

November 2018

Wellcome Review of PhD Training in Biomedical Research



...the ...

Table of Contents

Executive summary.....	4
Background.....	5
Methodology.....	6
Literature review	6
Interviews.....	6
Online survey	6
Findings	7
Wellcome-funded PhD programmes	7
UK-wide PhD programmes	7
Survey demographics	8
Purpose/value of PhD training	8
Structure of PhD training in the UK	10
PhD supervision.....	10
Assessment of a PhD	12
Core knowledge and skills development.....	13
Experience, qualifications and expectations	13
Next destinations	14
Work–life balance and mental health	15
Diversity and inclusion	16
Conclusions and recommendations	17
Acknowledgements.....	18

Executive summary

Wellcome has supported biomedical PhDs through its PhD programmes in basic science, including public health, since 1994, and has been an innovative funder in this area.

However, Wellcome's approach to PhD training has not changed significantly for over 20 years.

In 2017, we undertook a broad review of biomedical research PhD training to provide evidence on which to base future funding decisions. The review included an analysis of the literature, UK-wide and in-house datasets, and a community consultation involving both interviews and an online survey. Clinical PhD training is being looked at separately.

The review found that there have been positive system-wide changes in PhD training over the last 20 years. Students supported through programme-based cohorts, such as Wellcome's, appear well-placed to continue a career in research, with retention rates in academia and industry higher than the national average across all biomedical PhD graduates. However, certain concerns were consistently reported throughout our research. These included publication and time pressure, concerns about support or training, and numerous self-reported incidences of poor mental health.

Although Wellcome is a minority funder of PhD training in the UK, we have concluded that it is important for us to continue to fund biomedical PhD training. By playing a part, Wellcome will, in partnership with other funders and organisations, help set expectations regarding support for PhD training and the culture of research.

**We will work to
foster best practice
among supervisors,
directors, institutions
and other funders, to
deliver sustainable
changes in practice.**

Background

Wellcome has supported biomedical PhDs through its PhD programmes in basic science, including public health, since 1994.

Wellcome was the first in the UK to provide programme-based support for PhD training, in an effort to enhance the student experience and to provide peer-to-peer support and networking opportunities. Many comparable funders now support similar programmatic approaches.

In addition to the establishment of 4-year PhD programmes, Wellcome has supported the provision of student stipends that are based on graduate research assistant salaries after tax, and has provided realistic research costs. These have both helped transform the graduate experience.

This approach to PhD training has largely remained unchanged for over 20 years, so in 2017 Wellcome undertook a review to inform its future decisions on PhD funding. The review took into account the four pillars of **Wellcome's Science strategy** and **Wellcome's Success Framework**, as well as biomedical PhD training in the UK in general, including changes in the nature of research and the way it is conducted.

This work follows previous reviews of Wellcome's PhD training, which focused predominantly on the development and operation of its PhD programmes. These reviews consistently found that Wellcome's PhD programmes work well.

PhD training contributes, directly or indirectly, to all four pillars of Wellcome's Science strategy.

- It creates knowledge through the research carried out by PhD students.
- By recruiting the best young researchers, it helps identify and train the science leaders of the future.
- Through the work of PhD students, and with appropriate instruction and advice, it allows science to be translated effectively.
- PhD students who choose not to follow a career in academic research can make valuable contributions to society to ensure that science is recognised as the best way to understand the world.

While Wellcome PhD programmes generate scientific knowledge and equip students with the skills needed to be successful researchers, we also recognise the importance of highly trained scientists and the value of their contributions to different aspects of society, from business management to education to policy and politics. We know that the need for these contributions will increase rather than decrease in years to come.

Methodology

This review of PhD training has been undertaken in multiple phases.

Literature review

A literature review and analysis of datasets from the Higher Education Statistics Agency (HESA) and Wellcome was commissioned from Technopolis in 2017:

- A number of **JACS 3.0 codes** from HESA relevant to biological and biomedical sciences were selected. Analysis of the HESA dataset, which covers 2012/13 - 2015/16, was conducted by Technopolis. HESA data is submitted by higher education institutions soon after students start, so detailed information, including the funding source or chosen supervisor, is not available.
- Information from the **Wellcome Trust Basic Science Career Tracker** was used, specifically from waves 1 and 2, which cover individuals completing their PhD in 2009 and 2010 respectively.

Interviews

- Semi-structured interviews were conducted with the research community, including PhD supervisors and students (irrespective of funding source), university administrators, other funders and key opinion leaders. These also included individuals directly associated with Wellcome, including Wellcome-funded PhD programme directors, directors of Wellcome Centres, Wellcome governors and staff.

Online survey

- The web-based survey was hosted by Qualtrics and contained a combination of qualitative and quantitative questions. The survey was designed to be answered by anyone, irrespective of background, occupation or career stage, with different sets of questions for each audience. (This, together with the fact that individuals didn't always answer all the questions they were asked, explains the variation in number values across this report). The list of questions was drawn from a combination of sources, including engagement with the community via semi-structured interviews.
- The survey was open to new entrants from 28 November until 19 December 2017. For those already enrolled, it was

left open for an additional week to allow for completion of surveys that had been started.

- The survey was disseminated via email, social media (Facebook, Twitter, LinkedIn) and Wellcome's website. Email recipients included all active Wellcome grantholders, all Wellcome Centre and PhD programme administrators, administrators of doctoral colleges/academies as published on the internet, personal contacts within Research Councils and personal contacts from Wellcome staff.

Findings

Wellcome-funded PhD programmes

Demand for Wellcome PhD studentships is high. From 2010 to 2016, about 24,600 applications were received for 926 studentships across all Wellcome PhD programmes (26.6 applications per place and a 3.8 per cent award rate). The highest demand was in neuroscience (37.5 applications per place) and the lowest in genomics and population health (13.5 applications per place). The demand for studentships at the Wellcome Sanger Institute is also high. From 2006 to 2014, 2,103 applications were received for 108 positions (19.5 applications per place).

In 2017, 51 per cent of students enrolled in Wellcome PhD programmes were from the UK, 37 per cent from the EU/EEA (non-UK), and 12 per cent from non-EU/EEA countries. No dips were seen in the number of EU/EEA (non-UK) or non-EU/EEA students in 2017 after the EU referendum.

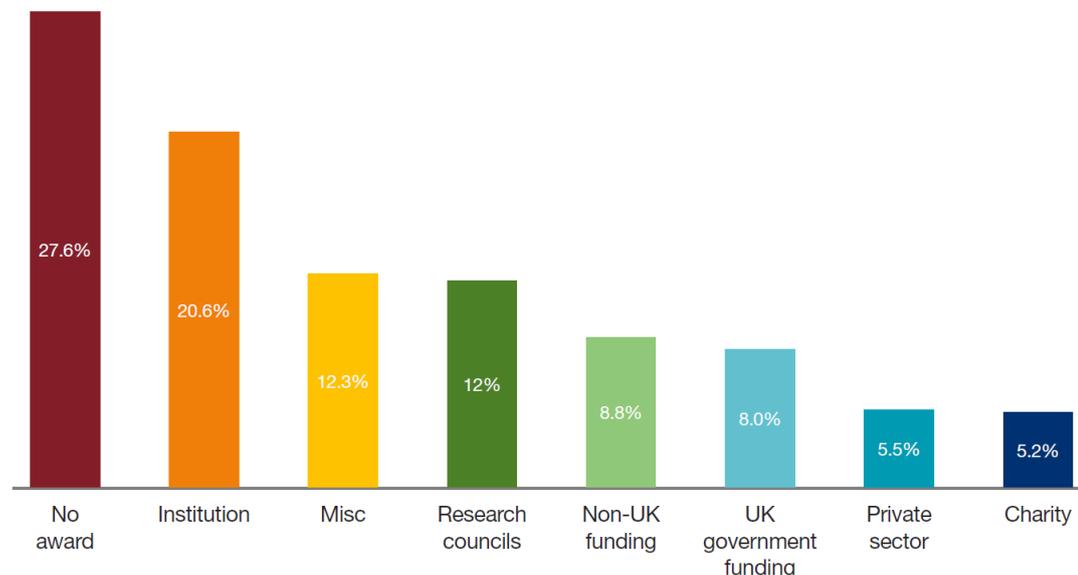
From 2001 to 2014, the Wellcome Sanger Institute had 50 per cent of its students coming from outside of both the EU and the UK, 25 per cent from the EU and 25 per cent from the UK.

UK-wide PhD programmes

It is difficult to obtain robust data for PhD training in the UK. Data from HESA indicates that 7,050 doctorates were awarded in the biological and biomedical sciences in 2015/16. These numbers include clinical academics, and if one takes account of Wellcome's clinical programmes, this suggests that Wellcome funds 3.1 per cent of PhDs in the biological and biomedical sciences. While we know that data on the total number of registered students is likely to be robust, we are aware that there is a disparity between HESA data on Wellcome-funded students and our own records.

HESA data suggest that the two most common funding sources for graduates undertaking further study in the biological and biomedical sciences in the UK are self-funding (27.6 per cent) and employer-supported (20.6 per cent) (Figure 1). No details are provided on miscellaneous sources. HESA data is submitted by higher education institutions soon after students start and institutions so complete information such as the funding source is not always available.

FIGURE 1: FUNDING OF PHD STUDENTS IN BIOLOGICAL AND BIOMEDICAL SCIENCES



Higher Education Statistics Agency (HESA)

For the purpose of this review, and with this uncertainty in mind, we focused on awards from biomedical research funders to which young researchers have access. We obtained numbers of active PhD students from the major funders of biomedical research in the UK: the Biotechnology and Biological Sciences Research Council (BBSRC), the Medical Research Council (MRC), Cancer Research UK (CRUK) and the British Heart Foundation (BHF). Together, figures suggest that Wellcome funds about 12 per cent of the biomedical PhDs in the UK that are available to most students, and that Wellcome is the largest charity funder.

We note that BBSRC funds in areas outside Wellcome's remit. MRC studentships are costed at 3.5 years per student, BBSRC and CRUK at up to 4 years, and BHF funds a mixture of 3-year and 4-year awards.

Survey demographics

3,467 people started the survey, with 2,703 completing it. Of the respondents, 53.3 per cent (1,440) had a PhD, 34.2 per cent (924) were undertaking PhD training, and 12.5 per cent (339) did not have a PhD nor were undertaking training. Of those engaged in research at an academic institution, 752 described themselves as research group leaders, 278 as postdocs and 88 as staff scientists. 96 survey respondents were engaged in research in a non-academic setting.

Primary purpose of PhD training

Our survey found that 39.7 per cent (1,067/2,685) of all respondents thought that the primary purpose of PhD training was “to develop highly skilled individuals who can contribute in a knowledge-based economy and meet changing skills needs in the workforce”. In comparison, 30.6 per cent (821/2,685) considered the primary purpose to be “to train the research leaders of the future”.

Views differed according to individuals, and there was a difference between what PhD supervisors considered the primary purpose of PhD training and the views held by PhD students. Among those who identified as PhD supervisors in the biological and biomedical sciences, 36.0 per cent (219/608) considered “to train the research leaders of the future” to be the primary purpose, and a similar number 34.0 per cent (207/608) considered the primary purpose of PhD training to be “to develop highly skilled individuals who can contribute in a knowledge-based economy and meet changing skills needs in

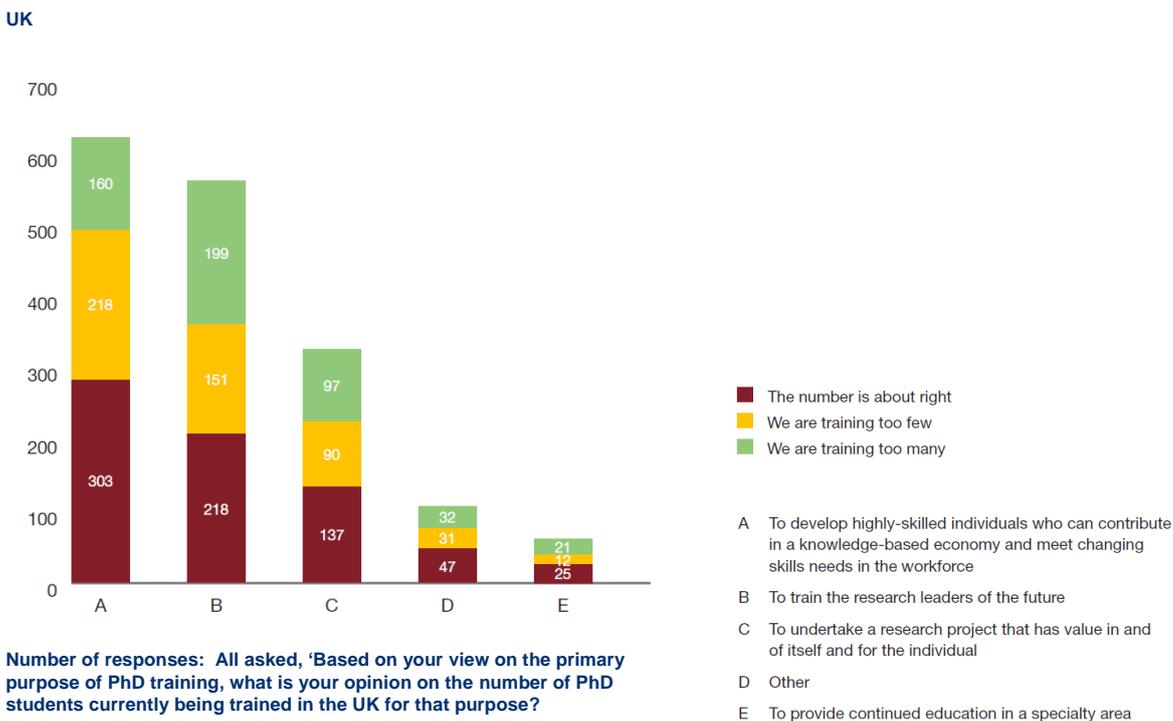
the workforce”. In contrast more PhD students in the biological and biomedical sciences, 43.5 per cent (327/752), considered “to develop highly skilled individuals who can contribute in a knowledge-based economy and meet changing skills needs in the workforce” as the primary purpose, while 29.1 per cent (219/752) chose “to train the research leaders of the future”.

Numbers of students being trained

Survey respondents also had different views on whether too many or too few PhD students were being trained, depending on what they considered to be the primary purpose of PhD training. Of those in the UK that chose “to train the research leaders of the future” as the primary purpose, 35.0 per cent (199/568) thought that too many PhD students were being trained, whereas among those that chose “to develop highly skilled individuals who can contribute in a knowledge-based economy and meet changing skills needs in the workforce”, only 23.5 per cent (160/681) thought too many were being trained (Figure 2).

Irrespective of whether survey respondents considered the number of students currently being trained to be too high or too low, 87.7 per cent (1,914/2,183) of them considered PhDs obtained from UK universities to be competitive with PhDs from other countries in Western Europe, the USA, Canada and Australia.

FIGURE 2: VIEWS ON NUMBERS OF STUDENTS BEING TRAINED



Structure of PhD training in the UK

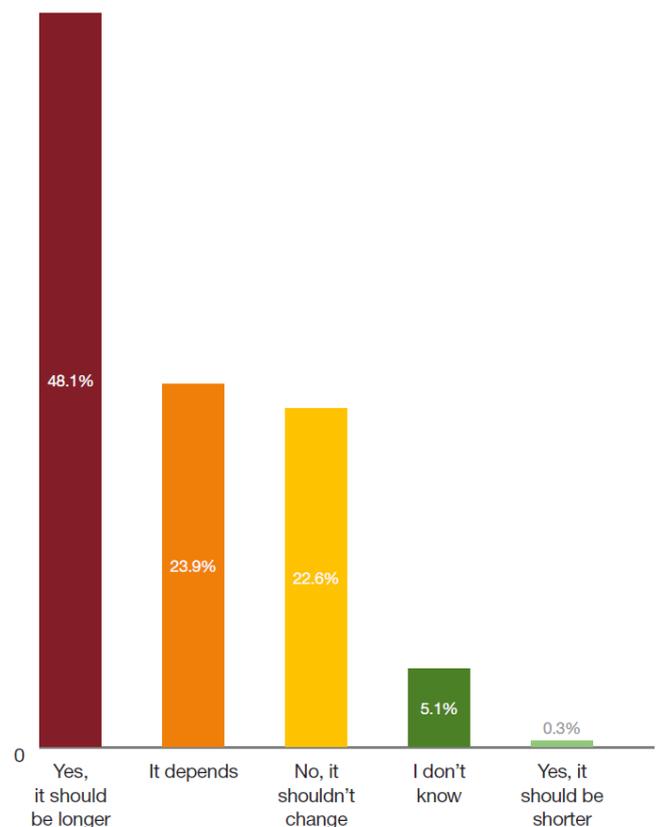
The overall average length of a PhD (from commencement to completion) in the UK, based on 2012/13–2015/16 data from HESA, is 3.4 years (range: 3.0 to 4.3 years). This average incorporates taught modules and rotations offered by an increasing number of programmes during the first year. Even within 4-year programmes, there are differences in the length of time dedicated towards research, with students spending between 2.5 and 4.0 years undertaking research for their thesis.

Nearly half the survey respondents – 48.1 per cent (1,071/2,228) – were of the opinion that 3 years was not long enough for most students to complete a research project for a PhD, with 23.9 per cent (533/2,228) indicating that the appropriate length of time depended on the particular circumstances of each student. 22.6 per cent (504/2,228) of the survey respondents felt that the current length of 3-4 years was sufficient (Figure 3).

Consistent with those findings, when asked for one thing they would change about the way PhD students are currently trained in the UK, the most common answer among survey respondents was to increase the length of time of training (285/1,939). And when asked whether the length of PhDs should change, the most common answer offered by both students and supervisors was that it should be longer. It is worth noting that the proportion of supervisors who wanted to see an increase in the length of PhD training was significantly higher than students (64.2 per cent [435/678] of supervisors vs 37.1 per cent [315/849] of students). The most commonly suggested length of time was 4 years (302/586); 165 of 586 respondents considered the ideal length to be between 4 and 5 years.

The current structure of Wellcome-funded PhD programmes requires that students spend a significant part of the first year in laboratory rotations. While some indicated that rotations are not always necessary, when current trainees who had completed rotations as part of their PhD were asked if they had found them useful, 203 respondents out of 214 answered positively. However, in interviews supervisors expressed the need to have a mixture of types of studentships, ie those which offer rotations and those with direct entry, as some students had more clarity with regards to the projects and supervisors they wished to choose.

FIGURE 3: STRUCTURE OF PhD TRAINING IN THE UK



Percentage of respondents: PhD students, PhD-qualified individuals and university administrators; all disciplines asked, 'Do you think the average length of time to complete the research project for a PhD in the UK should change?'

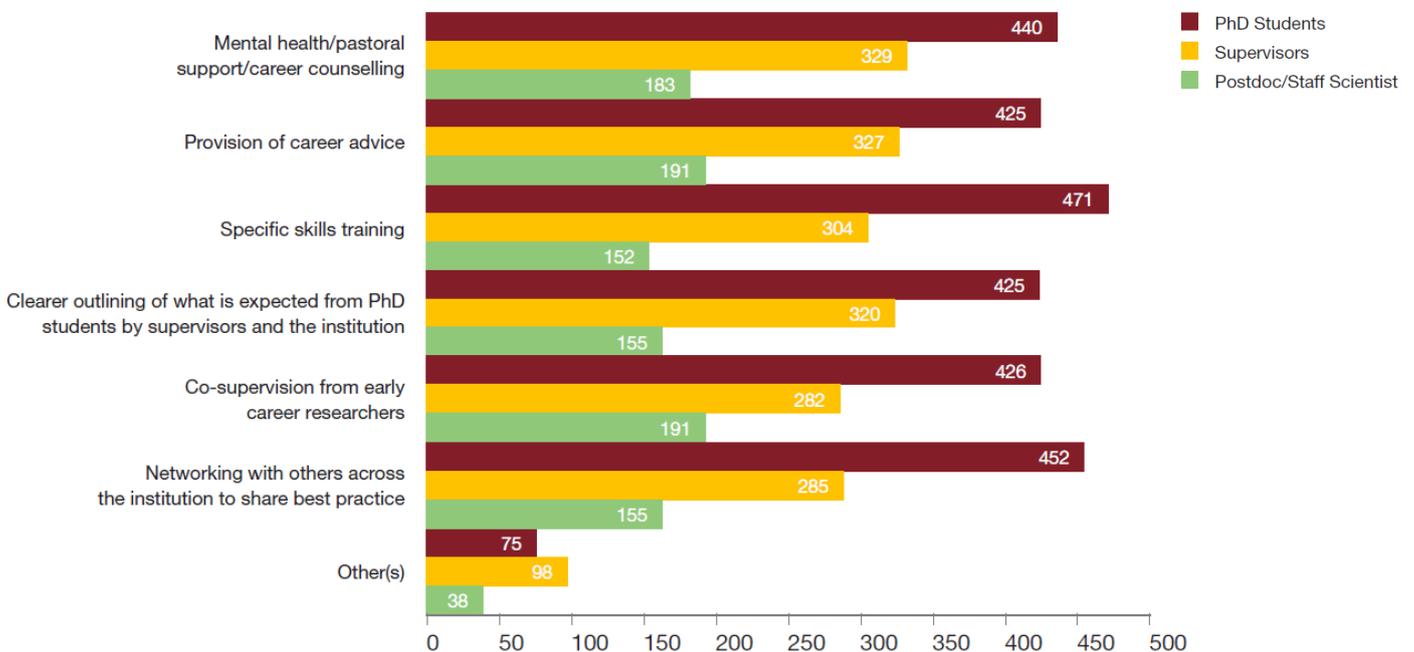
PhD supervision

Quality of supervision is a concern among PhD students in the UK. Inadequate or unsatisfactory supervision was most commonly identified as the main challenge faced by PhD students in the survey (225/1,837), while bullying from supervisors was cited on 28 independent occasions across the survey, including on six occasions in answer to the question of what the main challenge faced during PhD training was. At least 39 survey respondents also identified training for supervisors as important.

Students often cited a lack of recourse if they were unhappy with the supervision they are receiving. Providing mentorship by individuals not involved in their research – ideally those who are outside of their supervisor’s circle of influence and who can prioritise their needs over those of the supervisor or research project – may mitigate this problem by providing students with an alternate sounding board and source of advice.

Furthermore, well-structured thesis committees have been flagged as necessary and important for providing students with the guidance they need. They can also help with monitoring progress and mitigating any exploitative behaviours from supervisors, as well as serving as an additional source of mentorship.

FIGURE 4: AREAS IN WHICH SUPPORT FOR PHD STUDENTS COULD BE IMPROVED



Number of responses: PhD students and individuals undertaking research in an academic sector or who are university administrators asked to select all that apply

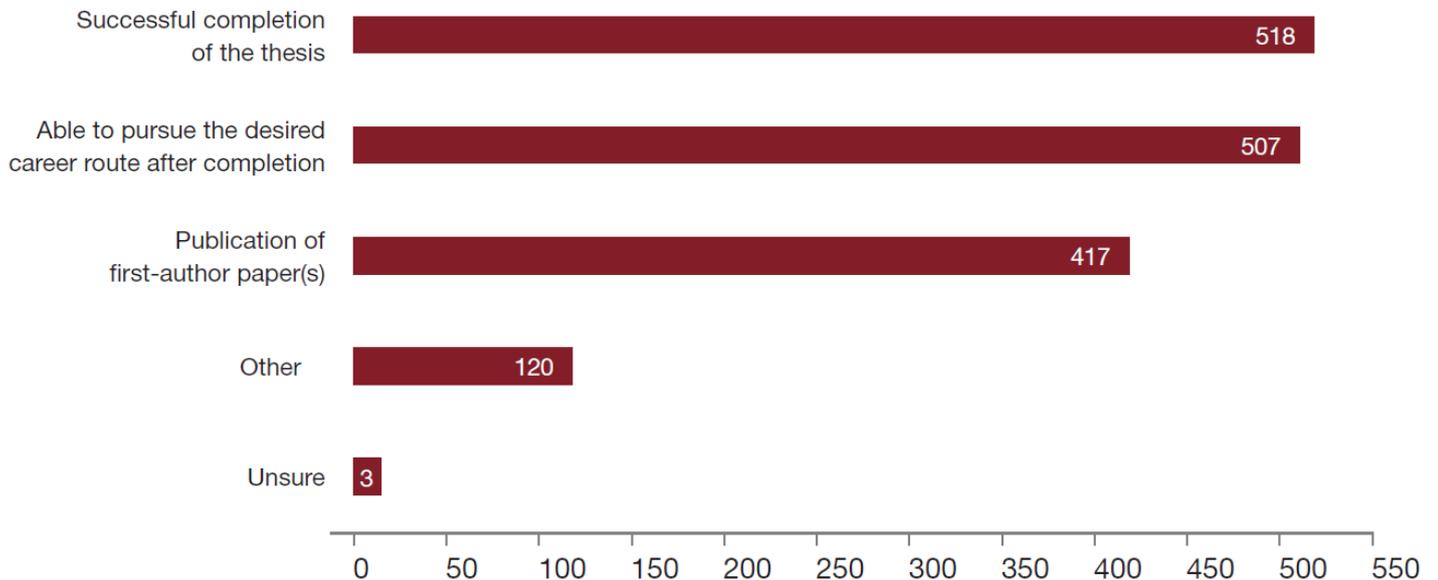
Assessment of a PhD

The survey indicated that PhD supervisors consider the successful completion of the thesis to be the primary method used to determine whether the training of a student has been effective (518), followed by the ability to pursue a desired career route (507), followed by the publication of first-author papers (417) (Figure 5).

In interviews, supervisors expressed concerns that in the UK, awarding of a degree to anyone undertaking a PhD is the default, giving rise to a perceived devaluation of the quality of PhDs. Some were of the opinion that PhDs should undergo more rigorous assessment and be held to a minimum level of quality, standardised across the UK. However, what this minimal level of quality would be or how it would be assessed was not articulated.

We asked whether assessment criteria should be put in place and used to assess both whether a student has successfully completed a PhD and whether PhD training has been successfully delivered. While successful completion of the thesis is still considered the primary measure of success, interviewees commented that the style of thesis preferred in the UK is anachronistic, and argued for a thesis style more like what is common in Northern Europe – a smaller, publication-focused thesis. In addition, a subset of the community also noted that a shorter thesis would be a welcome change, as many students spend significant amounts of time writing their thesis. However, they noted that valuing PhDs by publication could potentially increase the pressure not only to publish but also to publish primarily first-author papers. Some noted the potential benefit to preprint server publication.

FIGURE 5: ASSESSMENT OF PHD SUCCESS



Number of responses: PhD supervisors asked to select all that apply

Core knowledge and skills development

During our interviews, many areas were frequently highlighted as important for PhD trainees. These included compulsory statistics training, as well as training in scientific/grant writing, science communication, programming and teaching. The need for mentorship and data to support decision-making on future career choices was also a common issue raised.

When survey respondents were asked about the one thing they would change about how PhD students are currently trained, after length of time, the second most commonly cited answer was to increase opportunities for transferable-skills training and for exploring careers outside of academic research (11.1 per cent, 216/1,939). Interestingly, we found that although 85.4 per cent (608/712) of PhD supervisors and university administrators indicated that they support and encourage students to explore careers outside of research, only 55.1 per cent (402/729) of PhD students said they are encouraged and supported to do so.

During interviews with PhD supervisors and students, there were clear differences in what each considered to be important core skills to be learned, with supervisors placing greater importance on skills that are relevant to research (eg data analysis, science writing) and students favouring training that may be more directly applicable in the wider workforce (eg project management). In the survey, although the importance placed on a given skill may have differed between supervisors, students and non-research employers, the trends were consistent, with problem-solving skills considered to be the most important among the options available.

Non-research employers found that commercial acumen, translational and entrepreneurial skills were most often lacking in PhD graduates, followed by leadership skills, teamworking skills and project-management skills

Experience, qualifications and expectations

There is a difference between what supervisors consider to be the ideal amount of research experience prior to undertaking a PhD and the amount of experience that recruited students have. In the survey, when supervisors were asked what the ideal amount of research experience is that a prospective PhD candidate should have, the most common answer was “6 months to 1 year” at 32.4 per cent (235/725), followed by “3–6 months” at 27.9 per cent (202/725), with only 10.8 per cent

(78/725) of supervisors selecting “between 1–2 years” as the ideal amount. However, when students and postdocs were asked how much research experience they had prior to their PhD training, the most common answer was “between 1–2 years” (38.0 per cent, 411/1,082) followed by “6 months to 1 year” (24.6 per cent, 266/1,082), suggesting that applicants with more research experience are being selected to undertake PhD training.

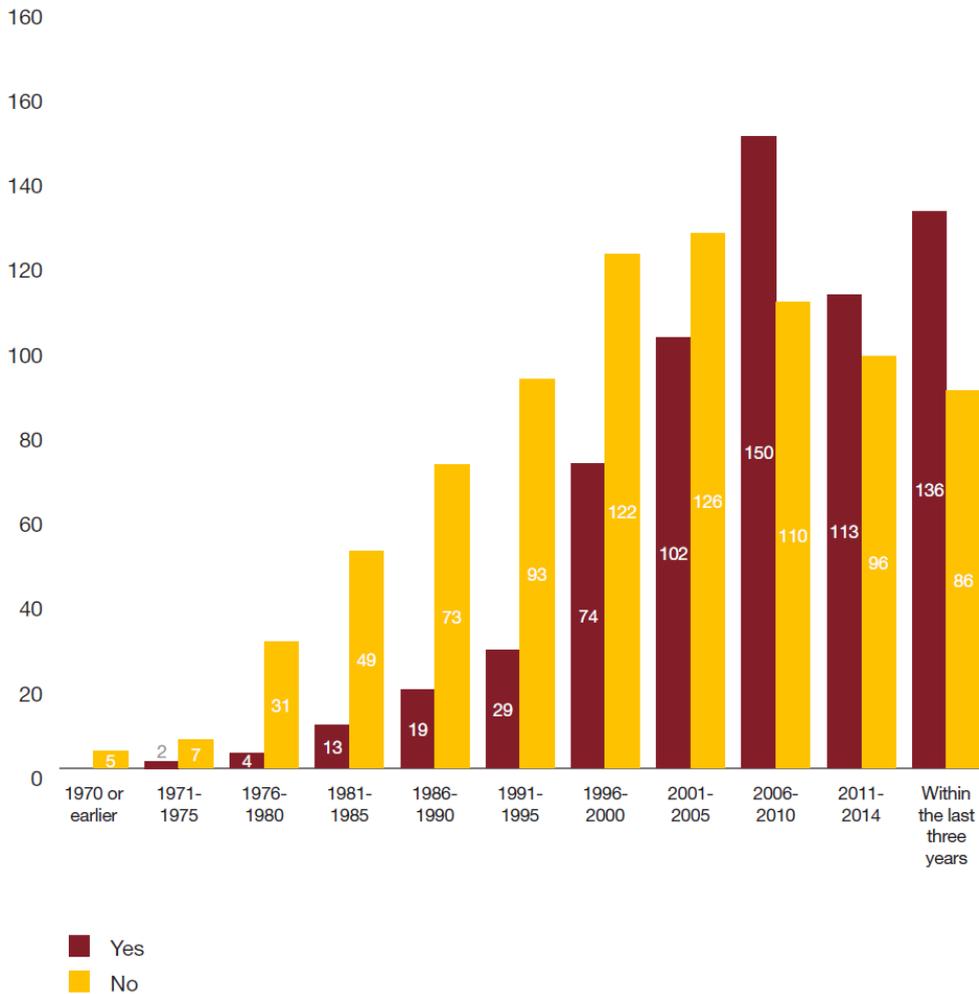
52.7 per cent (1,245/2,364) of our survey respondents had a Master’s degree prior to starting their doctoral training, with the proportion of students holding a Master’s degree having increased since the 1990s. The shift to the majority of PhD students holding a Master’s prior to commencing a PhD happened between 2001 and 2010 (Figure 6). These numbers do not include those who were awarded a Master’s degree as part of their PhD training.

The findings from the survey are consistent with HESA’s data, which indicates that from 2012/13 to 2015/16 a majority of PhD students (54 per cent) already had a postgraduate degree (excluding a Postgraduate Certificate in Education, or PGCE) before enrolling in a doctoral programme.

This review also found that many prospective students choose to undertake a PhD without fully understanding the requirements and commitments that are expected from a PhD student in the biological and biomedical sciences, or indeed what the career options are post PhD, in- and outside of academia.

In addition, prospective students are seemingly often unaware of what life in research is like, having spent a limited amount of time in a laboratory beforehand. There is therefore a pressing need for more information for prospective students on what the expectations are of the PhD candidate, the supervisor and the institution, before during and after the period of PhD training. This is consistent with reports from the **Council of Graduate Schools** and the efforts of **coalitions in the USA**, which are not only working to develop consistent methodologies for data collection but have started on this endeavour.

FIGURE 6: EXPERIENCE AND QUALIFICATIONS



Respondents: PhD-qualified individuals asked, 'Did you have a Master's degree prior to starting your PhD training?'

Next destinations

The main source of data on next destinations post PhD is the Destinations of Leavers from Higher Education (DLHE) dataset. However, this data is collected via a survey that gathers information on what all leavers from higher education programmes are doing six months after qualifying from their higher education course.

Based on findings from our survey, 46.0 per cent of respondents (661/1,437) spent additional time in the same group working on the same project after qualifying. Wellcome's Career Tracker allows Wellcome to follow the careers of its researchers. Of 131 PhD candidates who qualified in 2009 and 2010, 51 per cent were still in academic research in 2014/15. A further 5 per cent were working in industry, 3 per cent were unemployed and there was no data for 16.5 per cent. This

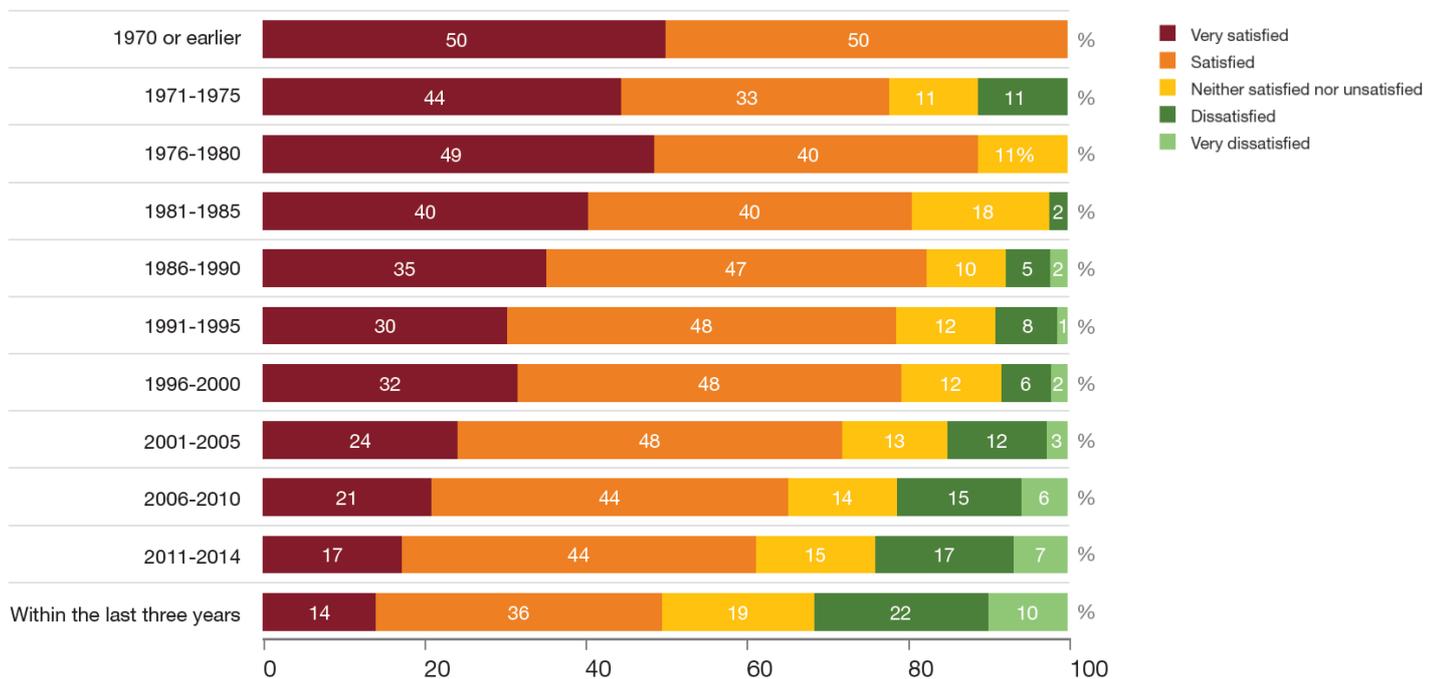
figure for candidates staying in academic research is comparable to those reported by BBSRC (~40 per cent) and the MRC (43–50 per cent); however, it is not clear whether these figures represent doctoral graduates immediately after qualification or after a length of time.

There is widespread consensus on the need to collect and robustly analyse career outcomes for PhD students and postdoctoral fellows across all disciplines, and to make this information publicly available.

Work–life balance and mental health

Although most indicated that they were satisfied with their work–life balance, PhD students in the survey mentioned all of the following as challenges that they faced: sustained pressure to finish on time; pressure to publish key authorship papers in high-impact journals; a culture of long working hours; a lack of clarity on career prospects; and a lack of supervision and mentorship. Interestingly, satisfaction with work–life balance as a PhD student was lower among those who have completed their PhD more recently, suggesting that satisfaction with work–life balance has fallen over time (Figure 7).

FIGURE 7: WORK LIFE BALANCE SATISFACTION



Percentage of respondents: PhD-qualified individuals; broken down by year of completion of PhD asked, 'As a PhD student, how satisfied were you with your work–life balance?'

When asked if they had noticed any recent changes in the number of cases of mental health issues in PhD students, 44.5 per cent (321/722) of PhD supervisors reported an increase. 55.0 per cent (397/722) reported no perceived changes in the number of cases.

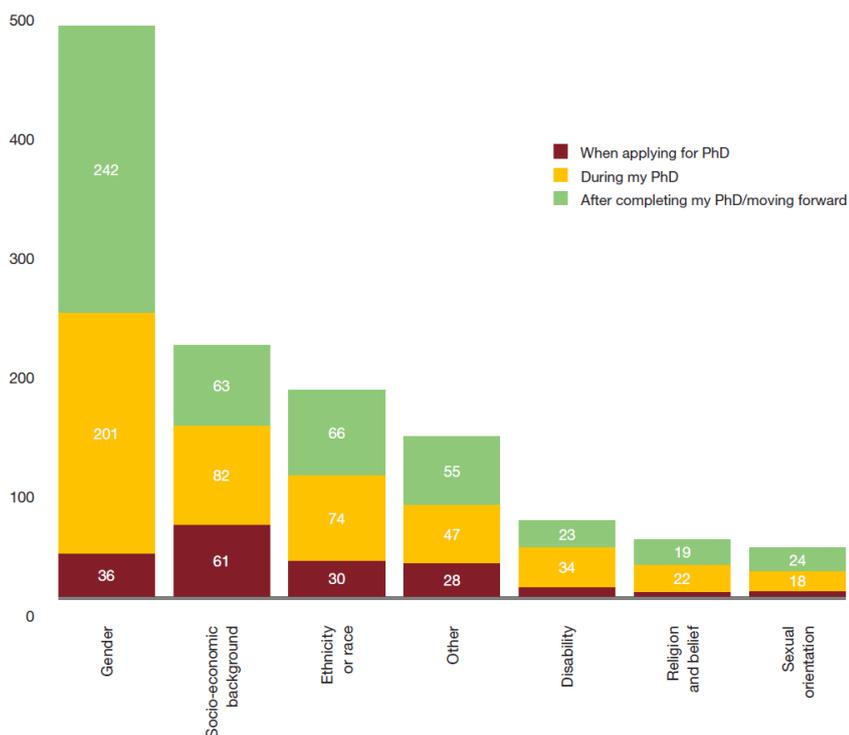
The survey found that supervisors believed better access to counselling or mental health support would help address the increase in mental health problems among the student population (38.2 per cent, 102/267). The next most commonly cited suggestion was to provide students with clearer understanding of expectations – of them as PhD students, of careers in research and of other career options – as well as information on where to find support if needed (12.7 per cent, 34/267).

Diversity and inclusion

Based on limited data from HESA, covering 2012/13–2015/16, 81.6 per cent (15,805) of PhD students in the biological and biomedical sciences in the UK are white, 10 per cent (1,930) are Asian, 2.9 per cent (557) are black and 5.6 per cent (1,076) consider themselves of mixed ethnic background. (However, no information was provided for 10,253 students undertaking PhDs in the biological and biomedical sciences.) From the same source, the ethnic distribution among Wellcome-funded PhD students is as follows: 50 per cent (200) white, 4 per cent (16) Asian, 2.5 per cent (10) mixed ethnic background and 0.25 per cent (1) black. There was no information for 175 Wellcome-funded students.

201 survey respondents indicated that they had experienced discrimination or unfavourable treatment on the basis of their gender during their PhD and 242 after completion of their PhD and/or during transition to the next stage. The second most cited basis for discrimination or unfavourable treatment was socioeconomic background, followed by race.

FIGURE 8: EXPERIENCE OF DISCRIMINATION



Respondents (PhD students and PhD-qualified individuals) asked to select all that apply

Conclusions and recommendations

The review found that there have been positive system-wide changes in PhD training in the UK over the last 20 years, with programme-based funding and 4-year programmes now widely adopted.

It was also clear that universities are increasingly taking an integrated, cross-institution approach to supporting PhD training, for instance by setting up doctoral training colleges or support mechanisms that oversee the entirety of PhD training at their institution, irrespective of funder. Students are continuing their careers in research, with 40–50 per cent remaining in research 3.5 to 5 years post PhD.

However, despite these positive developments, there were some striking concerns expressed about PhD training across our community interviews, the survey and in the literature, and which were shared by students and supervisors.

In particular, the interviews revealed:

- overly prescriptive and detailed training requirements from funders
- pressure to publish.

And the survey revealed the following to be key issues:

- incidences of poor mental health
- there being not enough time for or emphasis on scientific enquiry
- a need for enhanced support for training in data sciences, statistics and good research practice
- variations in the quality of supervision
- a lack of information available to students and prospective students to make informed decisions.

The review provides insights into concerns relating to PhD training. It highlights the need for **changes to PhD training that support a more positive research culture**. Although Wellcome is a minority funder, we have concluded that we should continue to fund biomedical PhD training. By playing a part, Wellcome will set expectations regarding the appropriate structure of PhD training and the culture of research by fostering best practice among supervisors, directors, institutions and other funders, which will deliver changes in practice.

Acknowledgements

With thanks to the following people for their valuable contributions to the review and in the preparation of both the data and the report:

- Elizabeth Adelanwa
- Chiann-Mun Chen
- Anne-Marie Coriat
- Sophie Drinkwater
- Richard Kindell
- Sarah Lloyd
- Rebecca O'Brien
- Dan O'Connor
- George Phillips
- Rob Reddick
- Nick Sherwood
- Jim Smith
- Kiri Tan
- Matthew Thakur
- Helen Thompson
- Nic Vogelpoel
- Paul Woodgate

...the first of these is the fact that the ...

...the second of these is the fact that the ...

...the third of these is the fact that the ...

...the fourth of these is the fact that the ...

...the fifth of these is the fact that the ...

...the sixth of these is the fact that the ...

...the seventh of these is the fact that the ...

...the eighth of these is the fact that the ...

...the ninth of these is the fact that the ...

...the tenth of these is the fact that the ...

...the eleventh of these is the fact that the ...

...the twelfth of these is the fact that the ...

...the thirteenth of these is the fact that the ...

...the fourteenth of these is the fact that the ...

...the fifteenth of these is the fact that the ...

...the sixteenth of these is the fact that the ...

...the seventeenth of these is the fact that the ...

...the eighteenth of these is the fact that the ...

November 2018

Wellcome exists to improve health for everyone by helping great ideas to thrive. We're a global charitable foundation, both politically and financially independent. We support scientists and researchers, take on big problems, fuel imaginations and spark debate.

**Wellcome Trust, 215 Euston Road,
London NW1 2BE, UK
T +44 (0)20 7611 8888, F +44 (0)20 7611 8545,
E contact@wellcome.ac.uk, wellcome.ac.uk**

The Wellcome Trust is a charity registered in England and Wales, no. 210183. Its sole trustee is The Wellcome Trust Limited, a company registered in England and Wales, no. 2711000 (whose registered office is at 215 Euston Road, London NW1 2BE, UK).