implants to help the ageing population and those with disabilities. The UK is heavily involved with the project, with 10 of the 26 partners being based in the UK, and with total funding of £26 million available for the projects. Our level of involvement is an important indication of the UK's strength in the area of medical implants and devices.

Medical devices

UK research into medical devices for cardiovascular applications is certainly strength for the UK however, when compared to the imaging and modelling fields, there are significant barriers in medical device research when moving from a technology or scientific model of concept to a device. These barriers include pre-clinical and clinical evaluation and tricky regulatory considerations.

Communities willing to work together

Communities researching in the cardiovascular area in the UK are very willing to work together and are also willing to look abroad for collaborations. This willingness to work together can help to bring the best minds together to make real progress. There is also a willingness amongst the basic research community to work alongside clinicians; though this is currently happening it is only in insolated situations such as through the Imperial College London affiliation with the Royal Brompton and Harefield NHS Foundation Trust. All of these relationships take time to develop and time is therefore a significant barrier to more coherent working across universities and NHS trusts. EPSRC's Integrated Knowledge Centres (IKC) were considered a strength to the UK as relevant centres now include a focus on the pull through from basic research in to the clinic.

Clinical trials

It was felt that the UK has a suitable structure in place (largely due to the NHS) to allow for world class clinical trials to be carried out and that this should be realised as a growing strength for the UK.

MRI

Our research into MRI, as appropriate to cardiovascular disease, is considered to be a strength for the UK and in particular the basic research that underpins MRI techniques and analysis is considered to be a strength.

Remote monitoring

Research in to remote monitoring and home monitoring is strong in the UK, with particular emphasis again on the basic underpinning research.

Telemonitoring

Again, there are some small pockets of activity in telemonitoring working to improve the quality of life for cardiovascular disease patients and to relieve the burden of these patients on the NHS and consequently the economy. Areas such as home monitoring and telemonitoring have the potential to have a large impact on patients' lives but also carry with them significant ethical issues that must be taken in to consideration.

The Wellcome Trust and British Heart Foundation (BHF)

Both the Wellcome Trust and BHF have large research budgets and are working to improve health in the UK with the BHF being specifically committed to funding work in the area of cardiovascular disease and circulation. The presence of these funding bodies is a great strength for the UK and provides an alternative funding route for work in this area. BHF has several schemes aimed towards clinicians and getting clinicians involved in research which is an important aspect of successful translation of technologies and products in to the clinic. In general we are lucky in the UK to have so many charities that are interested in funding medical research.

Drug discovery and development a strength

There is a lot of work going on in the UK in to drug discovery and drug development, with some of the work focusing on developing drugs for cardiovascular applications. Drug discovery and development is certainly a strength for the UK, although translation is difficult as major pharmaceutical companies have downgraded their UK effort and are moving abroad.

EU CE (Conformité Européenne) marking

The CE marking is a mandatory conformity mark placed on approved products being sold in the single market in the European Economic Area (EEA); the marking certifies that a product has met EU consumer safety, health and environmental requirements. The presence of this mark means that it is easier to carry out clinical trials in both the UK and in Europe. Additionally, a uniform conformity mark for all of the countries trading in the EEA, makes it easier to put products on to the European market. The EU CE mark is generally considered to be easier, quicker, less onerous and less expensive to obtain than approval from the American FDA (Food and Drug Administration).

Key strengths:

(1) Fundamental Research Base supported by multiple funding opportunity

(2) Imaging – do not need clinical trials and therefore easier to engage

(3) Modeling – again, do not need clinical trials and therefore easier to engage.

2.2.2 Weaknesses and Gaps

Application of MRI and remote monitoring

Although we are conducting strong research into MRI and remote monitoring, translation of the science is difficult because it is felt that translation in these areas needs to be done through major transnational companies rather than SMEs. It is SMEs however that are more likely to get involved with projects that are lower down on the technology readiness level.

Transnational agreements

Prior transnational research council agreements have not been focused in the healthcare area. Because of this, the healthcare domain may have suffered compared to those other areas in which there have been transnational research council agreements; transnational agreements are key to bringing the best minds together, opening up new industrial links and to the sharing of best practice.

Innovation

We have the basic networks (the NHS for example) and enthusiasm for successful innovation and translation of cardiovascular disease related technologies and devices in the UK but we are let down by the lack of bridging finance, the absence of large bioengineering companies such as Philips and a historical lack of interest amongst UK academia to create new companies to exploit their research.

Communication

In general the communication between the cardiovascular communities in the UK can be poor; whether this is communication between research groups at different universities, between academics and clinicians or between industry and academia. Our international communication can also be poor despite there being a lot to gain from improved communications. There is a general feeling that our EU competitors are much better at engaging.

Imaging and modelling

Despite UK research in imaging and modelling being internationally strong in this area the number of people employed in the sector is much lower than our competitors. Additionally although the UK is good at innovation the translation into products is weak.

NHS

The presence of the NHS is largely considered as a strength for the UK, however this is not always the uniform opinion when people are considering innovation and translation. It is felt that the competition between private hospitals in the USA, for example, drives support for innovation. More generally, it is felt that the USA is better placed to innovate and exploit research because of the way in

which the system is structured and the level of support that is provided to clinicians to enable this. For example, clinicians in large teaching hospitals are receptive to research and there is a suitable career structure present to support this.

Medical devices

Although the cardiovascular related medical devices research being conducted in the UK is strong there is a lack of critical mass in this area and the community is very dispersed. There is not any one place with a critical mass of people to really make advancements in this area. Additionally there are no obvious attractors for leaders working in this area abroad to come to the UK. These novel ideas that do develop tend to be acquired by bigger corporations outside the UK and hence there is little opportunity for these smaller companies to develop into bigger entities. Again, lack of significant funding that is required to take a product from its proof of concept, across the chasm of pre-clinical and clinical testing and onto market encourages this type of exit strategy.

Networks

The networks in this space are weak compared to other areas of healthcare. There is no cardiovascular network for NIHR for example and the Knowledge Transfer Network (KTN) in this area is not a significant strength. The Academic Health Science Centre (AHSC) model (where a healthcare provider partners with a university), which is already well established in countries such as the USA and Singapore, may be a good one.

Nanotechnology

The application of nanoscience and the use of nanotechnologies in cardiovascular disease research in the UK is much weaker than in the USA where the use of nanotechnology is much more focused in cardiovascular diseases areas.

Clinician engagement

The engagement of clinicians in research in the UK is in general fairly poor. In the USA for example research groups place individuals in hospitals to identify the research challenges with the clinicians themselves. This does not happen in the UK but could be a very effective way of identifying where a specific product or technology could make a massive impact and be translated successfully.

Assessment

There is a feeling amongst academics in the UK that it will be hard to get individual recognition through the Research Excellence Framework (REF) when working within a large team. This might prove to be a barrier to career progression.

Key gaps:

(1) The awareness and engagement to take research to the next stage

i. biologists and clinicians need to be more aware of what is being developed in EPS

ii. translation is weak

iii. awareness and engagement with the public on ethical issues and animal trials is relatively poor

(2) The interfaces between Research Councils

(3) The lack of a UK industry base to support translation from a clinical setting to industry and production.

2.2.3 Opportunities

Robotic surgery

There is a clear opportunity in the UK for Robotic surgery to be grown as an area. Although the UK has a growing strength in robotic surgery, the activity is presently very small. There is a great deal of potential for this area to have an impact on a variety of aspects of cardiovascular related surgery, for example, to develop methods to replace aortic valves non-invasively. Most robotic surgery is not currently in the cardiovascular area and there is therefore a significant opportunity for the application of the developing technologies here.

Ventricular Assist Devices (VADs)

There are small pockets of groups and activity within the UK that are doing some strong research in to Ventricular Assist Devices.

NHS and clinicians

We have the opportunity in the UK to bring together the research base and the NHS to increase the level of engagement between clinicians and academics. In house research within hospitals now sits in a better regulatory environment than before, so there is the opportunity to get academics and clinicians working together in the hospitals to identify and tackle the true research challenges for cardiovascular disease; we need clinicians to identify the objectives and metrics. There is a definite willingness amongst cardiologists to get involved on more fundamental research, which could help steer the research towards a more defined clinical need, and more broadly there is a feeling of willing amongst the NHS and surgeons to engage in research.

Stem cell research

Stem cell research in the cardiovascular disease area is becoming increasingly strong in the UK and has the potential to develop in to a definite global strength for the country. However we need to work to take advantage of this opportunity to ensure that stem cell work in this area does get the global recognition it deserves; for example we need to better expose researchers to the clinical issues to ensure that researchers are meeting a true clinical need. Similarly, regulatory routes need to be clearer and simpler, as per the US where for instance, the government has recently authorised the use of new lines of stem cells for researchers through the NIH.

BHF

EPSRC needs to identify how the research that the BHF (and other funders in the cardiovascular space) funds impacts and overlap with research in the EPSRC portfolio. They can then try to maintain regular communication with the relevant funders to avoid funding duplicate projects and to pursue the possibility of joint funding on projects that are of equal relevance and benefit to both parties. There is also the potential for BHF to work with The Research Councils on cross council issues.

NIHR collaboration

As there is not currently a NIHR network for cardiovascular disease research there is a clear opportunity for EPSRC to work with NIHR to develop one and instigate better coordination in across the board. The collaboration would ensure that there is a solid scientific and engineering aspect to the network.

Virtual cardiovascular network

A virtual cardiovascular network could improve communications within the community and help to raise awareness of the various challenges in this area. A network could also provide a good way of linking industrialists, clinicians and academics. Additionally, knowing who it is best to speak to in the community is key and a network would assist this.

UK conference

An annual UK based conference (or equivalent activity) would be a good way of bringing together cardiologists, surgeons, engineers, biologists and other stakeholders to identify the opportunities and challenges in this area in a focused way and to promote networking amongst the community.

Interdisciplinary Research Collaboration (IRC)

An IRC in cardiovascular disease would support existing IRCs that are relevant to this area and create a hub of sufficient critical mass to make a real impact in this area. An IRC would also facilitate industrial interaction in the area.

Identifying key individuals

Research groups in the UK tend to be smaller than those in competing countries and there is a definite lack of overlap between groups. We do however have extremely strong individuals working in cardiovascular disease (as shown by the number of British key note speakers on the international stage) and so there is an opportunity here to identify those key individuals, who can drive the research and have the ideas, and then develop strong teams around the individuals to create groups with specific goals or foci and the relevant skills and knowledge to tackle the research challenges.

Key opportunities:

(1) To create effective communities:

   i. linking universities, industry and clinicians
   ii. raising the UK profile internationally

(2) To focus on those areas in which the UK is already showing promise:

   i. anotechnology
   ii. stem cells
   iii. robotics
   iv. remote monitoring

(3) For NIHR to support research for patient benefit and for hospitals to have exception from specific research regulations in certain situations.

2.3 Group 3 - Convenor: Professor David Newby

2.3.1 Strengths

Presence in high impact publications

UK academics working in the cardiovascular area publish competitively on a global level.

A strong presence in respected publications has a high impact for the UK, for example, it brings economic benefit by attracting students to work in the area and thus increasing student recruitment.

Regenerative medicine

Government investment in this area is high, which is a large factor behind the UK's success in this area. Regenerative medicine is a cross cutting theme which involves many disciplines and funders and therefore embraces a multidisciplinary style of working.

Translational medicine

It is felt that there is a definite 'laboratory in the morning, hospital in the afternoon' feeling in the UK, which is not only an important strength for cardiovascular disease research but also a valuable opportunity for the area to make a real impact.

NHS

A unified healthcare system is widely considered as a strength for the UK; the nationwide record systems that are currently developing provide a wealth of opportunity for academics conducting research in cardiovascular disease for example.

Clinical studies

It is felt that the environment in the UK is good for large scale complex clinical studies. This is of particular strength to cardiovascular disease research as clinical trials in this area do tend to be on a larger scale.

Modelling

There are distinct pockets of excellence in modelling in the UK; for example in electrophysiology at the Universities of Leeds, Manchester, Oxford and Liverpool and in biomedical modelling.

Biomaterials

We currently have world leading biomaterials scientists working in the UK and this is reflected by our strength in this area. The UK research activity in biomaterials is much more focused that in other countries and particularly focuses on problem solving.

Innovative SMEs and spin-outs

The UK has a good collection of innovative SMEs and spin-outs from university activities in that are working in the cardiovascular area.

Medical devices

There is some very strong research being conducted and successful translation happening in the areas of stents and grafts in particular.

Early incubation stage

Groups in the UK are generally good at creating scientific capital for their projects and nurturing the projects when they are in the early incubation stage. This is particularly true of imaging (eg MRI and CT) related projects.

Underpinning biology

The underpinning cardiovascular biology, which is essential for much of the research in to cardiovascular disease, is a strong research area in the UK.

Drug delivery

Research in drug development and drug delivery is strong in the UK and as such companies look to the UK for innovative new ideas and developments. This is both a strength and an opportunity for the UK.

Geography and historic funding environment

As the UK is geographically smaller than most of our international competitors, our communities can link together and work together much more effectively. This promotes the sharing of knowledge and best practice. Additionally, UK research benefits from having a historic funding environment; this means that funding bodies and funding mechanisms, such as the CASE studentships (Collaborative Awards in Science and Engineering), are well established.

2.3.2 Weaknesses and Gaps

Patent production

Compared to our international competitors we are losing headway in terms of patent production in the cardiovascular area.

Engaging with large plc

We need to define and support a clear approach for instigating engagement between large public limited companies (plc) and academic research, whether the companies are based here in the UK or abroad.

Availability of people

It is difficult to recruit students with the necessary skills and expertise to assist with research in the cardiovascular area. There is a distinct shortage of UK based students to work on projects.

Training

We need to improve upon our ability to train people to work effectively in a multidisciplinary environment. We need to think about more effective training schemes that encompass multidisciplinarity and ensure that the physical and life sciences are seen as equal partners and of equal value.

UK based drug companies

Drug companies are increasingly looking to move their UK bases abroad as the UK is seen as expensive. This will have a negative impact on the ease of translation of new drug technologies etc.

2.3.3 Opportunities

Capturing unmet clinical needs

Identifying and providing solutions for clinical needs will help to facilitate the interaction between academics and clinicians; this interaction is extremely valuable and can be in important factor in the success of a project. Research that provides a solution for a clearly defined clinical need should be able to more effectively attract the attention of companies as there is a clear business case for the project outcome.

NHS funding environment

The NHS funding environment is changing and there is now a diverse funding landscape across the UK, with NHS foundation trusts, such as the University Hospitals Bristol NHS Foundation Trust, having much more freedom than health boards. Consequently there is a distinct funding opportunity here for researchers working in the cardiovascular disease space to take advantage of.

Social network

It is clear that increased engagement between clinicians and academics could be extremely beneficial for cardiovascular disease research as a whole. A social network could 'match make' academics and clinicians and stimulate collaborations.

Healthcare technology cooperatives

The NHS Healthcare Technology Cooperatives (HTCs) are an extremely good model and there is an opportunity therefore to develop the idea for the future, perhaps making the model more specific to engineering and the physical sciences and to cardiovascular disease research. (The HTCs are clinician-led collaborations between clinicians, patients, academia and industry that act as a focus for 'technology pull' in to the NHS. The HTCs will aim to address areas of unmet clinical need). Calls for outline proposals for the current HTCs still offer a definite opportunity for funding for members of the cardiovascular community and also offer an opportunity for longer term in-kind gain such as clinical and industry contacts.

Bridging the gap between academia and the clinic

Several opportunities lie within getting the academic world and clinical world to work together more coherently. Cross disciplinary PhDs are one way of achieving this and are good value for money, in fact it is felt that cross disciplinary working and training should be encouraged at all career stages, from a PhD level to an academic level.

EPSRC and MRC

A better link between EPSRC and MRC in this area could provide more direction and focus to the cardiovascular disease research activities, prevent duplication of projects and make the best use of resources.

Engagement with charities

Alongside increased engagement with clinicians to determine the clinical needs in the cardiovascular area, it would be beneficial for both EPSRC and the academic community to work more closely with charities in the cardiovascular space to determine what their needs are. More widely we should be taking advantage of the vast number of stakeholders that are in the cardiovascular disease area by

linking these parties together to create a more coherent and cohesive community.

Modelling

There is an opportunity in the UK to now develop our existing strength in modelling by translating the research in to the clinic.

2.4 Group 4 - Convenor: Professor Peter Weinberg

2.4.1 Strengths

Imaging

Imaging research, as applied to cardiovascular disease, is certainly a strength for the UK with our research rating globally second only to the US. Our strength in this area is recognised globally with international imaging conferences such as MICCAI (Medical Imaging Computing and Computer-Assisted Intervention) being held in the UK. The translation of imaging research is especially effective in the UK. For example, imaging software developed as part of an EPSRC-funded project has been commercialised and is now being used internationally. There are barriers to this, however, as much of the present industry in this area is aboard. An additional area of particular strength in the UK is preclinical imaging. Significant investment has been made in the area of imaging and there are several examples of large imaging centres such as the GlaxoSmithKline Imaging Centre at Imperial College London, funded in partnership with the Medical Research Council.

Biomaterials (and tissue engineering)

Biomaterials is an area in which we again are rated globally second only to the US. Biomaterials research is being conducted in relation to cardiovascular disease across many universities following a tremendous growth in the area since the 1980s. Medical devices that rely upon UK-developed biomaterials such as coronary stents and coated stents are being used worldwide which illustrates the strength in this area. This is not a mature discipline and is an area of growing strength, with areas such as biodegradable materials and smart materials offering great potential for the future. From the titles of EPSRC grants in the cardiovascular disease space, biomaterials does not appear to be a well funded area, although this may mean that there is a low volume of proposals being submitted in the area.

Modelling

The UK has a significant strength in modelling and its research rates amongst the top countries in the world. There is a large spectrum of work going on under the wide umbrella of modelling that is contributing to cardiovascular disease research: for example, there are many UK meetings and an EPSRC network in flow modelling. However, the translation of modelling from the basic research in to products and into the clinic is weaker, although we might perhaps still be a world leader in this area.

Rehabilitation robotics

There is some strong UK research in rehabilitation robotics. Areas such as the integration of imaging with control systems and minimally invasive surgery are particularly strong. Several universities have spin off companies in this area to commercialise the outcomes of their basic research.

Clinical trials

The UK is a world leader in carrying out clinical trials in the cardiovascular disease area.

2.4.2 Weaknesses and Gaps

Imaging

Despite imaging being a key research strength for the UK, it was felt that the delivery of healthcare from imaging research is not as strong.

Translation

Although UK research into cardiovascular disease may be globally strong, this is not reflected in the translation of the basic research in to products and into the clinic.

Gaps in funding schemes

There are gaps in present funding schemes that support research in to cardiovascular disease:

Large animal facilities

Large mammal facilities are expensive to run but necessary, and we should therefore share key centres in the UK. There are currently centres at the Universities of Nottingham and Strathclyde, Imperial College and some of the university vet schools. More financial support is needed to help maintain these centres and EPSRC could provide additional funding on grants to recognise the use of animal facilities. For basic cardiovascular research to be adopted by industry (or to secure funding for translation and clinical trials from funding bodies) there needs to be a large amount of evidence to support the validity of the research. Tests performed at these large mammal facilities can be used as evidence of this nature and can therefore aid the translation of basic research. Due to the underfunding of the large animal facilities in the UK, there is a danger that these studies may be carried out abroad.

Multidisciplinarity

Multidisciplinary teams and projects draw on a wide range of expertise and skills and make a significant impact on our progress in the cardiovascular area. However, the current peer review system acts as a barrier to the funding of multidisciplinary projects at panels. For example, each of the research councils currently has its own referee base and panel membership, but multidisciplinary proposals may need review by academics from a different research council's referee base and panel membership base to be assessed properly. This does not necessarily happen at the moment. Centres that encourage multidisciplinarity in projects, such as the four Centres of Excellence in Medical Engineering that have been jointly funded by the EPSRC and the Wellcome Trust (one of which is in cardiovascular imaging), are good examples of an alternative means of encouraging multidisciplinarity and giving more freedom to the researchers. Concern was expressed however that though reserved funding for multidisciplinary centres at universities is important, it should not perpetuate the status quo and there should still be money available for 'blue skies' research.

Fundamentals of cardiovascular biomechanics and disease pathogenesis

It was felt that funding in the areas of cardiovascular biomechanics and disease pathogenesis is comparatively weak in the UK, with the results from the Bristol Online Survey in cardiovascular disease supporting this conclusion. These areas are receiving a much higher level of investment overseas.

2.4.3 Opportunities

National facilities and initiatives

By sharing national facilities and running national initiatives such as equipment sharing initiatives, we can attempt to reduce costs.

Small Business Innovation Research (SIBR) type grant

There is an opportunity to promote the translation of cardiovascular disease research through grants based on the American SBIR model.

Cheap devices

We could exploit our research strength in medical devices for the cardiovascular system to develop cheap devices for those in the developing world.

EPSRC and BHF collaboration

An EPSRC collaboration with the British Heart Foundation (BHF) to provide co-funding and to establish a better communication channel between the two bodies would provide a more coherent approach to funding in the cardiovascular area. A regular dialogue with the National Institute for Health Research (NIHR) could also be important.

2.5 Group 5 - Convenor: Professor Rhodri Williams

2.5.1 Strengths

Technological

The UK's technological strengths in cardiovascular disease research include areas such as biodegradable polymers, computation fluid dynamics, imaging, modelling and diagnostic devices.

UK punching above its weight

It can be difficult to define our global standing versus the USA. What this does mean however is that the UK must be 'punching above its weight' and that we are making a significant contribution to the global advancement of cardiovascular disease research relative to the number of researchers working in this area. The Netherlands are also conducting some very strong research into cardiovascular disease.

Interdisciplinary working

Research groups working in this area are very good at working closely with teaching hospitals and consequently engineers and clinicians are brought together. These close links and collaborations are a strength for UK research.

Diverse range of funding opportunities

There are multiple sources that have funding available for cardiovascular disease research, such as the EPSRC, the Medical Research Council (MRC), the NHS (NIHR), the Knowledge Transfer Networks (KTNs), the British Heart Foundation (BHF) and other relevant charities. This may mean that funding in the area lacks clarity and focus, however on the other hand a range of different funding bodies in the area helps to maintain interdisciplinary working. It was noted however that in many cases valuable time had to be spent superficially re-focusing grant applications to meet the expectations of the reviewers at different funders, while the most important aspect of the project remains the same.

Flexible research council funding

The opportunity to apply for flexible funding from the Research Councils is a strength for the UK and of benefit to cardiovascular disease research. There is a perception amongst the community however that well established research groups are in a far better position to apply for funding and are favoured by peer review and panel members.

Strong academic base

The UK has a strong community of committed academics working to advance cardiovascular disease research. There is a high level of existing expertise and knowledge in the area.

Industry

Although there are many barriers to working with industry there is a definite willingness amongst the academic community to establish a better relationship; this willingness to engage is a strength for the UK and offers a wealth of opportunity for the future. It can take many years to establish trust in these relationships and get to a point where ideas are adopted by the company or funding for projects is given but in the short term small pilot studies can be carried out for mutual benefit.

NHS

The NHS is vast resource for the academic community: it offers an opportunity to engage with both clinicians and industrial partners and it provides a structure for the ethical and clinical governance of research.

Co-funding between the Research Councils

The Research Councils are increasingly looking to co-fund projects of mutual interest to promote multidisciplinary working. This provides a valuable opportunity for multidisciplinary groups as the perception can be that getting truly multidisciplinary proposals funded through only one research council can be difficult. It is perceived that their value is not perhaps fully appreciated at peer review stage because the peer review expertise is not there. The availability of grants that are co-funded by multiple research councils is a strength for the UK.

Geography

As the UK is smaller than many of our competing countries it is easier for stakeholders in the cardiovascular community to meet up and network.

Diversity

Cardiovascular disease is a broad research area and consequently a diverse range of subareas are being explored as a part of the research effort; advancements in these more basic research areas are often translatable outside of the cardiovascular disease area eg imaging.

2.5.2 Weaknesses and Gaps

In vivo validation of modelling

The modelling research being conducted around cardiovascular disease in the UK is strong and this is reflected by the publishing record in this area. The clinical impact of the modelling research is weak however and the level of uptake of the research by companies is extremely poor. Both reflect global trends. Validation of modelling research is currently on an ad hoc basis, however to improve the likelihood of the uptake of modelling research by companies and to improve the translation of modelling research to the clinic we need to encourage more in vivo validation of the research. The in vivo validation of modelling research is currently challenging in the UK environment and it is found to be easier to do this validation abroad.

Lack of adequate industrial base for engagement

The UK industry base in the cardiovascular disease space is small and made up of few large companies. Smaller industrial partners, although valuable, have a limited ability to pursue and sustain engagement with academia and struggle to provide the necessary pull-through for projects. The industry base we do have is increasingly looking to move abroad for financial reasons, which results in a wealth of high quality research having nowhere to go; for example much of the industry once involved with the development and manufacturing of stents and valves has moved abroad, leaving strong UK research into medical devices without any form of industrial pull-through.

Funding system

It is hard to tell whether the lack of pull through for cardiovascular projects is due to the size of the relevant industry base in the UK; poor communication between academia, the clinic and industry; or whether it is down to a gap in the

funding system. Increased funding and support for spin out companies is in theory a good idea and would help to build up the industry base in this space, however the healthcare domain is considered to be high risk for new start-ups and this may not be the most effective investment. The strategic partnership type route is a good model and can increase engagement and pull-through.

Technology Strategy Board (TSB)

The TSB can be too restrictive in their calls and consequently there may not in the past have been equal funding opportunity for cardiovascular disease research. The TSB should align to Research Council strategy; however they should not be as specific in their calls as to narrow down to a single disease state.

UK regulatory environment

The regulatory environment in the UK is considered difficult to work in and consequently a significant amount of academia chooses to conduct their translational work abroad. The regulatory environment in the USA for example is found by many to be much less restrictive. There is a feeling that the UK regulatory environment is too much of a "one size fits all" nature. This can be a significant barrier to the translation of basic cardiovascular research into the clinic in particular.

Seamless funding

We need seamless mechanisms between funding opportunities to maintain the momentum of projects. The current funding landscape is perceived as being too fragmented with too many stop-start projects which hamper follow-up, clinician engagement, group development, staff retention and industrial engagement. The flexible deployment of longer-term funding is required.

Proof of concept funding

Funding is available for research groups from the Research Development Agencies (RDA) to conduct proof of concept work. There is a perceived gap however between this proof of concept funding and the funding that the TSB offers. There needs to be more coherent use of the current types of schemes and a roadmap to guide academics through the funding opportunities in this space.

Validation

There are a lack of opportunities for academics to carry out validation work in the UK due to the cost and regulatory overheads. The academic community are increasingly looking to conduct this work overseas. This situation results in a slow rate of product development and decreases the opportunities for teams to follow-through their research.

2.5.3 Opportunities

Flexibility in funding approaches:

(i) The 'stage-gating' approach, as in EPSRC's Grand Challenge Awards, allows for the seamless exploitation and follow-on of projects. The approach involves inviting groups to apply for follow-on funding a set time after their initial projects begin. This approach ensures that staff working on the projects can be retained.

(ii) Funding should be available for short pilot or preliminary studies to build partnerships between academics and clinicians. There could also be the possibility of follow-on funding for those successful studies and partnerships.

Regenerative medicine

We have the opportunity in the UK to exploit the recent advances that have been made, and the effort that has been put in, to regenerative medicine research by focusing on the applications that regenerative medicine can have in the cardiovascular disease area.

Ageing population

There is a definite research challenge around the demographic changes that the UK is experiencing; our ageing population offers a high profile opportunity to develop minimally invasive technologies with applications in this area, to avoid open chest surgery for example.

Exploit in vitro models

We should exploit the opportunity to use in vitro models in the stages between basic research and the clinic.

Exploit other disciplines

The UK has a wide range of strengths across the breadth of science research so there is a distinct opportunity to acknowledge and use tools from other disciplines in cardiovascular disease research.

Future EPSRC calls

EPSRC could run more partnership calls, where there is a focus on the increased engagement of industry and clinicians on projects. These calls for proposals should be announced earlier than usual to allow sufficient time for research groups to team up with partners. The length of grants could be increased across the board to allow for the retention of staff and the growth of projects.

Regional funding opportunities

There could be better exploitation by the academic community of regional funding opportunities such as the Welsh Assembly Government and the Scottish Investment Fund.

3. Afternoon Session Discussions – Translation and Training

3.1 Convenor: Professor Alison Noble

3.1.1 Translation

Support use of large animal testing facilities

These facilities are expensive to maintain and do not currently receive sufficient support; however only a small number of facilities are required and these could be shared between institutions. Large animal testing facilities are very important to cardiovascular research and it is felt that funding for the use of the facilities could be supported within EPSRC grants.

People are not aware of support available

Members of industry and academia are not always fully aware of the support that is available for translation or where to look for it. From discussions at the meeting, the degree of awareness varies dramatically from institution to institution. A 'one stop shop' for funding opportunities and useful contacts and links could really stimulate interest in translation and also advertise the funding opportunities to a wider range of people than before.

Multidisciplinary teams

Multidisciplinary teams, with a wider range of skills and expertise, are in the best position to take basic research through to products or into the clinic. In the cardiovascular area teams need a consistent and solid clinical input to help identify the challenges that can be addressed and give a user perspective on emerging technologies. Increased engagement between research teams and clinicians is of utmost importance to overcoming the barriers that lie in the way to translation. Additionally, if clinicians can champion the work of research groups then the research becomes much more accessible to a wider group of people and raises the profile of the work – opening the door up to many more translational opportunities.

A small number of inclusive mechanisms

It is currently felt that there are too many different mechanisms available for translation which results in a 'splintering' of funds. Translation of basic research can be an expensive process so a smaller number of inclusive mechanisms could help support projects more effectively and focus the funding available more efficiently.

Industry base in the UK small in this area

The UK industry base in this area is very small, especially when compared to other countries such as the USA as well as in Europe; this is an extremely significant barrier to translation as academics find it very difficult to find relevant industrial partners in this country and find it much easier to look abroad for industry collaborations. Linking up with small to mid sized companies in the EU could prove to be a solution of sorts along with increased collaboration with international companies such as Phillips and Siemens.

Early product development is difficult

Early product development in the area of cardiovascular disease is difficult globally as large studies are needed. Theses studies are expensive and time consuming which discourages industry from investing and taking up the development.

EPSRC to continue to encourage schemes requiring industry input

Early involvement of industry in research projects can boost the chances of the research eventually being taken up and successfully translated. One way of ensuring the early involvement of industry in research projects is for EPSRC to continue to encourage schemes which require an industry input, be this cash input or in-kind. More specifically, a scheme targeting the cardiovascular area could really stimulate progress in the area and help to set up longer term contacts and links between academic groups and industry. It was suggested that it would be beneficial to increase awareness of any such calls prior to the actual call to give academic groups sufficient time to approach industry. It was also suggested that EPSRC could set up network meetings prior to these calls to stimulate the collaborations between academia and industry; these network meetings could be a good opportunity to get more SMEs involved and increase the academic awareness of the range of SMEs that are currently operating in the UK.

3.1.2 Training and Skills

Doctoral research training

The concept behind the EPSRC funded Doctoral Training Centres (DTCs) is good and very appropriate for this type of research; this method of training PhD students could be translated into 'hubs', some of which are relevant to cardiovascular disease, which could be shared between multiple universities. This would give a longer term solution to PhD training and would also help to develop communities in the cardiovascular area and encourage multidisciplinary working with all students receiving the same training in the first year. There could also be a clinical engagement element to the PhD training with clinicians training some of the engineering and physical sciences students.

Training clinicians

As discussed in Section 3.1.1, a move towards having increased clinical engagement on research projects would ensure that research is addressing real and relevant challenges in this space and provide a better user perspective on proposed technologies and products. To this end EPSRC need to look towards making more support available for doctoral research training for MD/PhDs and Specialist Registras (SpRs).

Maintaining the momentum in academic training and career paths

We need to ensure that there will be a constant supply of highly trained and experienced individuals working in the area of cardiovascular disease in the future. One way this might be achieved is to put in place better career development mechanisms for pursuing research in the cardiovascular area so that the momentum in academic training and career paths is maintained more effectively. Longer posts and longer term fellowships such as those that BHF offer are one method of maintaining momentum in academic career paths and EPSRC could have an input on these to encourage academics from the EPS area to apply.

EPSRC partnership with the British Heart Foundation(BHF)

An EPSRC partnership with BHF could result in more of a focus on cardiovascular disease by researchers and funders alike. It could also make BHF funding more accessible to academics working in the Engineering and Physical Sciences (EPS) space and likewise make EPSRC funding more accessible to those researchers and clinicians working in the BHF space.

Summer schools and workshops

Summer schools and workshops on cardiovascular disease would not only provide an academic training opportunity but also something that clinicians and industry could get involved with. This could stimulate industry-academia collaborations and give clinicians an opportunity to get involved with the teaching of the engineering and physical sciences based students.

Annual symposia

It was also suggested that an annual cardiovascular disease symposia for engineering and physical sciences (EPS) EPS students, incorporating two-way tutorials for EPS researchers and clinicians, would be beneficial.

Annual meeting for EPSRC grant holders

An annual meeting for the EPSRC grant holders working in the cardiovascular space could provide an valuable networking opportunity which could help build the community up and stimulate academic collaborations. The meeting could also be made more open by inviting key researchers, clinicians and industry representatives and thought provoking topics could be introduced by invited speakers.

3.2 Convenor: Professor Andrew Lewis

3.2.1 Translation

Group expertise

No one cardiovascular group has the expertise to take their basic research all the way through the translation spectrum to products and into the clinic. This is a significant barrier to translation and we need to address how group dynamics and expertise should change to reflect the technology readiness level of projects.

Pharmaceutical industry

There is a well defined path for innovation to market in the pharmaceutical industry but sadly the operating costs are deemed too high in the UK and large pharmaceutical companies are abandoning their UK bases and moving abroad. This is a threat to the translation of innovative drug discovery and drug development research in the cardiovascular area.

No clear pathway for translation

In general, there is not a clear route to translate basic research into products and clinical technologies. There needs to be a more defined pathway, with clear follow-on funding available for projects, so that industry are more likely to take up projects. Currently immediate 'next stage' research is considered too high risk by other parties so there needs to be some money available to support projects until they are at a suitable stage for industry to take them on and take on the responsibility of fuelling the projects. Alternatively, longer term funding for projects would limit the risk for a company to take the project on board and avoid the project grinding to a halt as the team search for follow-on funding. Additionally the metrics that companies sometimes require before agreeing to taking on a project can be expensive (around £200,000) and it is not clear where this investment should come from. Exemplars of successful translation in the cardiovascular area, with details of the funding, would be a useful resource for the community and might help to lay out a pathway for translation.

Lack of industry base in UK

There is a comparatively poor company presence in the UK and in the cardiovascular area in particular, which means that the Technology Strategy Board (TSB) and the Research Development Agencies (RDAs) may be less likely to support projects in the area.

Clinical input

To give basic research an improved chance of being successfully translated in to products and into the clinic it is key that the original research is conducted with a clinician; hopefully this would ensure that the research is targeted towards addressing a specific, and very real, clinical problem in the cardiovascular disease area. We need to encourage clinicians to get involved in research early on in projects, to support clinical trials and champion research by asking the questions around how we can get research into clinical practice.

Intellectual Property (IP)

Even once the matter of IP has been addressed, and a decision made, it is difficult to publicise the information to all stakeholders as there is not a well defined and linked cardiovascular community; this acts as a significant barrier to dissemination.

Clinical trials

The financial cost of carrying out clinical trials is a considerable barrier to the translation of research and there is a large jump between the funding required for basic research and the funding needed to carry out clinical trials, even though patient numbers can be relatively small. As mentioned above there are few large companies working in the UK in the cardiovascular area and it is therefore difficult to find organisations that are able to fund projects through expensive clinical trials; this is especially relevant more generally in the area of medical devices. Both the NHS and the British Heart Foundation (BHF) however do offer support for clinical trials, although pressures on the NHS mean that they tend to be very high-risk averse and will rarely, if ever, commit. The BHF on the other hand will support modest clinical trials (from around £250,000 to £2 million).

Absence of clinicians to champion research

Clinicians can help to support projects through their entire life-span, from the basic research all the way through to the commercial stage, by helping to address many of the barriers to translation. Unfortunately, although the involvement of relevant, interested and influential clinicians is crucially important to the success of projects, there are currently only a limited number of these individuals and so the absence of clinicians to champion research is a barrier to successful translation for many research groups.

Key points:

(1) The need for a multi-disciplinary review.

(2) The lack of clear next steps to translation (for example it is not clear where funding is available form for clinical trials).

(3) The importance of involving the right clinician early on in a project to support the project through the various stages of translation. Clinicians need to be motivated by the project and have influence in the relevant areas.

3.2.2 Training and Skills

Recruitment

The recruitment of young, highly motivated and talented individuals into the area is crucial for future development. We need to ensure that a good number of PhD students and postdoctoral researchers are being recruited into the area to provide fresh ideas and direction for the future and also to give senior researchers the opportunity to pass on their knowledge and expertise to the individuals that will be leading research in the area in the future.

Continuity of funding

To maintain momentum in a student's academic career we need to address the gap in funding between PhD level and Postdoctoral Research Assistant level as this can be a barrier to career progression. If we can address this we might be able to retain more postdoctoral research students in academic research; currently only around 25% of postdoctoral students with doctorates in the natural sciences continue to undertake postdoctoral research. There is a particular problem with the retention of engineers in the UK academic base as there are many other attractive employment opportunities for engineering graduates.

Funding for PhDs

It can be hard to get funding in the UK for PhDs, but where it is available students have the opportunity to make a real impact. A PhD student at the University of Nottingham for example developed a sensor device that could continually monitor babies' heart rates; with funding from the charity Action Medical Research the team are approaching the end of clinical trials and expect to commercialise the device and estimate the annual EU and US market could be £18 million. PhD students have also made a notable contribution to device development.

Multidisciplinary training

The focus on multidisciplinary working and training has become increasingly strong in the last few years and is particularly relevant to work in healthcare where a range of expertise and backgrounds are especially valuable. There are currently fairly few funding mechanisms for PhD studentships that actively encourage multidisciplinary training, however the BHF PhD funding scheme adopts a good model; students have two supervisors, one a clinician and the other an engineer, with the aim that the student will gain a greater appreciation of the engineering/clinical interface. More widely we need increased support for multidisciplinary teams and individuals (from organisations such as the National Institute for Health Research (NIHR) for example) and to more publicly recognise the need for professional scientists who can work and communicate at the relevant interfaces. It is felt that there is a shortage of UK PhD students who are properly equipped with the necessary skills to succeed in both research and the translation landscape.

Research technicians and nurses

It is difficult to bring research technicians and research nurses in to work on cardiovascular projects on short-term contracts whilst also expecting them to understand the project. This can be bypassed to some degree by asking willing RAs (Research Assistants) to work overtime.

A problematic career path for clinicians engaging in academic research

This problem is being partially addressed with a new career path for clinicians (the academic clinical fellowship programme http://www.nihrtcc.nhs.uk/intetacatrain). It was noted that when a clinician is included under Full Economic Costs (FEC) on a proposal the value of the grant can be significantly higher which can disadvantage the project as appearing to be too expensive at a selection panel meeting.

Peer review of multidisciplinary proposals

We need more academics in the cardiovascular community with the necessary skills and expertise to peer review and sit on panels for truly multidisciplinary proposals. It is currently difficult to find individuals with an in depth knowledge of cardiovascular disease and a solid, multidisciplinary background.

Key points:

(1) Training individuals in multidisciplinary teams

i. encourage projects which feature multiple supervision for PhD students, especially at the larger centres

ii. additional support for multidisciplinary teams

(2) Improved continuity in funding to support the progression of postgraduate students to RAs

(3) Recognition of the need for professional scientists, such as research nurses, who can work and communicate at the interfaces

(4) Equipping UK PhD students with the skills to succeed in both the research and translation landscape

3.3 Convenor: Professor David Newby

3.3.1 Translation

Strengthening academic interactions with industry

Collaboration with industry is often an important aspect of successful translation; we need to strengthen the interaction between academia and the smaller industry groups (such as SMEs) that are working in the cardiovascular space to more effectively translate the research in to products and into the clinic. More widely we need to stimulate more academic collaborations with industry and more focused collaborations.

Funding

There is a shortage in funding for translational work, despite the work being necessary and often very costly. Translational work can include expensive pre-clinical animal work for example, which is commonly required for developing basic cardiovascular disease research. Additionally, all translation activities much be done under the good manufacturing practice (GMP) -regulatory environment which can incur additional cost and therefore present an extra barrier to translation. In terms of clinical trials, there is now more money available for human trials from the National Institute for Health Research (NIHR) but the strict regulations can still act as a barrier to the successful translation of research to this stage.

3.3.2 Training and Skills

Academic careers

We need to work towards making an academic career a more attractive prospect for graduates and post graduate students to ensure a future supply of great minds in the cardiovascular disease area; this could mean improving the career structure and academic environment and providing greater job security.

Defined career path to NHS

There is currently no clear path to jobs in the NHS from academia, however if this were addressed it could make a career in academia seem much more attractive to a range of people.

Small UK industry base in cardiovascular disease

The lack of large UK based cardiovascular related companies means that an academic career in cardiovascular disease research may not lead as neatly to a role in industry as other areas such as imaging. This could put people who ultimately hope to have a more secure role in industry off pursuing an academic career in cardiovascular research.

3.4 Convenor: Professor Peter Weinberg

3.4.1 Translation

Cardiovascular industry base

The UK industry base relevant to cardiovascular disease is small. This presents a significant barrier to the translation of basic cardiovascular research as money and support from industry are not readily available. Actions need to be taken to stimulate the industry base in the UK and to make them less risk averse so that there can be increased adoption of cardiovascular research in to industry.

3.4.2 Training and Skills

Doctoral Training Accounts (DTAs) and Doctoral Training Centres (DTCs)

A DTC with a focus on cardiovascular disease would provide a fantastic opportunity for the area by helping to develop more of a community and by introducing aspects of multidisciplinarity to the working of the future leaders of cardiovascular research. Rebadging of DTAs to make them appear as cardiovascular DTCs would be unhelpful. The British Heart Foundation (BHF) is currently funding Centres of Research Excellence which have a similar remit to DTCs. However, these will soon be coming to an end and BHF alone is unlikely to be able to fund their continuation. This would be one possible area for collaboration with BHF.

3.5 Convenor: Professor Rhodri Williams

3.5.1 Translation

Establishing first clinical contact

It can be extremely challenging for academics to first establish a contact within the clinic; this acts as a significant barrier to the development and translation of products and technologies in to the clinic, especially for the early career academics that may well not have clinical contacts. Consequently we need to establish an appropriate forum for knowledge exchange between academics and clinicians to help academics to establish this first clinical contact. Such a forum could also be used to increase academic awareness of the clinical imperatives and culture and help academics to identify the right research challenge, the right approach and the right type of clinician to engage on the project.

Regulatory barriers

The regulatory environment in the UK can act as a definite barrier to the translation of basic cardiovascular disease research. Academics are increasingly looking to conduct the later stage translational work abroad in countries where the regulatory environment is more conducive to innovation, often taking potential profit from the successful translation of ideas out of the UK economy.

Intellectual Property (IP) issues

There is a clear need to promote early stage awareness and appreciation of IP issues, particularly in emerging areas of research involving multidisciplinary teams. A perceived lack of such awareness by academics could discourage future commercial involvement. There is also a perceived need to raise industry awareness but, for effective outcomes, there is a parallel need to promote IP portfolio funding within institutions. This could involve more efforts by institutions to fund their own IP applications or Research Councils giving a lump of money to institutions for this. A significant perceived barrier to development is the fact that IP patent costs can not at present be claimed from grants.

Funding landscape

The current funding landscape for cardiovascular disease research is perceived to be too complex; this can result in the available funding opportunities not being fully exploited. There is a particular uncertainty around where to go for later stage funding. The Research Councils should make their funding landscape more transparent and signpost the appropriate entry points for academics. This should go some way to helping research groups to maintain the momentum of their projects.

Cultural barriers

Basic scientists working together on projects need to establish good relationships and maintain effective communication channels to ensure that they each understand the culture that the other scientists have come from. It is important that the scientists each understand what the other individuals hope to gain from the project and what the advantages of being involved on the project are for them. If the basic scientists on a project are not communicating effectively then the project can be stunted by conflicting ambitions and ideas and lack direction.

3.5.2 Training and Skills

PhD training

It is widely felt in the cardiovascular disease research community that longer (four year) more interdisciplinary PhD training in the area would be of significant benefit to the students, the community and the research. It was noted that EPSRC's Doctoral Training Centres (DTCs) are a particularly good model of four year interdisciplinary PhD training and clearly illustrate the advantages of having not only the fourth year, but also the excellent start in the foundation year and the added benefits of being a part of a large local research community (neither of which the majority of PhD students experience). Teaching students in the future, as a part of their PhD training, about the routes to achieving impact with their research would be an interesting way of educating the next generation of principle investigators in this important topic and would give the students a specialism that they can take with them in to their research groups and use to educate their colleagues.

Recruitment and retention

Postgraduate students are considered as valuable additions to research teams as previously many have made important contributions to research projects and have conducted research that has lead to spin out companies; however it is now harder to attract postgraduate students. Within the discussion group alone members had had experiences of postgraduate students championing product development and driving this through to products. Both the recruitment and the retention of postgraduate students is a challenge for the research community, with many postgraduate students choosing to work in the financial industry, for example. For many students, academia does not look like an attractive career option.

Early clinical engagement

We need mechanisms to establish and manage the immersion of PhD students into clinical settings and allow sufficient time for this in PhD training. The DTCs allow the requisite flexibility for this. PhD students and postdoctoral students can typically be quite naïve about hospital research so allowing students to experience a clinical environment can be an important aspect of their training. There is currently a lack of a formal structure for implementing PhD training within hospitals. For the efficient translation of research there needs to be a clear link with the clinical environment so the earlier we can begin engagement, the better.

Problem solving with clinicians

Academics can engage clinicians by working to identify and address clinical needs.

Appropriate fora for training

There is a need for appropriate fora for training academics in key areas such as ethics, regulations and IP. Summer schools could be very effective here. Guidelines are specifically required around understanding and protecting IP. Knowledge and skills in these three key areas across the workforce would be extremely useful to those academics conducting basic research and also to those academics working to translate their research.

4. Key messages from the day

4.1 Strengths

- Modelling of the cardiovascular system
- Device development
    - stents developed in the UK for example are now being used worldwide
- Cardiovascular imaging
    - more specifically, UK research in magnetic resonance imaging and image analysis is very strong

The three areas detailed above are not areas of strength unique to the UK however, but are strengths in the USA and Europe too.

The following on the other hand, are areas of up and coming strength in which the UK could further strengthen its international presence:

- Regenerative medicine
- Point of care diagnostic techniques
- Robotic surgery

Additional UK strengths include:

- A strong fundamental research base to underpin research into cardiovascular disease
    - supported by multiple funding bodies which leads to increased diversity
- National Health Service
    - one regulatory process to go through when getting techniques and devices adopted in to the clinic nationwide
    - high level of national investment in the system.
    - presence of the NHS in University Hospitals allows for better engagement between clinicians and academics

4.2 Weaknesses and Gaps

- The interfaces between the different Research Councils, the British Heart Foundation (BHF) and other charities working in this area are not well defined
    - funding routes are often perceived as unclear
    - there is a lack of awareness of where to get follow-on funding
    - it would be helpful if funding opportunities in the cardiovascular area could be mapped to give a clear funding guide

- Clinical engagement
    - need to encourage early clinical engagement on more projects
    - once feasibility studies have been successfully completed research groups need to rapidly increase the amount of clinical engagement on projects
    - need mechanisms (funding and training) to nurture engagement
- Small, risk adverse UK industry base
    - industry is often risk averse and requires evidence of high levels of clinical research before investing; usually includes evidence of costly Phase 1 clinical trials and often Phase 2 as well
    - one way to overcome this barrier is to keep ideas and projects within the universities and to equip academics with the knowledge and skills to exploit the technologies themselves
- Cardiovascular disease over the life span
    - an emerging area, where there is not enough research being conducted that looks at cardiovascular disease over the life span or in the early years
    - this is high on the clinical agenda and a priority for the NHS
- Cheaper cardiovascular devices for use in less economically developed countries
- Cardiovascular based clinical trials require a large number of patients and are expensive
    - level of patient interest in participation in trials is not sufficiently high, although this can differ from area to area
- Regulatory framework is challenging
    - would be helpful to have a consultant within EPSRC to advise academics on the regulations relevant to their EPSRC project
    - need the advice of experts on the regulations in this area
    - a pooled knowledge resource for academics to go to when they have regulatory queries would be very useful
    - help and advice in this area would be especially useful with work related to stem cells and medical device

- Large animal facilities
    - there are few large animal facilities in the UK
    - the facilities are expensive to run so EPSRC needs to promote the sharing and accessing of facilities
    - EPSRC could give grants to help support the running of existing facilities
    - need to publicise the existing centres and raise awareness, however the publicising of animal facilities is sensitive and difficult
- Dispersed community
    - the cardiovascular community is very dispersed
    - it would be useful to coordinate the community to improve the information flow
    - a cardiovascular network could be useful but the output of any proposed network would need to be considered to ensure that it has impact
- Cardiovascular biomechanics
    - from the Bristol Online Survey results it seems that there are few EPSRC grants in this space
    - a lack of funding in biomechanics could result in the leading UK researchers in this area moving to work abroad where there is more funding
- Assessment of multidisciplinary grant applications
    - there is a perception amongst the community that it is difficult to get multidisciplinary grant applications through panels, in part because it is difficult to get reviewers who have the expertise to assess a whole grant versus part of it. It is also the case that at a Panel meeting there are unlikely to be experts capable of moderating any discrepancies that may result from non-expert evaluation of parts of a project
    - there is a perception that there is less of an emphasis on biological reviewing
    - Principal Investigator references could be shared between Research Councils to encourage multidisciplinary working and allow good reputations to transfer between councils
    - research councils could co-opt college members from other research councils to sit on their panels when multidisciplinary proposals are being looked at

4.3 Opportunities (with overlap with Section 4.2 Gaps)

- Working with the NHS
    - decentralising healthcare
- Overseas exportation
    - exportation of low cost medical devices to the developing world for example
    - exportation of devices, technologies and drugs that have been developed in the UK for adoption by other healthcare systems overseas
- Therapeutics over diagnostics
    - drug discovery and drug delivery
    - opportunity here for the UK to have a significant contribution

4.4 Translation

- Assessment of multidisciplinary grant applications
    - multidisciplinary projects tend to lend themselves to translation more than single discipline projects
    - as discussed above in Section 4.2, there are several problems associated with the assessment of multidisciplinary grant applications and these can act as barriers to the funding of these projects
- Multiple disconnects down translation chain
    - for example: clinical trials are costly and funding is hard to get
    - need a road map showing the funding available for projects at all stages, from all relevant funding bodies in the cardiovascular space
    - needs to be a central team of people to advise research groups and answer queries related to funding and translation
    - it is hard to provide capability and pilot data for industry due to the cost as these studies have to be large
- Research base funding
    - it is considered difficult to get projects at higher technology readiness levels through 'responsive mode' peer review
    - targeted calls could offer a solution
    - when projects are more developed, pitching to a committee might be a fairer way of making funding decisions than peer review
- Earlier clinical involvement
    - early active clinical involvement can open doors on projects and should be encouraged
    - clinicians can help to give the right direction to projects at the right time
- Industry involvement
    - though it is widely felt that there is value to this step not everyone knows who to contact
    - networks such as the Knowledge Transfer Networks (KTNs), run by the Technology Strategy Board (TSB), offer academics the opportunity to network with individuals from business and get information on policy and regulation
    - targeted calls which require industry involvement should be announced earlier than standard calls as research groups need time to manage meetings with industry and nurture these relationships

4.5 Training and Skills

- Opportunity to work with the National Institute for Health Research (NIHR)
    - increase academic engagement with clinicians and vice versa
    - the application process might be difficult
    - peer review in NIHR opposed to EPSRC
- Doctoral Training Centres (DTCs) opposed to summer schools
    - one or more DTCs relevant to cardiovascular disease across the country would be a great benefit to the area
    - summer schools in the area would help the community to get to know each other more and would be a good way of sharing skills and knowledge
    - due to the nature of cardiovascular research the summer schools should have a very multidisciplinary feel to them so as to attract a wide range of academics with a broad range of expertise
- EPSRC collaboration with the British Heart Foundation (BHF)
    - EPSRC could collaborate with BHF on a specific call, for example Centres of Excellence with an engineering and physical sciences focus, a DTC or a fellowship scheme
- Annual symposia in cardiovascular disease
    - for engineering and physical sciences researchers
    - for clinicians and industry
- Establish career fellowships
- PhDs in the UK
    - need to consider new mechanisms for PhD-training for postgraduate students who are following an NHS career trainee pathway (akin to the academic clinical fellowships for medical students/trainees but with an emphasis on technology development)
    - there is an under supply of highly qualified postdoctoral researchers in cardiovascular engineering and physical sciences research pointing to the need to train more people at the PhD level and to find mechanisms to maintain them in the UK academic research environment. This is being compounded by the recent introduction of tuition fees, with the first students affected by this now graduating, which discourages able undergraduates from considering studying for a PhD. Mechanisms need to be considered to address this, for instance, helping students who complete a higher degree pay off educational loans.

5. Conclusions

Some of the issues raised at this meeting are not surprisingly issues shared with researchers at the other Theme Days.

What is perhaps interesting about this UK community is that is relatively small in comparison to the importance of the disease, and this meeting was the first that had brought researchers together to discuss common interests.

Taking things forward:

- It would be particularly important to look in more depth at current barriers in cardiovascular engineering and physical sciences research including the implications of the lack of a UK industry base.
- There is significant interest in developing stronger links in research and training with the British Heart Foundation and the National Institute for Health Research.
- It would be very useful to have a map of the cardiovascular engineering and physical sciences portfolio of funding over which researchers can navigate.
- Finally, the community is keen to develop better ways to network and collaborate to build a critical mass of UK research in the cardiovascular engineering and physical sciences area

Appendix 1: List of Attendees

Name	Organisation
Kadem Al-Lamee	Arterius Ltd
David Atkinson	University College London
Milan Bates	University of Bristol
Neil Bressloff	University of Southampton
Fiona Broughton-Pipkin	University of Nottingham
Iain Buchan	University of Manchester
Gaetano Burriesci	University College London
Simon Capewell	University of Liverpool
Andrew Chipperfield	University of Southampton
Richard Clayton	University of Sheffield
Geraldine Clough	University of Southampton
Timothy Coats	University of Leicester
David Crosby	Medical Research Council
Sanja Dogramadzi	University of the West of England
Darrel Francis	Imperial College London
Daniel Gibbons	Imperial College London
Robert Glen	University of Cambridge
Terry Gourlay	University of Strathclyde
Sian Harding	Imperial College London
Dorian Haskard	Imperial College London
Barrie Hayes-Gill	University of Nottingham
Thien How	University of Liverpool
Alun Hughes	Imperial College London
Eileen Ingham	University of Leeds
Name	Organisation
Simon Kerley	BBSRC
Matthew Lim	University of Cambridge

Name	Organisation
Raoul van Loon	Swansea University
Steve McLaughlin	University of Edinburgh
Chris McLeod	Imperial College London
Majid Mirmehdi	University of Bristol
Alan Murray	Newcastle University
Ian Nabney	Aston University
Stuart Nicklin	University of Glasgow
Nikolay Nikolaev	Loughborough University
Ernesto Oviedo-Orta	University of Surrey
Kim Parker	Imperial College London
Stephen Payne	University of Oxford
Jeremy Pearson	British Heart Foundation
Kawal Rhode	King's College London
Daniel Rueckert	Imperial College London
Michael Schneider	Imperial College London
Alexander Seifalian	University College London
Spencer Sherwin	Imperial College London
Geoff Tansley	Aston University
Mehdi Tavakoli	Healthcare KTN
Andrew Taylor	University College London
Ruediger Thul	University of Nottingham
Brian Tighe	Aston University
Cathy Tralau-Stewart	Imperial College London
Ben Varcoe	University of Leeds
Name	Organisation
Graeme Ward	ActiveSignal Ltd
Terry Wilkins	University of Leeds
Nigel Wood	Imperial College London

Appendix 2: EPSRC – Cardiovascular Disease Day – Guoman, London

Agenda for attendees – 24 February

Time	Activity
10:00	**Registration and Coffee**
10:30	**Welcome, Background and Introduction to Panel** Aims and expected output - EPSRC
10:50	**Panel's Expectations for the Day** Panel Chair
11:00	**Format of the Day** EPSRC
11:10	**Sessions with Panel** - to look at questions (1) and (2) (1) What are the areas of Strength for this community in the UK? (2) What are the Gaps and/or opportunities for this community in the UK?
12:30	**Lunch and Networking** An opportunity to mix with colleagues and panel members
13:45	**Feedback from Sessions**
14:15	Sessions with Panel - to discuss the issues (3) and (4) (3) Translation of basic research into the clinic or into products for cardiovascular disease (4) Training/skills needs across the workforce in EPS healthcare related to cardiovascular disease
15:15	**Networking Coffee**
15:45	**Feedback from Sessions**
16:15	**Closing Remarks and Next Steps** EPSRC

Appendix 3: Breakout Groups

Green Group 1: Alison Noble and Rosie Jackson

- Simon Capewell
- Daniel Gibbons
- Eileen Ingham
- Ian Nabney
- Stuart Nicklin
- Nikolay Nikolaev
- Michael Schneider
- Simon Kerley
- Andrew Taylor
- Cathy Tralau-Stewart

Yellow Group 2: Andrew Lewis and Carmine Ruggiero

- Iain Buchan
- Geraldine Clough
- Sian Harding
- Chris McLeod
- Majid Mirmehdi
- Ernesto Ociedo-Orta
- Kim Parker
- Geoff Tansley
- Ben Varcoe

Blue Group 3: David Newby and Amanda Chmura

- Milan Bates
- Andrew Chipperfield
- Richard Clayton
- Dorian Haskard
- Thien How
- Daniel Rueckert
- Alexander Seifalian
- Mehdi Tavakoli
- Brian Tighe
- Ruediger Thul
- Terry Wilkins

Red Group 4: Peter Weinburg and Tom Headen

- Kadem Al-Lamee
- David Atkinson
- Fiona Broughton-Pipkin
- Sanja Dogramadzi
- Robert Glen
- Terry Gourlay
- Alan Hughes
- Stephen Payne
- Jeremy Pearson
- Kawal Rhode
- Spencer Sherwin

Pink Group 5: Rhodri Williams and Linda Sayers

- Gaetano Burriesci
- Timothy Coats
- David Crosby
- Darrel Francis
- Barrie Hayes-Gill
- Mathew Lim
- Raoul van Loon
- Steve McLaughlin
- Graeme Ward
- Nigel Wood

Appendix 4: List of EPSRC grants relevant to the Cardiovascular Disease Day

Grant Ref	PI Name	Grant Title
EP/D503035/1	Whiteley, Dr J	Adaptive Finite Element Computations of Nonlinear Elasticity Problems
DT/F006314/1	Hart, Dr SL	Adjunct Gene Therapy for Coronary Artery Bypass Surgery
EP/E004156/1	Goulermas Dr JY	An Automated Image Analysis and Measurement System for Video-fluoroscopic Evaluation of Swallowing Dysfunctions
EP/F058640/1	Elwyn Prof G	An Innovative Multidisciplinary Patient-centric Early Detection Care Model
EP/C539834/1 EP/C539842/1	Sherwin, Professor SJ	Arteries and Algorithms: Computational Physiological Flow and Arterial Disease Modelling
GR/T01983/01	Langley, Dr P	Atrial Repolarisation: New Measures for Non-Invasive Assessment of Heart Disease
EP/F011628/1	Pitt-Francis, Dr JM	Chaste - Developing Software for Realistic Heart Simulations
EP/G007527/1	Smith, Dr NP	Computer to Clinic: Personalised Fluid-Mechanical Models Applied to Heart Failure
EP/D060834/1	Robson, Dr MD	Development and Validation of Automated Analysis Tools for Clinical Interpretation of Vascular Magnetic Resonance Images
EP/F012764/1	Murray, Professor A	Development of an Intelligent Blood Pressure Measurement Device to Reduce Measurement Variability
EP/D060877/1 EP/D061474/1	Hill, Prof DLG Razavi, Prof RS	Electro-Anatomical Fusion for Guiding EP Procedures and Patient Specific Modelling

Grant Ref	PI Name	Grant Title
EP/E003281/1	Kazarian, Professor SG	FTIR Spectroscopic Imaging Applied to Atherosclerosis
EP/D073618/1	Korossis, Dr SA	Guided Functional Re-engineering of the Mitral Valve
EP/F059140/1 EP/F059175/1 EP/F059361/1	Hose, Dr DR Razavi, Prof RS Smith, Dr NP	Grand Challenge: Translating Biomedical Modelling into the Heart of the Clinic
EP/C532759/1	Holden, Prof A	High Throughput Electrophysiological, Electromagnetic and Electromechanical Cardiac Virtual Tissue Engineering
EP/G002800/1	Hilton, Prof A	i3Dlive: Interactive 3D Methods for Live-Action Media
EP/E009258/1 EP/E009697/1 EP/E009832/1	Peyton, Prof AJ Griffiths, Prof H Williams, Prof R	Imaging Low Conductivity Materials in Magnetic Induction Tomography - LCOMIT
EP/C535219/1	Bencsik, Dr M	Imaging of Viscous Fluid Pressure for Flow in Porous Media with MRI using Gas-Filled Liposomes
EP/F03010X/1	Gil, Dr AJ	Immersed Finite Element Method for Haemodynamic Medical Applications
EP/F042868/1	Quinn, Dr TA	Integrated Experimental and Computational Research Tools for the Study of Acute Ischaemic Effects on Cardiac Mechano-Electrical Interactions
EP/E038379/1	Burrowes, Dr KS	Investigation of Perfusion Control Mechanisms in the Pulmonary Circulation via a Computational Model
GR/T23428/01	Rockett, Dr PI	JEFI: Preliminary Investigation of the Quantitative Imaging of Collateral Circulation from Digital Subtraction Angiograms

Grant Ref	PI Name	Grant Title
EP/G500274/1	Cheong, Dr A	JEFI: Targeting the Electric Field of Blood Vessels for the Treatment of Vascular Disease
EP/E504477/1	Kohl, Dr P	JEFI:Technologies for 3D Histologically-detailed Reconstruction of Individual Whole Hearts
EP/D50953X/1	Glen, Professor R	JEFI: Statistical Complexity Measure as a Diagnosis Tool for Cardiac rhythms
TS/G002142/1	Schaeffter, Professor TR	Magnetic Resonance Guided Therapy of Cardiac Arhythmia (MaRGiTA)
EP/G045798/1	Mattia, Dr D	Mass Transport at the Nanoscale
EP/C523008/1	Rueckert, Professor D	Model-based 2D-3D Registration and Tracking of Deformable Objects for Image-Guided Minimally Invasive Cardiac Interventions
EP/C523016/1	Hawkes, Professor D	Model-based 2D-3D Registration and Tracking of Deformable Objects for Image-Guided Minimally Invasive Cardiac Interventions
EP/F043929/1	Niederer, Mr SA	Modelling Cardiac Energy Supply during Heart Failure
EP/F00382X/1	Rodden, Professor T	Motivating Mobility: Interactive Systems to Promote Physical Activity and Leisure for People with Limited Mobility
EP/D061555/1	Seifalian, Prof AM	Nanocomposites and Electrohydrodynamic Forming: The new route for the development and construction of biocompatible cardiac valves
EP/D064678/1 EP/D064732/1 EP/D064872/1 EP/D064945/1	Stevens, Dr M You, Dr Zhong Seifalian, Prof AM Lu, Professor J	Novel Functional Nanocomposite Engineering of Stents

Grant Ref	PI Name	Grant Title
EP/E066240/1	Weinberg, Professor PD	Of Mice and Men: Adjustment of Endothelial Cells to the Different Haemodynamic Wall Shear Stresses Occurring in Arteries of Different Species
EP/D070554/1	Nithiarasu, Prof P	Patient Specific Computational Modelling of Human Upper Airway Collapse
GR/T06735/01	Yang, Professor G	Platform: Cardiovascular Magnetic Resonance: from Morphology to Function
EP/C513037/1	Williams, Prof PR	Portfolio Partnership In Complex Fluids and Complex Flows
EP/F057016/1 EP/F057059/1	Bates, Professor D Hardman, Dr JG	Preventing Ventilator-Associated Lung Injury using Feedback Control Engineering
EP/G030693/1	Noble, Professor JA	Quantitative 4D Echocardiography using Fusion Techniques and Spatio-temporal Analysis
EP/E032990/1	Halliwell, Prof N	Replacement Laser for the Optical Engineering Research Group (Equipment for Multiple Projects Proposal)
EP/D074746/1 EP/D074789/1	Barkley, Prof D Biktasheva, Dr IV	Response Functions for Drift of Spiral and Scroll Waves
EP/F001835/1 EP/F001916/1 EP/F001959/1 EP/F002815/1	Hawley, Prof M Eccleston, Prof C Black, Prof ND Mountain, Prof GA	SMART: Self Management supported by Assistive, Rehabilitation and Telecare Technologies
EP/E028241/1	Blyth, Dr M	The Motion of Red Blood Cells Through Capillary Bifurcations
EP/F065574/1	Bernus, Dr OG	Three-dimensional Optical Imaging of Cardiac Electrical Activity using Alternating Illumination
EP/E001076/1 EP/E001564/1	Razavi, Prof R Atkinson, Dr D	Time-resolved Whole-Heart Cardiac Imaging using Highly Parallel Magnetic Resonance

Grant Ref	PI Name	Grant Title
EP/E056733/1 EP/E056741/1 EP/E05739X/1	Health, Dr WP Chipperfield, Dr AJ Khan, Dr M	Transgenic Modelling of Beta-cell Homeostasis.

Appendix 5: Results from Bristol on Line Survey

Cardiovascular Disease Survey Results

Survey Overview

Number of respondents: 40
Expected number of respondents: 200
Response rate: 20.0%
Launch date: 10 Dec 2009
Close date: 05 Feb 2010

Section 1: Personal Details

1. Name

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

2. Affiliation

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

3. Email address

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

Section 2: Background Information

4. Please tick boxes which relate to your research area.

Medical Modelling and Simulation:	n/a	26
Medical Instrumentation, Devices and Equipment:	n/a	23
Image and Vision Computing:	n/a	11
Disease and Treatment:	n/a	16
Drug Formulation and Delivery:	n/a	4
Materials Research:	n/a	9
Multiphase Flow:	n/a	5
Other *(please specify)*:	n/a	15

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

5. Have you been awarded any EPSRC grants in the last 5 years as a Principal Investigator or Co-investigator?

Yes:	53.8%	21

No:		46.2%	18

5.a. If yes, please give details e.g. grant reference number.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

6. Do you hold any current research grants that have been awarded by another funding agency?			
Yes:		71.8%	28
No:		28.2%	11
6.a. Which other agency have you received funding from?			
MRC:		n/a	6
BBSRC:		n/a	8
Technology Strategy Board:		n/a	1
Other Government Department:		n/a	6
Industry:		n/a	7
Charity:		n/a	18
EU:		n/a	6
Other *(please specify)*:		n/a	9

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

6.b. Please provide details of the research grants you currently hold that are related to this area.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

7. Have you encountered any barriers to funding the next stages of your research e.g. into products?			
Yes:		53.8%	21
No:		46.2%	18

7.a. If yes, please describe these barriers.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

8. Do you engage with users in developing your research e.g. clinicians, patients and industry?			
Yes:		94.9%	37
No:		5.1%	2
8.a. Please indicate which users you engage with			
Clinicians:		n/a	37
Patients:		n/a	13
Large companies:		n/a	13
SMEs:		n/a	16
Other *(please specify)*:		n/a	3

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

8.b. How often do you engage with users and what form does this take?

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

9. How much consideration do you give to future clinical adoption when developing ideas for your research?			
High:		82.1%	32
Medium:		17.9%	7
Low:		0.0%	0

9.a. If appropriate, please explain your answer.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

Section 3: Strengths in EPSRC's Healthcare Portfolio

10. What are the UK's strengths in the area of Cardiovascular Disease research? Please use evidence to back up your statements (e.g. citations, bibliometrics, RAE returns, conference invitations)

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11. For your areas of expertise within the field of Cardiovascular Disease, how does UK research compare internationally?			
11.a. Medical Modelling and Simulation			
UK is World leader:		6.1%	2
UK is internationally excellent:		48.5%	16
UK is recognised internationally:		24.2%	8
UK is recognised nationally:		3.0%	1
UK is below national recognition:		0.0%	0
Not area of expertise:		18.2%	6
11.a.i. Medical Modelling and Simulation -- Please provide comments and evidence to explain your response.			

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.b. Medical Instrumentation, Devices and Equipment			
UK is World leader:		6.5%	2
UK is internationally excellent:		32.3%	10
UK is recognised internationally:		25.8%	8

UK is recognised nationally:		6.5%	2
UK is below national recognition:		6.5%	2
Not area of expertise:		22.6%	7

11.b.i. Medical Instrumentation, Devices and Equipment -- Please provide comments and evidence to explain your response.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.c. Image and Vision Computing

UK is World leader:		6.5%	2
UK is internationally excellent:		25.8%	8
UK is recognised internationally:		32.3%	10
UK is recognised nationally:		3.2%	1
UK is below national recognition:		0.0%	0
Not area of expertise:		32.3%	10

11.c.i. Image and Vision Computing -- Please provide comments and evidence to explain your response.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.d. Disease and Treatment

UK is World leader:		10.3%	3
UK is internationally excellent:		37.9%	11
UK is recognised internationally:		20.7%	6
UK is recognised nationally:		6.9%	2
UK is below national recognition:		0.0%	0
Not area of expertise:		24.1%	7

11.d.i. Disease and Treatment -- Please provide comments and evidence to explain your response.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.e. Drug Formulation and Delivery

UK is World leader:		7.1%	2
UK is internationally excellent:		17.9%	5
UK is recognised internationally:		7.1%	2
UK is recognised nationally:		10.7%	3
UK is below national recognition:		3.6%	1
Not area of expertise:		53.6%	15

11.e.i. Drug Formulation and Delivery -- Please provide comments and evidence to explain your response.			
View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.			
11.f. Materials Research			
UK is World leader:		3.3%	1
UK is internationally excellent:		16.7%	5
UK is recognised internationally:		16.7%	5
UK is recognised nationally:		10.0%	3
UK is below national recognition:		3.3%	1
Not area of expertise:		50.0%	15
11.f.i. Materials Research -- Please provide comments and evidence to explain your response.			
View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.			
11.g. Multiphase Flow			
UK is World leader:		0.0%	0
UK is internationally excellent:		6.9%	2
UK is recognised internationally:		24.1%	7
UK is recognised nationally:		0.0%	0
UK is below national recognition:		0.0%	0
Not area of expertise:		69.0%	20
11.g.i. Multiphase Flow -- Please provide comments and evidence to explain your response.			
Strong generic multiphase flow research, particularly physical aspects; simulation, however, rather poor.			
what is multiphase flow (outside fluid mechanics)?!			
11.h. Other (please specify in comments)			
UK is World leader:		25.0%	3
UK is internationally excellent:		25.0%	3
UK is recognised internationally:		0.0%	0
UK is recognised nationally:		8.3%	1
UK is below national recognition:		0.0%	0
Not area of expertise:		41.7%	5
11.h.i. Other (please specify in comments) -- Please provide comments and evidence to explain your response.			
View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.			
11.i. Other (please specify in comments)			
UK is World leader:		11.1%	1

UK is internationally excellent:		22.2%	2
UK is recognised internationally:		0.0%	0
UK is recognised nationally:		0.0%	0
UK is below national recognition:		0.0%	0
Not area of expertise:		66.7%	6

11.i.i. Other (please specify in comments) -- Please provide comments and evidence to explain your response.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.j. Other (please specify in comments)

UK is World leader:		0.0%	0
UK is internationally excellent:		25.0%	2
UK is recognised internationally:		12.5%	1
UK is recognised nationally:		0.0%	0
UK is below national recognition:		0.0%	0
Not area of expertise:		62.5%	5

11.j.i. Other (please specify in comments) -- Please provide comments and evidence to explain your response.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

11.k. Other (please specify in comments)

UK is World leader:		0.0%	0
UK is internationally excellent:		0.0%	0
UK is recognised internationally:		0.0%	0
UK is recognised nationally:		0.0%	0
UK is below national recognition:		0.0%	0
Not area of expertise:		100.0%	5

11.k.i. Other (please specify in comments) -- Please provide comments and evidence to explain your response.

Section 4: Gaps in EPSRC's Healthcare Portfolio

12. Please describe any gaps that you consider exist within UK research in Cardiovascular Disease, giving evidence for your statements.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

12.a. How do you think these gaps may be addressed?

View All Responses - There are too many responses to display on this page and so all the responses to this question

are available on a separate page.

Section 5: Looking ahead to 2019

13. What do you consider is needed in the future to ensure that there is a sufficient balance of skills across all levels (from early training through to highly skilled specialists) within the area of Cardiovascular Disease?

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

14. Do you have any success stories from EPSRC funded research related to this area? For example, patents, spin outs, impact or good news case studies. Please provide details below.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

14.a. Do you have any success stories from research in this area from other funding sources? Please provide details below.

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

15. We welcome any more general comments, not already covered in this survey, that you would like to make about EPSRC funding in the area of Cardiovascular Disease (200 words maximum)

View All Responses - There are too many responses to display on this page and so all the responses to this question are available on a separate page.

Appendix 6: Bibliometric Data

Section 1 – Introduction and Summary

This report has been put together with citation data from Thomson Reuters' Web of Science (WoS). From this I have extracted citation counts for articles and review articles from both a set of journals suggested by the panel, and for the Thomson Reuters-defined "Cardiac and Cardiovascular Systems", with the aim of assessing the performance of the UK in this field. The UK is compared to world average values, as well as those counties who produce a large volume of papers in this subject, namely, the USA, France, Germany, Italy, Canada, Japan and China.

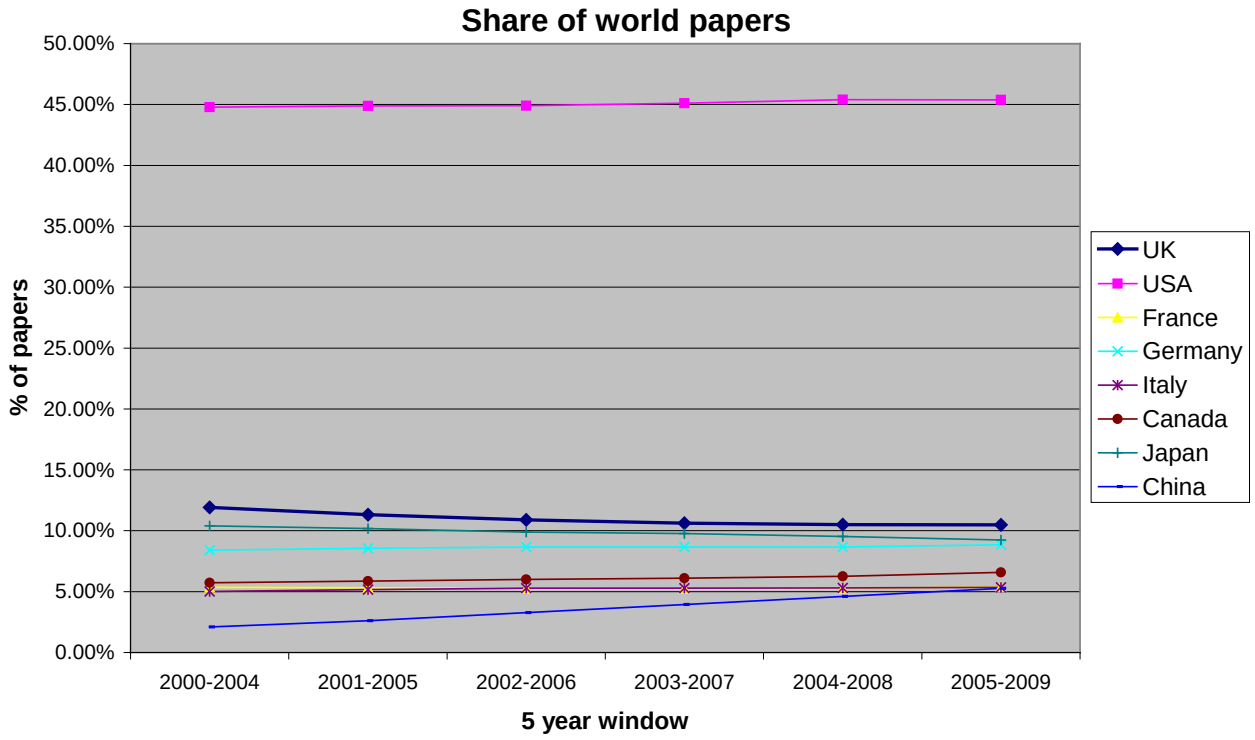
To indicate the quality of research, we use the citation impact (defined as the number of cites per paper) of a set of papers. WoS was last updated 13 February 2010. To smooth out trends, I have put the data across five-year rolling windows, starting with 2000-2004, up to 2005-2009. Citation impact is represented in two ways, either citations to present, or five-year citations. Citing to present represents the lifetime impact of a set of papers, by counting all citations received for papers published over a five-year window. This is represented relative to world average in the field. Five-year cites shows, for papers in a five-year window, the citations received in those five-years. This can be shown as actual values.

Summary

Overall we see that the UK's output in the field is shrinking. The effect of this is compounded by the fact that world output is increasing. Despite this fall in the share of papers, the quality of our work remains above average, and rising, as shows by the citation impact. In both the panel defined and the predefined Thomson Reuters' fields, the UK comes out well in terms of citation impact.

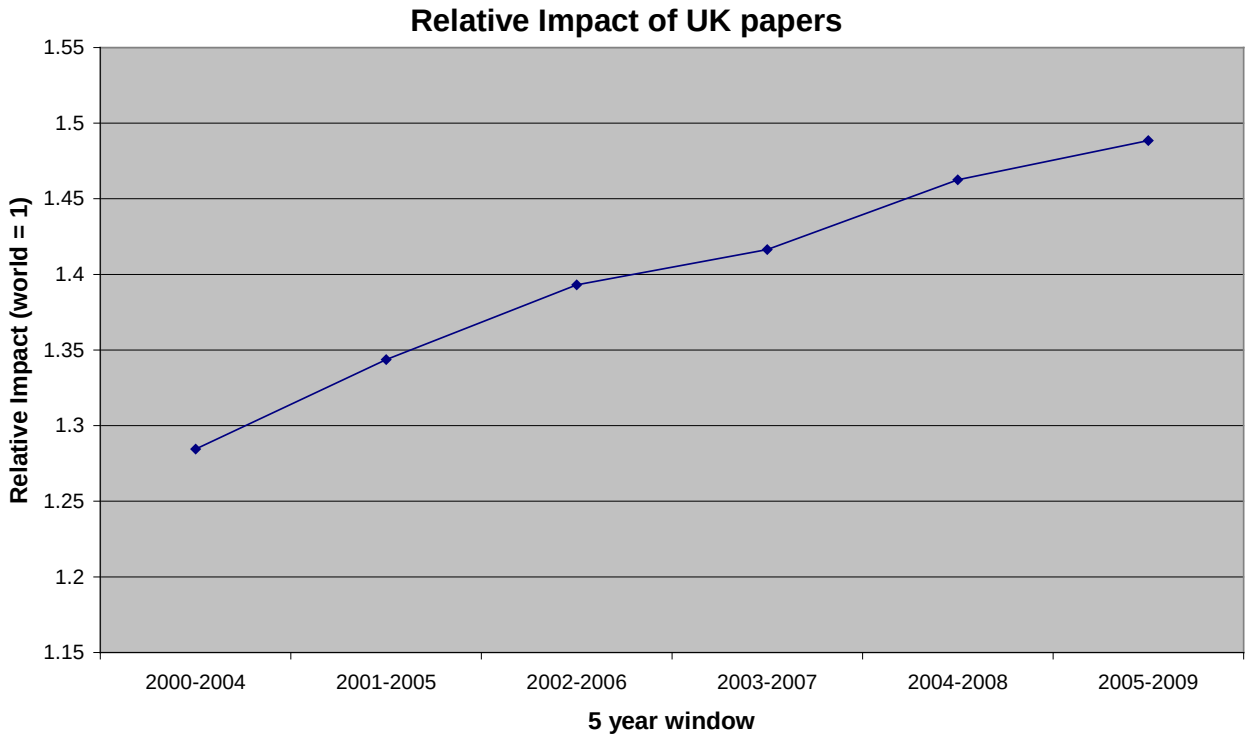
Section 2 – Panel Journals

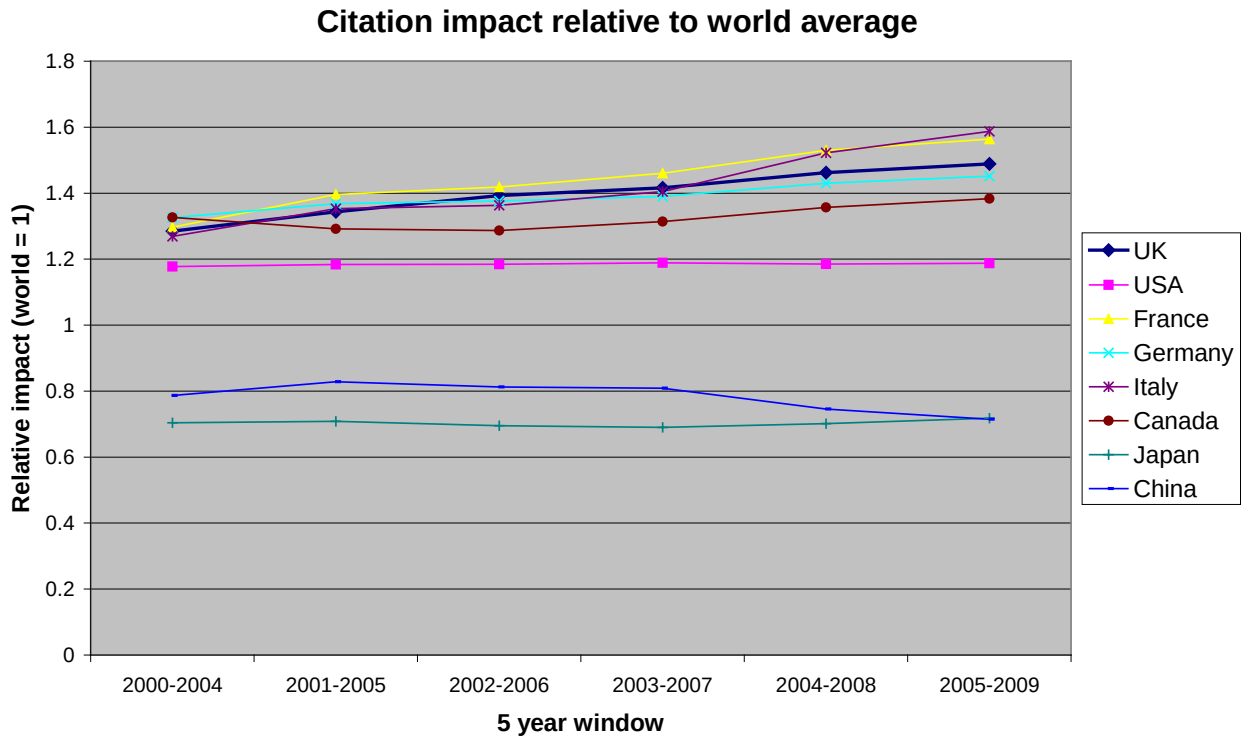
This journal set was chosen as the top journals the panel members were likely to publish in. As such they represent the publication habits of some of the top researcher sin the area in the UK, and may, therefore, show the UK in a more positive light than an international list of journals. Below is a chart showing the UK share of world papers. As is normally the case, the USA dominates, in terms of volume. The UK is consistently in second place, but we have a falling trend in both the number of publications and the shore of world publications. The UK published 8096 papers in 2000-2004, and 7776 in 2005-2009, a fall of 3.95%. This is against the worldwide rise in publications of 9.23%.



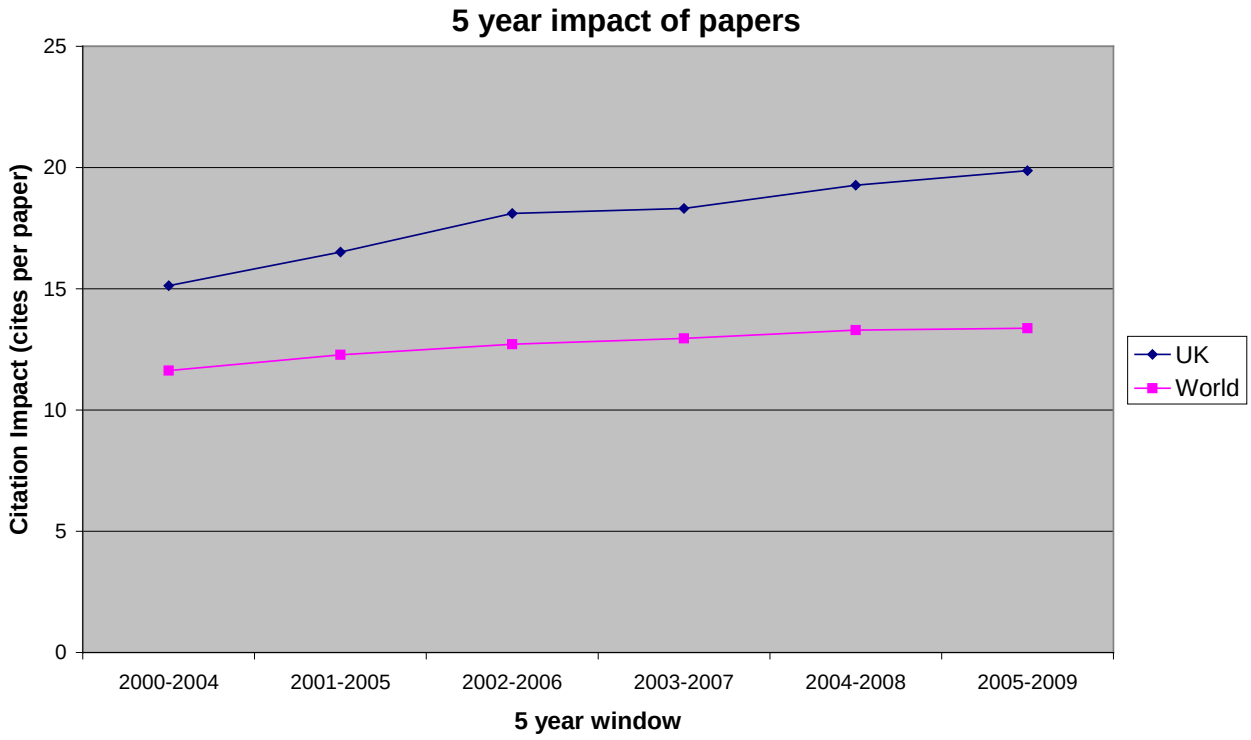
Relative Impact

The next chart shows the relative impact of UK papers. This shows that the UK's performance is pleasingly above average, and rising. The relative score rises from 1.28 times the average for the field in 2000-2004, to 1.49 in 2005-2009. Below this is the relative impact for the UK, and the competitors mentioned above. This shows that, although the UK is performing well, so are her competitors. The main competitors are Italy, France and Germany. Surprisingly, the USA comes out far below many of the competitor countries. This could be accounted for by differing publishing habits.



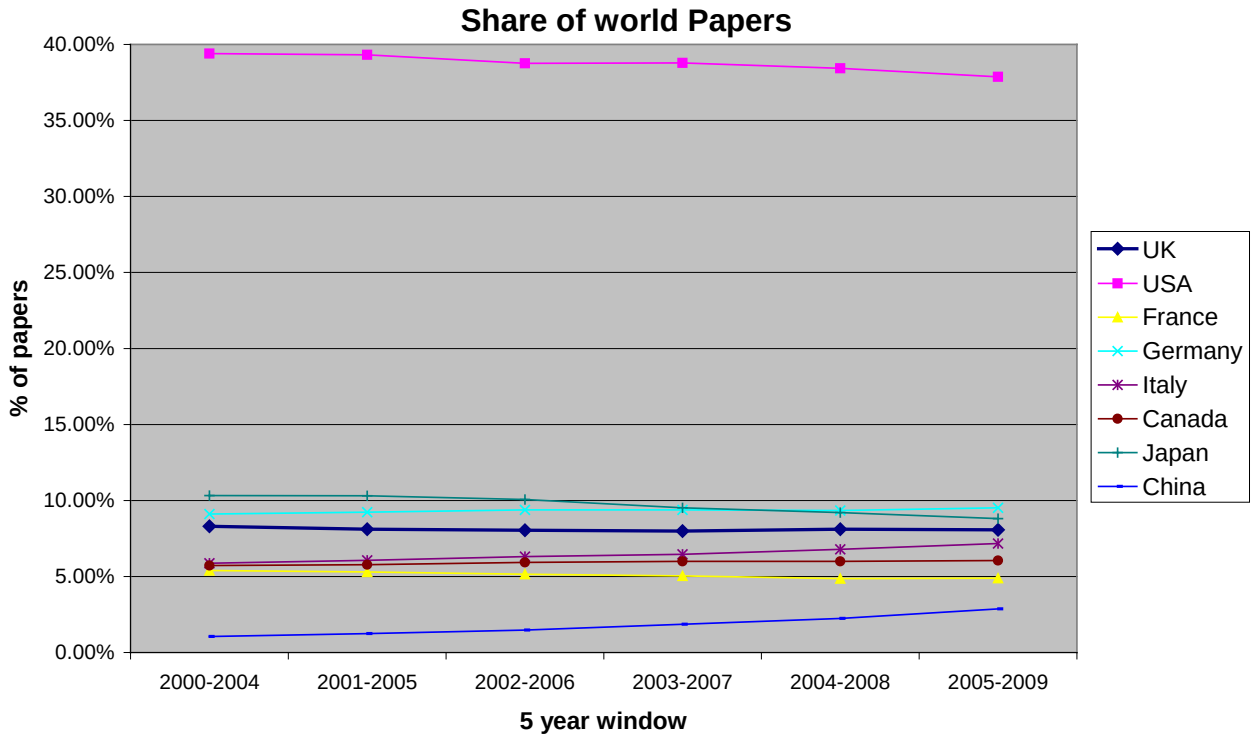


To use non-relative values for the citation impact, the five-year impact graph is below. This shows the UK and world levels. You can see that the UK has a higher citation impact than the field worldwide, and is increasing at a quicker rate, demonstrating the high quality of our research.

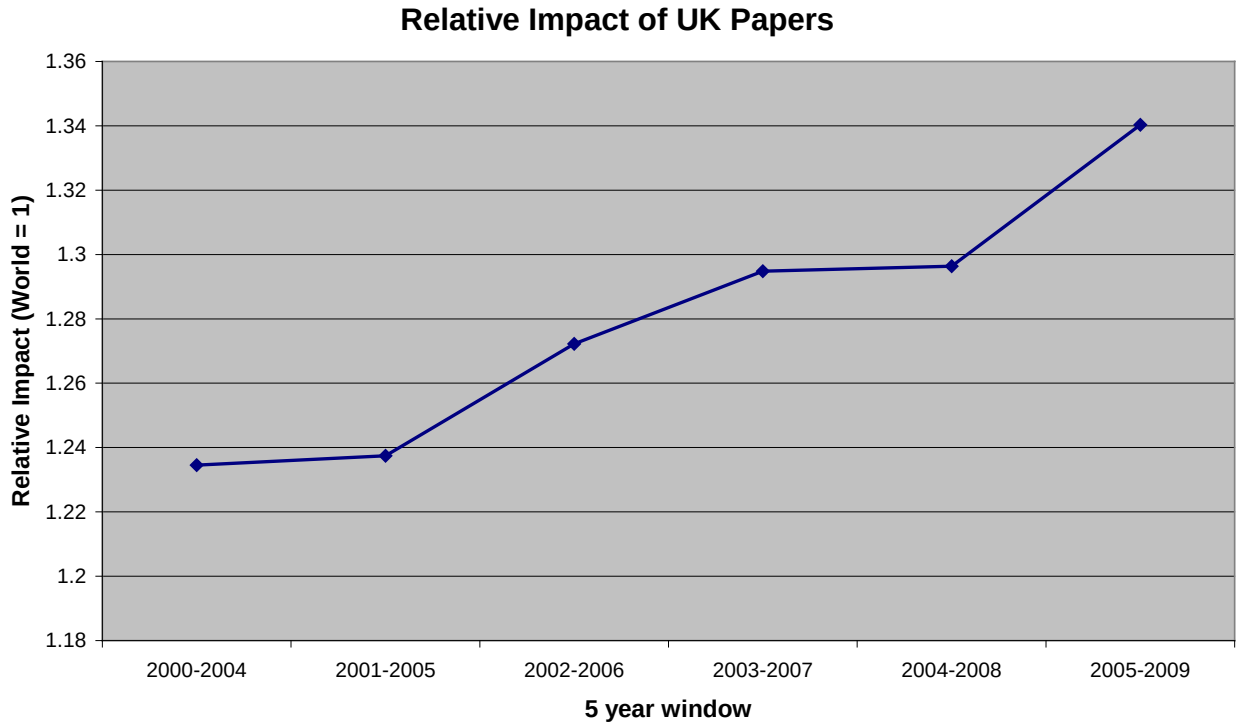


Section 3 – "Cardiac and Cardiovascular systems"

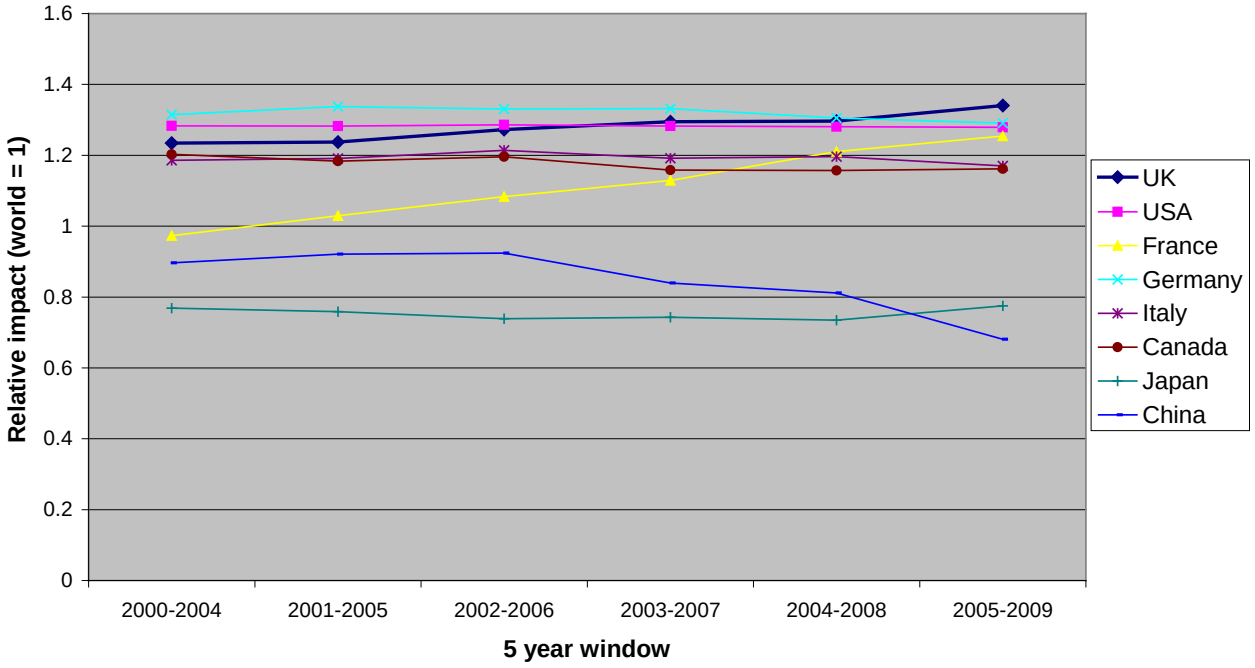
The data from the Thomson Reuters defined subject are broadly in agreement with those for the panel's list of journals. They still show that the UK has a falling share of papers, but an increasing 'impact'. Notable differences are that the UK's actual publication volume in this journal set has increased over the time-frame, and that, in terms of relative impact, the UK has risen to first place in the most recent five-year window. UK publications were 4315 papers in 2000-2004, rising to 4989 in 2005-2009 (a rise of 1.56%). This comes against a world increase of 1.90%.



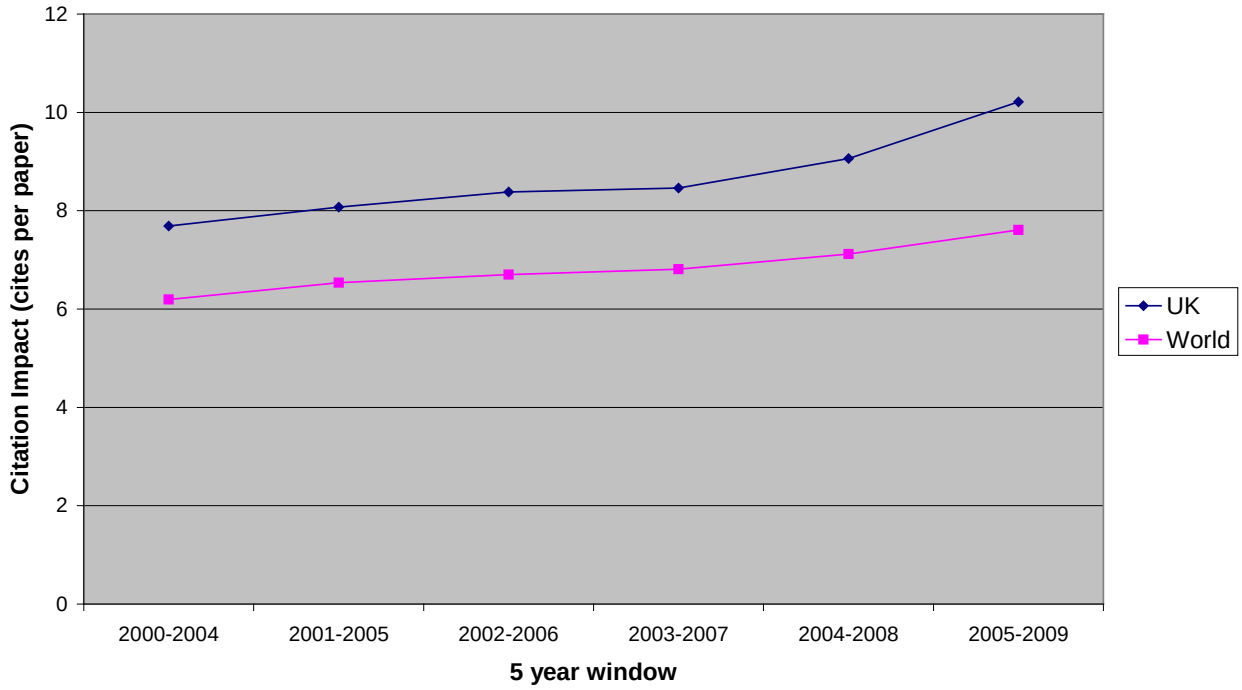
The graphs for impact show much the same trends, except for that mentioned above, ie the UK is in first place for 2005-2009, and that the USA comes much higher. The five-year impact shows a similar trend, with lower values of cites per paper. This is matched by lower world-wide values, so the UK's performance seems much the same.



Citation Impact relative to field



5 year impact of papers



Additional Information

Panel Journal List

- American Journal of Cardiology
- American Journal of Physiology-Heart and Circulatory Physiology
- Annals of Biomedical Engineering
- Arteriosclerosis Thrombosis and Vascular Biology
- Biochemical and Biophysical Research Communications
- Biomaterials
- Biophysical Journal
- Blood
- British Medical Journal
- Circulation
- Circulation Research
- Clinical Hemorheology and Microcirculation
- European Heart Journal
- Heart
- IEEE Transactions on Biomedical Engineering
- IEEE Transactions on Medical Imaging
- Journal of Biomedical Materials Research Part A
- Journal of Biomedical Materials Research Part B-Applied Biomaterials
- Journal of Controlled Release
- Journal of Vascular Surgery
- Journal of Vascular and Interventional Radiology
- Journal of Materials Science-Materials in Medicine
- Journal of The American College of Cardiology
- Journal of Biomechanics
- Journal of Cardiovascular Magnetic Resonance
- Journal of Non-Newtonian Fluid Mechanics
- Journal of The Royal Society Interface
- Journal of Thrombosis and Haemostasis
- Lancet
- Magnetic Resonance Imaging
- Magnetic Resonance in Medicine
- Medical Image Analysis
- Medical Physics

- Nature Medicine
- New England Journal of Medicine
- Physics in Medicine and Biology
- Radiology
- Regenerative Medicine
- Ultrasound in Medicine and Biology

Cardiac and Cardiovascular systems journal list

- Acta Cardiologica
- American Heart Journal
- American Journal of Cardiology
- American Journal of Geriatric Cardiology
- American Journal of Physiology-Heart and Circulatory Physiology
- Annals of Non-invasive Electrocardiology
- Annals of Thoracic Surgery
- Archives of Cardiovascular Diseases
- Archives des Maladies du Coeur et des Vaisseaux
- Basic Research in Cardiology
- Canadian Journal of Cardiology
- Cardiology Clinics
- Cardiology in the Young
- Cardiology
- Cardiovascular Drug Reviews
- Cardiovascular Drugs and Therapy
- Cardiovascular and Interventional Radiology
- Cardiovascular Pathology
- Cardiovascular Research
- Cardiovascular Therapeutics
- Cardiovascular Toxicology
- Catheterisation and Cardiovascular Interventions
- Circulation Journal
- Circulation Research
- Circulation
- Clinical Cardiology
- Clinical Research in Cardiology
- Current Opinion in Cardiology
- Current Problems in Cardiology

- Echocardiography- A Journal of Cardiovascular Ultrasound and Allied Techniques
- European Heart Journal
- European Heart Journal Supplements
- European Journal of Cardio-Thoracic Surgery
- European Journal of Cardiovascular Prevention and Rehabilitation
- European Journal of Echocardiography
- European Journal of Heart Failure
- Europace
- Heart
- Heart Failure Reviews
- Heart and Lung
- Heart Rhythm
- Heart Surgery Forum
- Heart and Vessels
- Herz
- International Heart Journal
- International Journal of Cardiology
- International Journal of Cardiovascular Imaging
- Journal of The American College of Cardiology
- Journal of The American Society of Echocardiography
- Journal of Cardiac Failure
- Journal of Cardiac Surgery
- Journal of Cardiothoracic and Vascular Anesthesia
- Journal of Cardiothoracic Surgery
- Journal of Cardiovascular Electrophysiology
- Journal of Cardiovascular Magnetic Resonance
- Journal of Cardiovascular Nursing
- Journal of Cardiovascular Pharmacology
- Journal of Cardiovascular Pharmacology and Therapeutics
- Journal of Cardiovascular Surgery
- Journal of Electrocardiology
- Journal of Heart and Lung Transplantation
- Journal of Heart Valve Disease
- Journal of Interventional Cardiac Electrophysiology
- Journal of Molecular and Cellular Cardiology

- Journal of Nuclear Cardiology
- Journal of Thoracic and Cardiovascular Surgery
- Kardiologiya
- Nature Clinical Practice Cardiovascular Medicine
- Nutrition Metabolism and Cardiovascular Diseases
- Pace-Pacing and Clinical Electrophysiology
- Pediatric Cardiology
- Progress in Cardiovascular Diseases
- Respiratory Medicine
- Reviews in Cardiovascular Medicine
- Revista Espanola de Cardiologia
- Scandinavian Cardiovascular Journal
- Texas Heart Institute Journal
- Thoracic and Cardiovascular Surgeon
- Trends in Cardiovascular Medicine