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Bringing medicines to *life*

Bridging the skills gap in the biopharmaceutical industry: Maintaining the UK's leading position in life sciences

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1 Contents

Foreword 3

Executive Summary 4

Aims and objectives 6

Introduction 7

- Industry landscape 7
- Brexit 9
- Recruitment trends 10
- Education 10

Methodology 13

Findings and discussion 15

- Top priorities 15
- Biological science areas 20
- Chemical science areas 23
- Clinical areas 25
- Pharmacy 27
- Informatics, Computational, Mathematical and Statistics 29
  - Regulatory areas 33
  - Business areas 35
- Core skills 35
- Recruitment 38
- Threats to job growth 39
- Future issues 40

Appendix – list of participating companies 41

Survey 43

- Section 1 Biological science areas 43
- Section 2 Chemical science areas 43
- Section 3 Clinical areas 43
- Section 4 Pharmacy areas 43
- Section 5 Informatics, Computational, Mathematical and Statistics areas 43
- Section 6 Regulatory areas 43
- Section 7 Business skills 43
- Generic skills issues (to be completed by all respondents) 44

Survey respondents 46

- Pharmaceutical companies 46
- Contract Research Organisations (CROs) 46
- Other 46

Section summaries 47

- Section 1 – Biological science areas 47
- Section 2 – Chemical science areas 57
- Section 3 – Clinical areas 61
- Section 4 – Pharmacy 65
- Section 5 – Informatics, Computational, Mathematical and Statistics areas 68
- Section 6 – Regulatory areas 76

Foreword

The UK is a leading global hub in life sciences. Survey after survey tells us that this is, in large part, driven by the quality of our UK workforce with outstanding skills and talents in companies, universities and, of course, the NHS. This is why developing the best UK talent in the life science disciplines has been an ongoing priority for the ABPI. It is even more important now as we seek to maintain the strength of our life sciences sector as the UK prepares to leave the EU.

To remain at the cutting edge, we have to relentlessly review and adapt our skills and workforce requirements. Since the ABPI's last survey in 2015, the skills requirement in computational disciplines has increased in prominence across our membership. And interdisciplinary skills, in areas such as chemo-informatics, where scientific disciplines overlap has emerged as a key requirement for the future.

Genomics is another priority area emerging in this survey. Many of our member companies have highlighted that the use of genomics is driving a new era of drug discovery. Increasing skills capabilities in genomics will help reduce the high attrition rates for medicines discovery and make it more likely that future medicines are better targeted and safer for patients.

Our surveys of 2015 and 2018 show certain skills continue to be highly valued – specifically clinical pharmacology and bioinformatics. These core skills in pharmaceutical sciences allow us to interpret the big data sets required to understand complex disease and identify new drug targets.

But how do we get young people interested in using their core scientific skills for the benefit of the life sciences?

What our report demonstrates is that we need to amplify our encouragement of young people to study STEM subjects. And we also need to find better ways of enticing young people across all scientific disciplines into careers in life sciences. This could be through greater uptake of apprenticeships. But it also requires Government, the Life Science industry, educational institutions and the NHS to work together to develop new ways to create a sustainable skills pipeline and an innovation-ready workforce.

I hope you use this report to inform conversations about the skills our industry needs. I look forward to working with you and using our collective power to develop the next generation of life sciences workforce.

Carole Longson
Chief Scientific Advisor at the Association of the British Pharmaceutical Industry

Executive summary

This updated skills survey and report comes at a pivotal time for the UK Life Sciences industry. The UK government is negotiating its exit from the European Union and has made clear it wishes to see an end to Free Movement of people. It is beginning to implement the Life Sciences industrial strategy and has set ambitious targets for increased R&D spend in the UK, including by business.

For the government to succeed in its aims, it is crucial that the most R&D intensive sector in the country – pharmaceuticals – continues to invest. For that to be possible, it must have access to highly skilled people.

There is some good news. Some of the key areas of skill shortage – including notably clinical pharmacology, which has seen consistent and intensive effort from the ABPI and partners in life sciences and the NHS – are improving. Challenges however, remain. The work undertaken following previous surveys is beginning to pay off.

Since the last survey, we have also noted a general reduction in the percentage of respondents who see core skills as a concern, with particularly significant reductions in scientific and mathematical knowledge. This may be the result of consistent efforts over time to improve the quality of the scientific and maths curriculum in schools – it appears, in this respect, at the compulsory school level, the education system in the UK is increasingly meeting sector needs.

However, this survey also identifies a number of areas of continued concern.

The top priorities for the sector, from this survey, are in three broad categories:

- In **core scientific disciplines of biological and chemical sciences;**
- in a **wide variety of computational disciplines; and**
- with a **remaining challenge in clinical pharmacology.**

We also see, across disciplines, **rising challenges in areas where innovation in medicine development are changing the skills required.** For example:

- In the **biological sciences** the highest priority areas – immunology and genomics – are directly related to shifts in how drugs are developed. It is likely that the increased demand in immunology is a result of increased interest in biological drugs such as antibodies. The requirement for genomics skills is, in large part, because an increased understanding of the genetic profiles of patients is helping target research.
- In **Informatics, Computational, Mathematical and Statistics** areas, unsurprisingly, we see an increase in prominence and concern across the board. This is a reflection of the overall opportunity for data science across the economy, including in medicine. Interestingly, we see the most acute concerns around lack of skills in areas of interdisciplinary overlap – such as computational chemistry, chemometrics and chemoinformatics – where people must combine scientific and data experience.

At one level this is exciting – it is a sign that innovation is happening across the industry. This ultimately will mean better treatment for patients. But it also means that research and development will go where those skills can be found. We must ensure our people can keep pace with technological development. Automation has, unsurprisingly, become a ‘future concern’ for our respondents (which was not true in the previous survey).

Finally, we see that there are shortages for different disciplines throughout the skills pipeline – including graduates, PhD and postdoc candidates. This suggests the UK needs to build on current efforts to attract and train those candidates. For computational skills, the responses to the survey suggest this needs to form a larger part of training across disciplines as it becomes a more foundational part of work in the industry as a whole.

The industry and government are working together to tackle these problems. As part of the Sector Deal, announced on 5th December 2018:

- The **Science Industry Partnership, with key partners including the ABPI, will commission a Life Sciences 2030 Skills Strategy**, funded by £100,000 from SIP, with further funding from trade association partners and government. It will build on this evidence base of the status of life science skills and future scenarios to 2030, focusing on medicines manufacturing for established medicines and advanced therapies (supported by the Medicines Manufacturing Industry Partnership), as well as other emerging technologies, such as AI, and to identify what is needed in addition to current provision.
- Industry is also developing innovative new solutions to encourage young people to take up and pursue STEM subjects and careers:
    - **ABPI** will support the **British Science Association's** work to deliver a new government-funded competition for young people, inspiring them about STEM through learning how society, technologies and jobs will change as a result of addressing the Industrial Strategy Grand Challenges.
    - **ABPI** will convene key partners in healthcare and industry to identify opportunities to improve support focused on research and innovation for medics throughout their training and career, e.g. developing ABPI's careers resource into a new joint portal that will support, amongst others, medical students with their career.
    - **ABPI** will also work with **Health Education England** to align industry's support for work on medical careers with the Topol Review, which will make recommendations next year on how to prepare the healthcare workforce to deliver the digital future.

Together, we hope these efforts will continue to address long-term skills shortages and tackle some of the new challenges that have emerged from this survey.

Andrew Croydon
Skills & Education Policy and Examinations Director.
The Association of the British Pharmaceutical Industry.

Aims and objectives

The objective of this report is to provide an update to the 2015 survey producing robust evidence of the current skills needs and future concerns in the pharmaceutical and biopharmaceutical industries.

This report seeks to:

- Benchmark changes in the current and future skills needs for the pharmaceutical industry against those identified in 2015;
- Assess how well the UK education and skills system is meeting these needs; and
- Identify activities and actions by the various stakeholders, including Government, research and training funders, academy and industry which could address new or ongoing skills needs identified.

Introduction

Industry landscape

The UK pharmaceutical sector employs 63,000 people[1] and in 2017 had a turnover of £33.3bn[2]. In 2016, the pharmaceutical industry accounted for 19% of all R&D expenditure in the UK, investing around £4.1 billion[3]. This was almost as much as computer programming, information services and aerospace combined. The pharmaceutical industry's R&D expenditure peaked in 2011 (approaching £5bn) but has trended downwards since. In our last report, we highlighted two key challenges facing the industry: the slow uptake of innovative medicines and the increased pressure on the NHS to find savings. Unfortunately, both these challenges have persisted. While the 2018 Budget confirmed a welcome boost for the healthcare service[4], increasing by £20.5 billion a year in real terms by 2023-24, years of funding pressures have had a knock-on effect on the pharmaceutical industry. These fundamental challenges must be addressed in order for the UK's leading position in life sciences to be maintained.

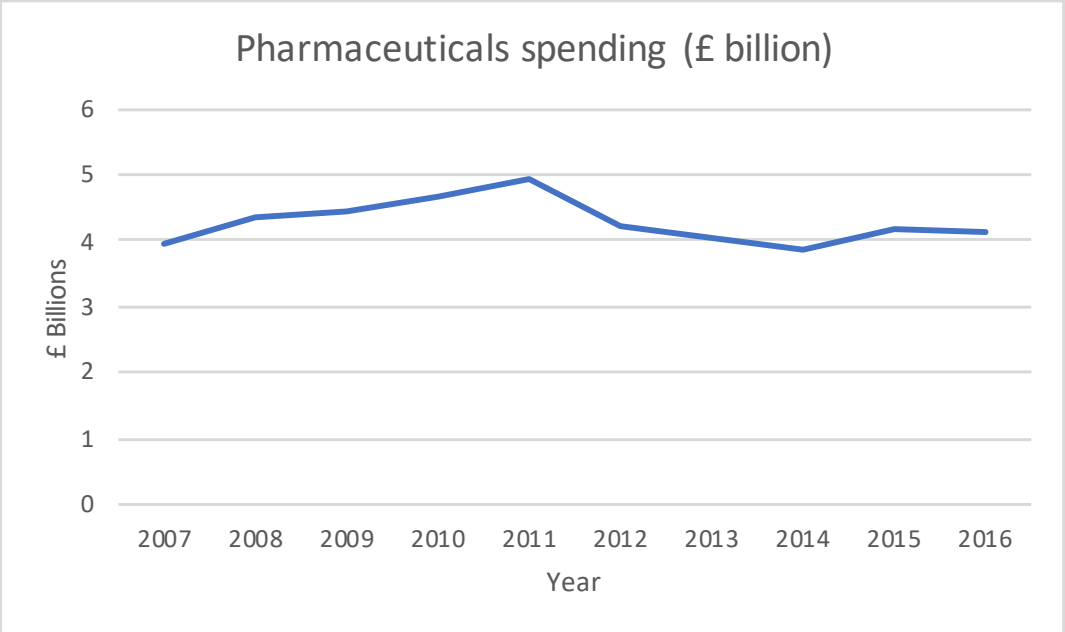
1 ONS, BERD statistics, 2016

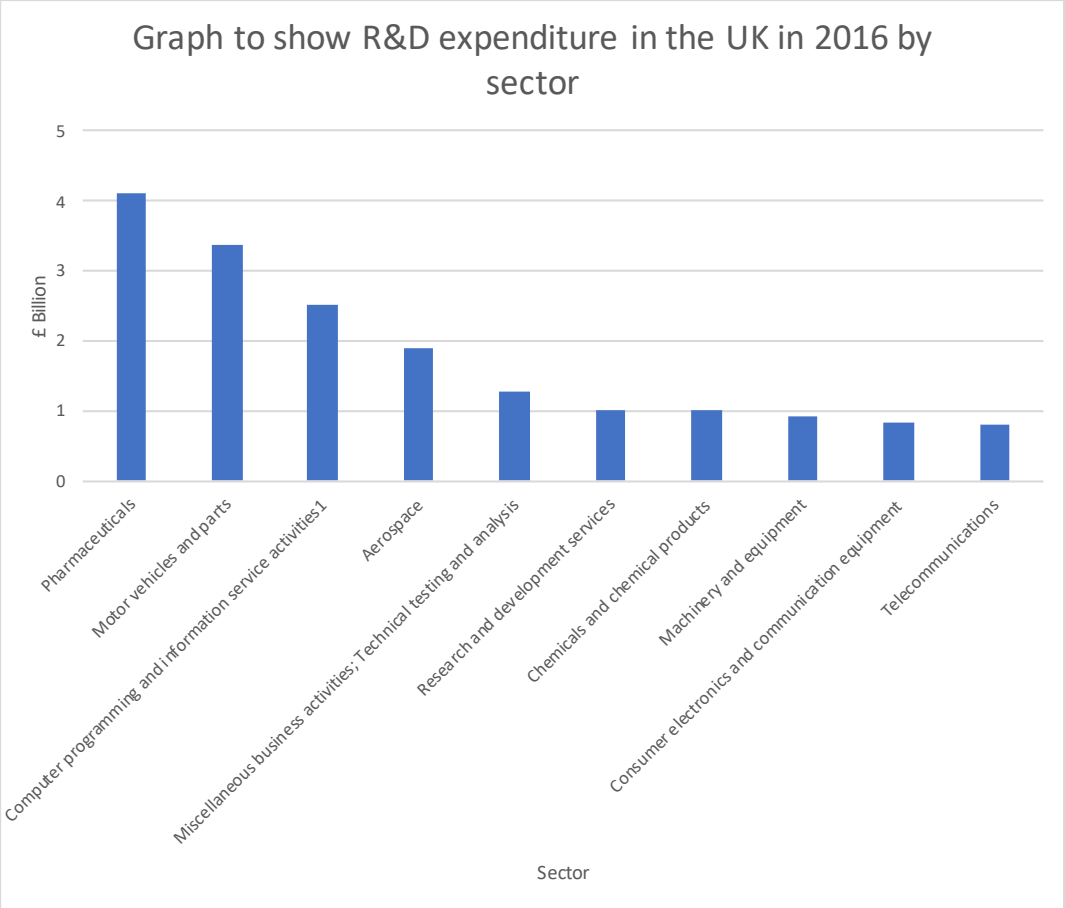
2 Office for Life Sciences, Strength and Opportunity, 2017

3 ONS, BERD statistics, 2016

4 HMT, Budget 2018

Figure 1: R&D expenditure in the UK in 2016 by sector.





Brexit

Since the last survey, the UK voted to leave the European Union.

The ABPI has set out clear priorities to maintain and grow the UK's world leading life sciences sector[5]. Our key policy priorities are as follows:

- Medicines regulation
- Innovation, science and research
- The ability to freely trade and move medicines and pharmaceutical supplies across borders
- Access to the best talent

The ease of movement of highly-skilled talent in life sciences is crucial in giving context to the survey results. Key areas of focus for the ABPI in the area of securing access to the best talent include:

- Delivering a UK immigration system that is needs based, straightforward and rapid
- Agreeing reciprocal arrangements with the EU that facilitate ease of movement for scientists, researchers and highly-skilled workers, maintaining current systems such as the intra-company transfer (ICT) process
- Guaranteeing the rights of scientists, researchers and highly-skilled EU citizens already in the UK, alongside securing the rights of UK citizens working and operating in the EU

The life sciences sector (of which the pharmaceutical industry is a part) published its own Life Sciences Industrial Strategy in 2017. Following this, the Government published the Industrial Strategy White Paper and the Life Science Sector Deal. The latter represents a joint investment commitment between industry, universities, charities and the Government.

The House of Commons Business, Energy and Industrial Strategy Committee has included the pharmaceutical industry in their specific inquiries looking at the impact of Brexit on a range of industries[6]. Among the Committee's conclusions they highlighted that "EEA employees (and employees from the rest of the world)…provide skills that are not currently readily available from UK recruits, including shortages on translational medicine, clinical pharmacology and novel therapies.[7]" These shortages, the Committee argued, "could increase depending on the post-Brexit immigration approach as well as any changes to pharmaceutical regulation".

The Brexit backdrop increases the saliency of this survey. Concerns about recruiting highly qualified workers have increased. The ease and speed with which biopharmaceutical companies can bring talent to the UK, such as through ICTs, is a fundamentally important factor which drives companies to maintain their European headquarters in the UK.

SMEs are particularly concerned about any increased bureaucracy that may be generated by changes to the visa system. For global biopharmaceutical companies, Tier 2 general visas are arguably even more important mechanisms to recruit scientists, researchers, and those with skills in IP law, software development, finance and regulation.

Many respondents to this survey highlighted the uncertainty they felt because of Brexit and expressed their concerns about how it could affect recruitment. The uncertainty of a post-Brexit regulatory framework was also raised as an issue. It should also be noted that this keenly felt sense of Brexit-induced uncertainty may have coloured respondents' answers to a range of questions – even those not closely related to Brexit. This may account for some changes in the results.

5 Maintaining and growing the UK's world leading Life Sciences sector in the context of leaving the EU, September 2016, https://www.abpi.org.uk/publications/maintaining-and-growing-the-uk-s-world-leading-life-sciences-sector-in-the-context-of-leaving-the-eu-1/

6 BEIS Select Committee, Brexit and the implications for UK business: Pharmaceuticals inquiry, https://www.parliament.uk/business/committees/committees-a-z/commons-select/business-energy-industrial-strategy/inquiries/parliament-2017/inquiry4/

7 https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/382/38210.htm

Recruitment trends

In the UK, the industry employs 63,000 people, with 24,000 devoted to R&D[8]. Pharmaceutical companies specialising in small molecule therapeutics are the biggest employers, providing jobs for 77% of those working in the pharmaceutical industry. The majority of the sector are SMEs. Roughly half of all pharmaceutical businesses are based in the East and South East of England[9].

Globally, employment has grown in recent years. The pharmaceutical industry employed 3.6m people worldwide in 2006; by 2014 that number had risen to 5.1m.[10] Yet across Europe, employment has dipped slightly (737,000 in 2006 compared to 736,000 in 2014). The bulk of employment growth has come from Asia, with strong employment growth also present in Latin America. Employment trends in the UK have been similar to Europe's, with the industry seeing a slight decline over recent years. At the time of our last report, 70,000 people were employed by the pharmaceutical industry in the UK – 6,000 more than today.[11]

Education

Just under half of undergraduates study STEM subjects – a proportion that has remained reasonably constant over many years. 'Biological sciences' and 'subjects allied to medicine' are two of the three most popular categories of degree, with 'business and administrative studies' in top position. These three degree types topped the list in our last report as well. While the overall number of STEM undergraduates has increased over the last decade, part of that is due to overseas students (who currently make up 13% of STEM undergrads). Over the last decade, the number of UK undergraduates studying STEM subjects increased by 16% (compared to an overall increase across all subjects of 13%). By comparison, undergraduate numbers for (non-UK) EU and non-EU students increased by 52% and 63% respectively over the same period.

However, the increased popularity of STEM amongst UK students is still welcome news. As we stressed in our last report, it is vital that the number of STEM students is sustained and keeps increasing in the future[12]. It is also important that the pharmaceutical industry continues to be proactive in attracting STEM graduates; it is encouraging to note that undergraduate placements in the industry have increased by 17% since our last report.[13]

The growing popularity of STEM at degree level probably reflects progress at secondary level. At GCSE, the picture is encouraging. Biology, Chemistry and Physics (known as 'triple science' when taken together) have been available as individual subject choices for many years. However, until relatively recently, the majority of pupils in England have taken combined science courses at GCSE. In 2006, the Government introduced a requirement for every school to offer triple science to their pupils. Since then, uptake has increased dramatically: entries for individual science GCSEs have more than doubled in the last decade. As we noted in our last report, the figures dipped in 2014. This was followed by another dip the next year, but figures are now rising again, and the overall increase since 2006 is promising.

The growing take-up of single science at GCSE has had a knock-on effect on science A-Level entries, which also grew over the last decade. Biology entries rose by 13%, Chemistry by 30% and Physics by 33%. Further Maths A-Level entries have more than doubled, increasing every year; Maths entries are up 58%.[14]

Of course, university degrees are not the only way into the pharmaceutical industry, and good work has been done to improve access through vocational routes. Since our last report in 2015, apprenticeships in the pharmaceutical industry are up 31% (and up by 169% since 2013), including a 278% increase in higher-level apprenticeships (levels 4 and above) between 2015 and 2017.[15,16]

8 https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/datasets/ukbusinessenterpriseresearchanddevelopment/current

9 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707072/strength-and-opportunity-2017-bioscience-technology.pdf

10 https://www.ifpma.org/wp-content/uploads/2017/02/IFPMA-Facts-And-Figures-2017.pdf

11 https://www.abpi.org.uk/media/1365/skills_gap_industry.pdf

12 http://www.gatsby.org.uk/uploads/education/reports/pdf/stem-indicators-2017.pdf

13 https://www.abpi.org.uk/media-centre/news/2018/june/apprenticeships-hit-4-year-high-in-pharmaceutical-industry/

14 http://www.gatsby.org.uk/uploads/education/reports/pdf/stem-indicators-2017.pdf

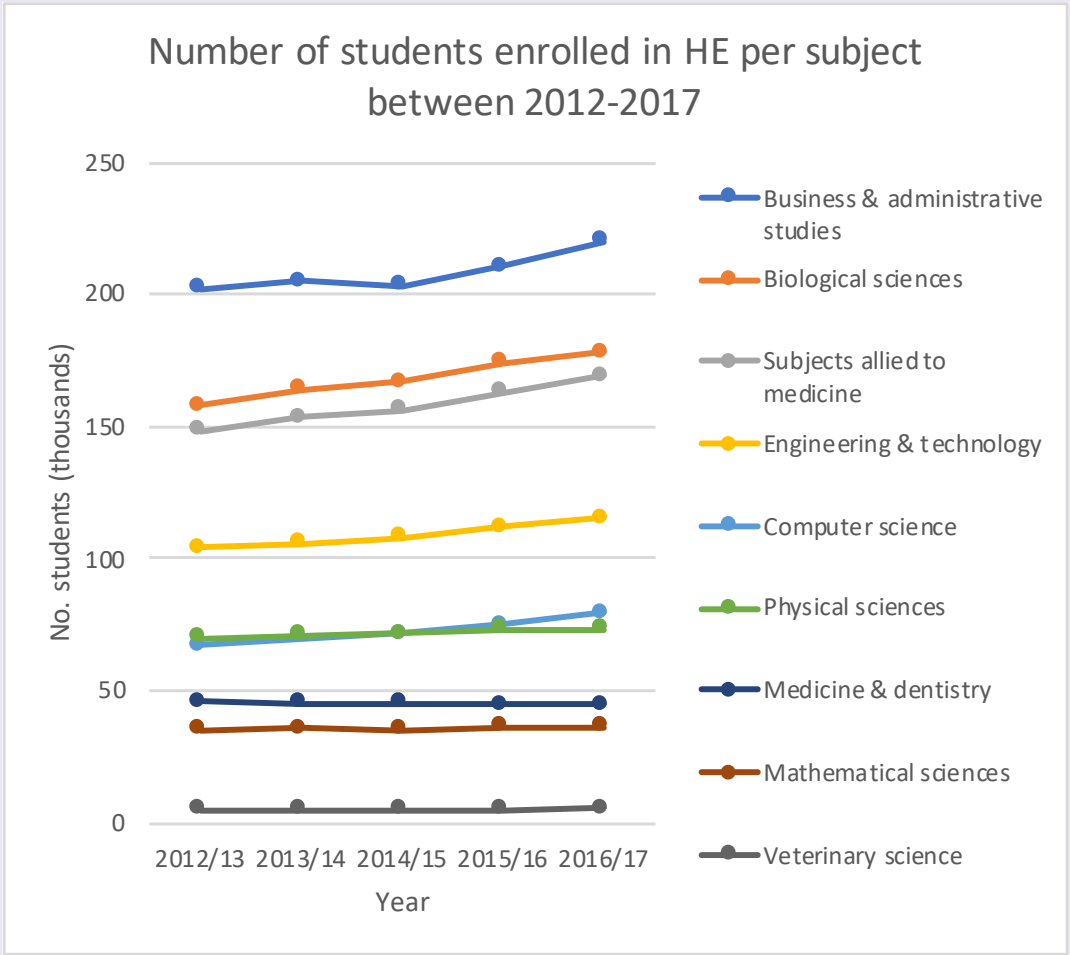
15 https://www.abpi.org.uk/media-centre/news/2018/june/apprenticeships-hit-4-year-high-in-pharmaceutical-industry/

16 https://www.abpi.org.uk/what-we-do/education-and-employment/links-between-industry-and-academia/apprenticeships-by-level/

"Whilst we need both a much greater uptake of apprenticeships within the biopharmaceutical industry, and an awareness that apprenticeships alone will not bridge the skills gaps, the sector remains incredibly enthusiastic about the apprenticeship route at the higher levels. Following the sector's early commitment to adopting apprenticeships as a valuable method for growing the talent base, fantastic careers in areas such as bioinformatics, advanced manufacturing and scientific research are now achievable through this route. Furthermore, new standards continue to be developed to support need and enhance further, routes into fulfilling careers in industry."

Dr Malcolm Skingle C.B.E, Director of Academic Liaison at GSK, Chair of the ABPI Academic Liaison Expert Network and Chair of the Science Industry Partnership

Figure 2: Number of students enrolled in HE per subject between 2012-2017.



Methodology

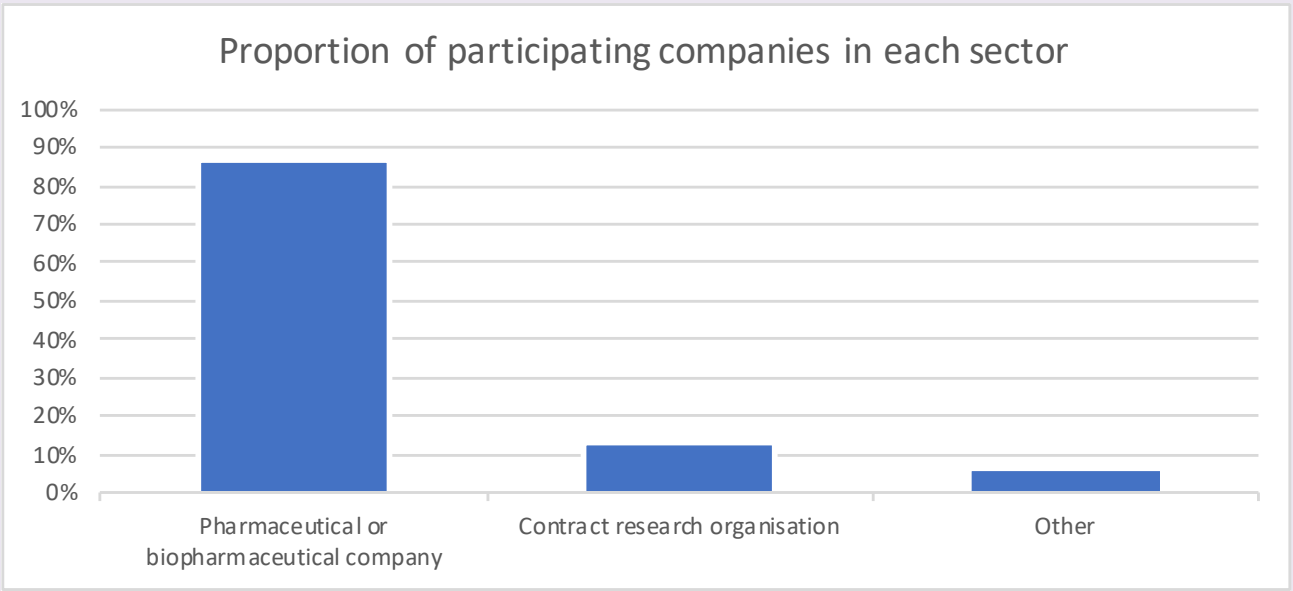
An online survey was used to seek views from the sector about the challenges of recruiting suitably qualified and suitably skilled staff. The survey was designed to provide data which could, as far as possible, be compared with those obtained in 2015 when the ABPI last reported data on the skills concerns of the sector.

Responses were sought from pharmaceutical and biopharmaceutical companies and contract research organisations (CROs). The majority of respondents were from pharmaceutical companies, with a very small minority from CROs. The survey data were collected between July 2018 and September 2018.

In total there were 56 respondents from 30 different companies. Five companies gave more than one response, with some giving up to 14 responses. In many cases, companies gave multiple responses for the same discipline.

In order to ensure that the report represents the views of the industry as a whole, in the main body of the report we have summarised responses on a weighted basis, ensuring that when a company provided more than one response these were averaged out and each company's overall views are counted equally. In order to provide better comparability with past editions of the survey, in the appendix we include a non-weighted version of the data and identified where weighting makes a difference to the overall story. Overall, however, we found that weighting the data did not create a significant difference to the overall high priorities identified.

Figure 3: Proportion of participating companies in each sector.



The survey was grouped into the following overarching areas of: biological science; chemical science; clinical; pharmacy; informatics, computational, mathematical and statistics; regulatory; business. Within each of these overarching areas individual disciplines were listed. The definitions for these disciplines were generally the same as those used for our earlier survey if the discipline was included in 2015 – although our expert group updated some of the domains to reflect the changing industry landscape.

Participants were asked to comment on concerns with recruitment into the discipline areas that were relevant to them and/or their companies, as well as general questions about core competencies.

For each discipline area respondents were asked:

- Whether there is a problem with the number and/or quality of candidates;
- Whether recruitment for this area is expected to become more difficult in future;
- To rank the area's recruitment priority as low, medium or high;
- What qualification level of candidate recruitment is affected; and
- To rate the level of concern with practical skills (where applicable).

Additional general questions sought information on core competencies, which were rated in terms of how much of a concern they are. Information on the qualification level of individuals that companies are recruiting, and from where these individuals are being recruited, was also sought. (For a general version of the questionnaire and a list of discipline areas included, see Appendix 1, Survey.)

Findings and discussion

Top priorities

At a glance

- With the exception of clinical pharmacology and bioinformatics, top priorities have changed since the previous survey;
- There is an increase in the importance of core scientific disciplines (biological and chemical) and a relative decrease in clinical and applied areas such as Health informatics; Health economics; and Qualified Persons; and
- Large numbers of computational disciplines are a high priority, each for a relatively small number of companies. This suggests that while the exact computational discipline varies (and therefore, the number of response rates for very specific sub-disciplines are low) as a whole this is becoming a major priority for the pharmaceutical industry.

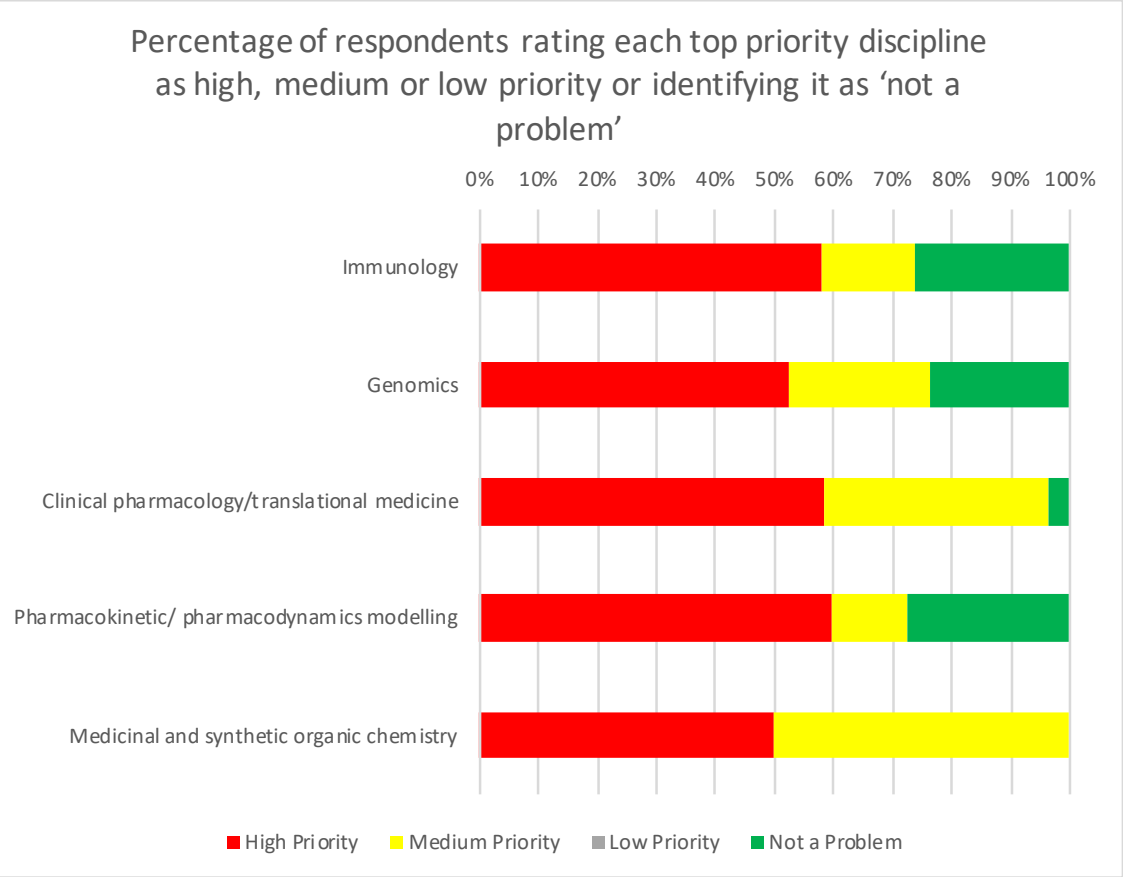
We therefore predominantly see challenges in the **core scientific disciplines of biological and chemical sciences;** in a **wide variety of computational disciplines; with a remaining challenge in clinical pharmacology.**

The data obtained was analysed in order to determine the areas where immediate action is required to address skills gaps. Any discipline area that over 50% of respondents identified as 'high priority' was considered a top concern and thus was analysed further. Results and findings for other discipline areas can be found in the appendices; in this section, we identify the disciplines of highest priority. These are then discussed further below under their broad scientific areas.

We have also expected at least two weighted responses before considering areas a high priority. These were

- **Biological sciences:** Immunology and Genomics;
- **Clinical areas:** Clinical pharmacology;
- **Informatics, Computational, Mathematical and Statistics:** Pharmocokinetic/pharmacodynamics modelling; and
- **Chemical sciences:** Medicinal and synthetic organic chemistry.

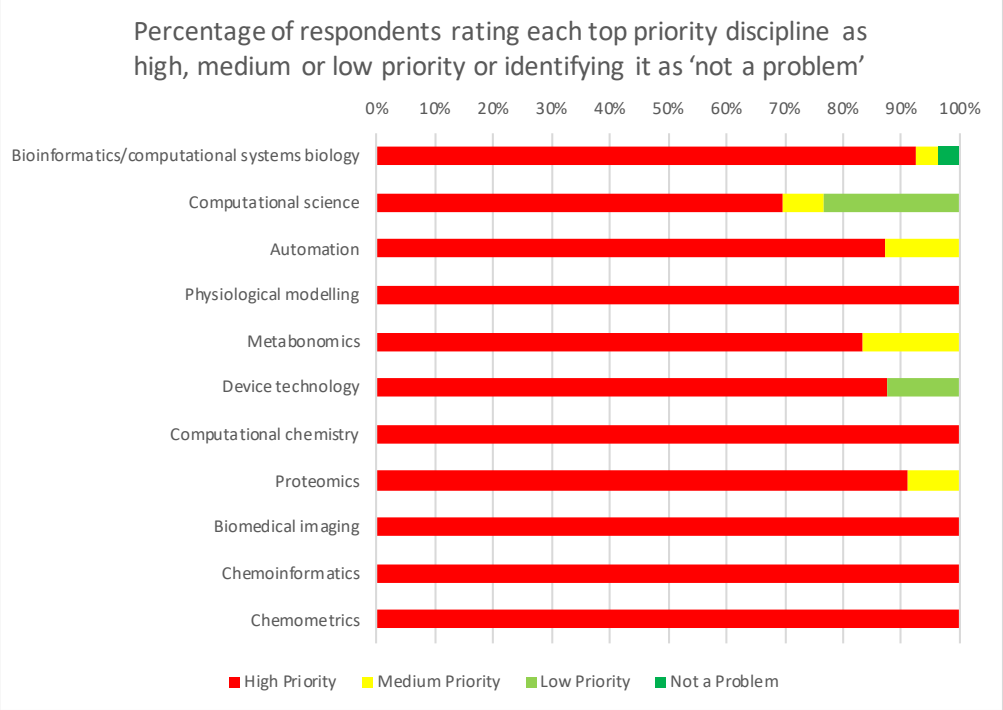
Figure 4: Percentage of respondents rating each top priority discipline as high, medium or low priority or identifying it as 'not a problem'.



By disapplying the numbers threshold, we also saw the following disciplines emerge.

Discipline	Area
Bioinformatics/computational systems biology	Informatics, Computational, Mathematical and Statistics
Computational science	Informatics, Computational, Mathematical and Statistics
Automation	Informatics, Computational, Mathematical and Statistics
Physiological modelling	Informatics, Computational, Mathematical and Statistics
Metabonomics	Biological Science
Device technology	Pharmacy
Computational chemistry	Informatics, Computational, Mathematical and Statistics
Proteomics	Biological Science
Biomedical imaging	Informatics, Computational, Mathematical and Statistics
Chemoinformatics	Informatics, Computational, Mathematical and Statistics
Chemometrics	Informatics, Computational, Mathematical and Statistics

Figure 5: Percentage of respondents rating each top priority discipline as high, medium or low priority or identifying it as 'not a problem'.



Again, these are different from the previous survey. We have directly compared them below. Those in red appear in both surveys.

Table 1: Comparison of 2015 core priorities with 2018 core priorities.

Core priorities 2018	Core priorities 2015
High priority with number minimum	*High priority with number minimum*
Immunology	Clinical pharmacology/translational medicine
Genomics	Bioinformatics/computational systems biology
Clinical pharmacology/translational medicine	Statistics
Pharmacokinetic/pharmacodynamics modelling	Data Mining
Medicinal and synthetic organic chemistry	Qualified Person PV
Bioinformatics/computational systems biology	Qualified Person QA
	Veterinary and toxicological pathology
	Health informatics
	Health economics and outcomes
	Formulation
High priority without number minimum	*High priority without number minimum*
Computational science	Chemoinformatics
Automation	Clinical pathology
Physiological modelling	In vivo physiology
Metabonomics	Computational chemistry
Device technology	Biomedical imaging
Computational chemistry	Proteomics
Proteomics	Process chemistry
Biomedical imaging	Metabonomics
Chemoinformatics	
Chemometrics	

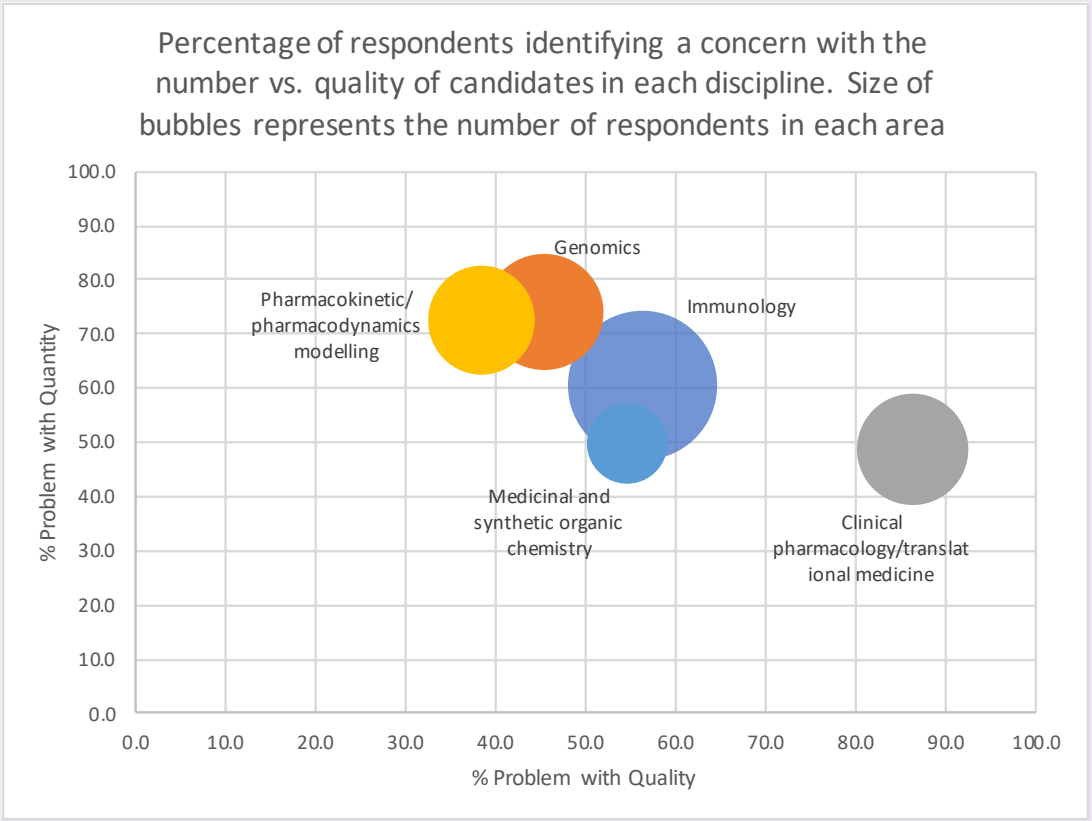
There are a number of points of interest to note in these responses:

- With the exception of clinical pharmacology, **these are not the core priorities that emerged in the previous survey.**
- We see an increased relative importance of **core scientific disciplines** (biological and chemical) and a relative decrease in clinical and applied areas such as Health informatics; Health economics; and Qualified Persons.
- By disapplying the numbers weighting, there are **extremely large numbers of computational disciplines appearing as high priority.** This suggests that while the exact computational discipline varies (and therefore the number of response rates are low) **as a whole, this is becoming the biggest priority for the pharmaceutical industry.**

We also asked respondents whether the key challenges were number of applicants; quality of applicants; or both.

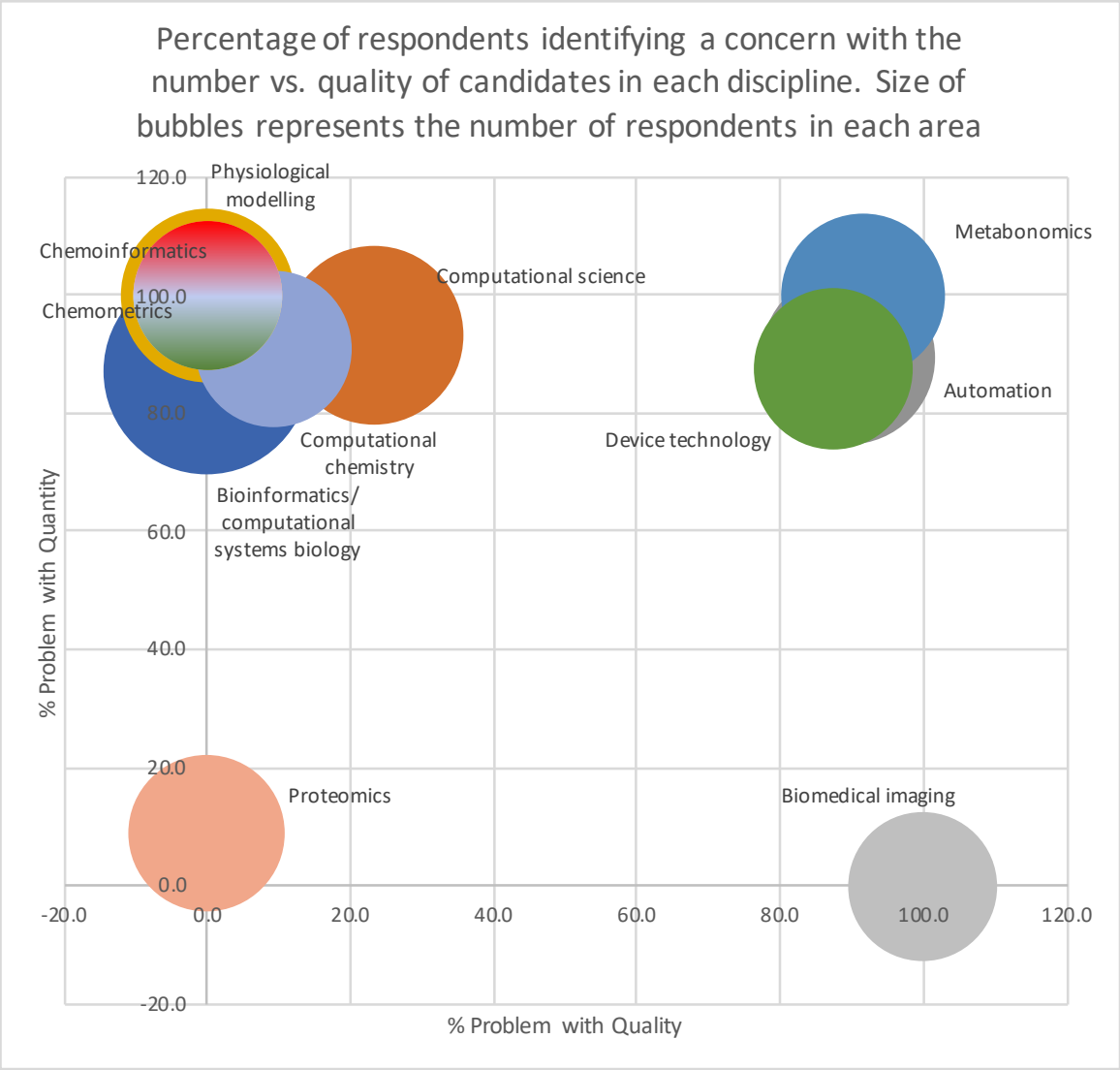
For those with the highest responses, we see a greater quantity challenge with *genomics* and *pharmacokinetic modelling*, and a relatively greater quality challenge with *clinical pharmacology.*

Figure 6: Percentage of respondents identifying a concern with the number vs. quality of candidates in each discipline.



Meanwhile, the lower response high priority areas show areas – automation; device technology; and metabonics – where quality and quantity issues exist. Biomedical imaging is predominantly a quality problem and computational disciplines and chemoinformatics and chemometrics are mostly quantity issues.

Figure 7: Percentage of respondents identifying a concern with the number vs. quality of candidates in each discipline.



Biological science areas

At a glance

- A large number of biological science disciplines are of concern – either high priority high volume; high priority low volume; or very high percentage high and medium priority;
- There is a wide variety of shortages in terms of the level of staff – although experienced staff are consistently most demanded;
- Practical skills are of particular concern in: Biotechnology; Immunology; Molecular/transitional pharmacology; Structural biology; Toxicology; and
- The highest priority areas – immunology and genomics – are directly related to shifts in how drugs are developed.

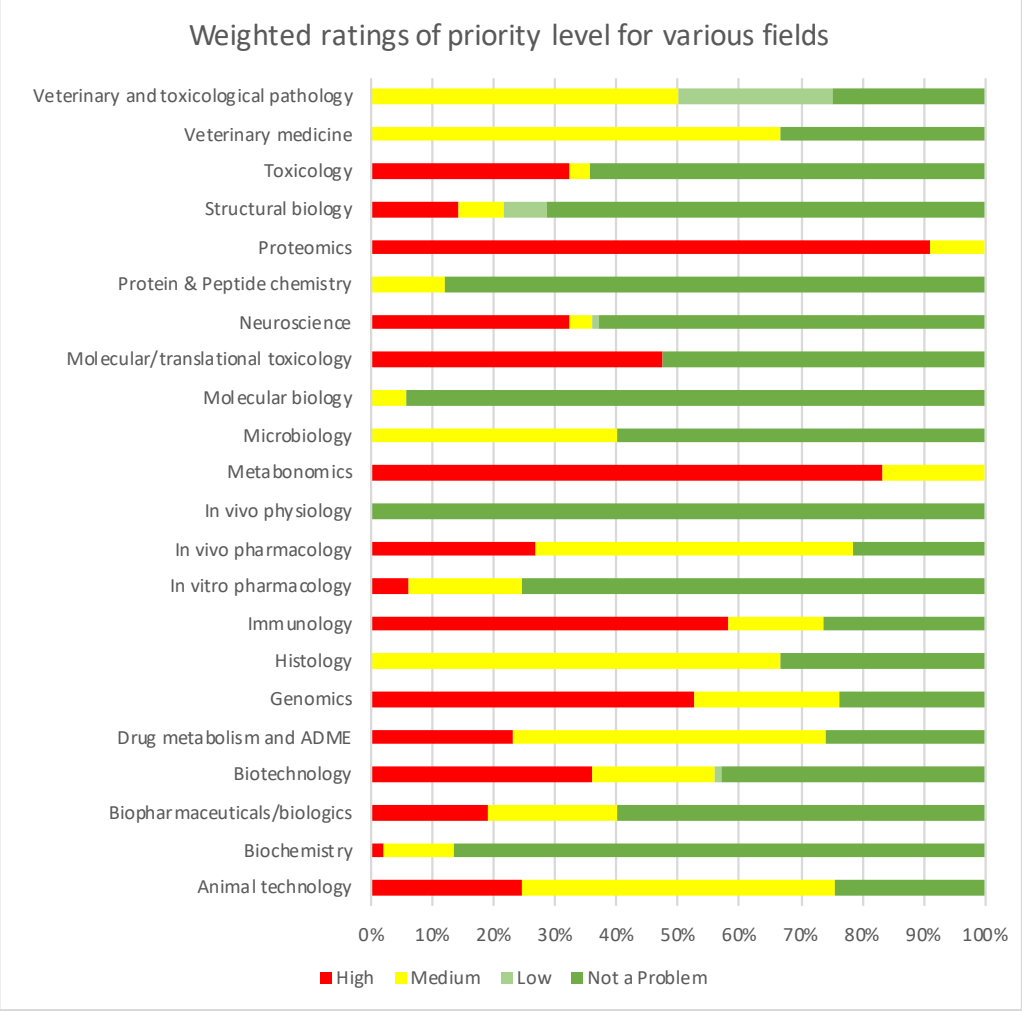
Immunology and genomics were the biological science disciplines considered to be of high priority at high volume in recruitment terms. However, across the biological sciences there were concerns about both the quality and number of recruits. Moreover, it should be noted that many disciplines in this area were ranked at least 50% high or medium priority, suggesting the need for careful attention to ensure they do not move into the high priority category.

The level at which the shortages were seen varied by discipline. For those which were overall high priority we tended to see shortages at all levels. For some others, the discipline itself determined shortages (for example in animal technology non-graduates were needed).

Table 2: Biological science areas where at least 50% of weighted respondents consider it high or medium priority, and the associated experience of staff most needed.

Biological science areas where at least 50% of weighted respondents consider it high or medium priority	Experience of staff most needed (most cited)
Veterinary and toxicological pathology	Post-doc; Experienced staff
Veterinary medicine	PhD; Experienced staff
Proteomics (very high priority; low respondents)	All levels
Metabonomics (very high priority; low respondents)	All levels
In vivo pharmacology	All graduate + levels
In vitro pharmacology	Experienced staff
Immunology (overall top priority)	All levels except non-graduate
Histology	Non-graduate
Genomics (overall top priority)	PhD; Post-doc; Experienced staff
Drug metabolism and ADME (very high percentage medium or high priority)	Graduate; experienced staff
Biotechnology	Experienced staff
Animal technology (very high percentage medium or high priority)	Non-graduate

Figure 8: Percentage of respondents rating each biological science discipline as high, medium or low priority or identifying it as 'not a problem'.



The disciplines where **practical skills** were considered most problematic on a weighted basis were:

- Biotechnology
- Immunology
- Molecular/transitional pharmacology;
- Structural biology; and
- Toxicology

The disciplines with **no concerns over practical skills** were:

- Biochemistry;
- Histology;
- Metabonics
- Microbiology
- Molecular biology
- Protein and peptide chemistry
- Proteomics
- Veterinary medicine; and
- Veterinary and toxicological pathology.

This suggests either the training given, or the nature of the discipline itself, means that practical skills are well represented in the candidates selected.

Immunology

Immunologists study the immune system. Their work often forms part of biochemistry and in vivo pharmacology roles, although specialist immunologists are often recruited to more senior positions. High levels of concern were expressed about both the number of candidates and quality of candidates. Every respondent said this shortage affected the recruitment of experienced staff primarily, but also ranked post-doc, PhD and graduate recruitment concerns as high.

Immunologists can either study for a first degree that specialises in the subject or pursue a post-graduate degree after a broader training in biological sciences. Most will have Biology, and probably Chemistry and Maths at post-GCSE level.

Immunology was added from the last survey because the ABPI expert network deemed it both a separate discipline in its own right and one of potential concern.

It is likely that the increased demand in immunology is a result of increased interest in biological drugs such as antibodies. Immunologists often work in research positions but can also work in applied fields such as, for example, medical-liaison.[17]

Genomics

Genomics is a discipline where techniques to sequence, assemble and analyse genomes are used to establish their structure and function. According to some pharmaceutical companies "genomics is driving a new era of drug discovery"[18] and there have been large investments in the UK using, for example, the UK biobank's resource.

Genomics recruitment was considered a high priority by 50% of respondents, moving into the high priority bracket, from the more moderate priority it held in 2015. A problem with the number of candidates was markedly the biggest concern as well as its effect on the recruitment of experienced staff specifically.

This is, in large part, because an increased understanding of the genetic profiles of patients is helping target research. This in turn should help reduce the very high attrition rates as drugs are developed and tested, thereby improving the probability of them being useful to patients.

> *"The skillset for the analysis of these types of data has moved from a specialist requirement to being needed in the vocabulary of all researchers – it is here where the challenge lies."*
>
> (Survey respondent)

17 Nature, Industrial Immunology https://www.nature.com/naturejobs/science/articles/10.1038/nj7462-367a

18 GlaxoSmithKline, December 2017 https://www.gsk.com/en-gb/behind-the-science/innovation/how-genomics-is-driving-a-new-era-of-drug-discovery/

Chemical science areas

At a glance

- The chemical sciences are not in general considered to be high priority.
- The exceptions are medicinal and synthetic organic chemistry (a top priority) and analytical chemistry/ biochemistry; and
- Process chemistry – a priority in the previous two surveys – is no longer considered a priority.

In general, the chemical sciences were not considered very high priority by respondents, with two exceptions: medicinal and synthetic organic chemistry, which is a top priority; and *analytical chemistry/biochemistry.*

Chemical science areas where at least 50% of weighted respondents consider it medium or high or medium priority	Experience of staff most needed (most cited)
Medicinal and synthetic organic chemistry	All levels
Analytical chemistry/biochemistry	All levels

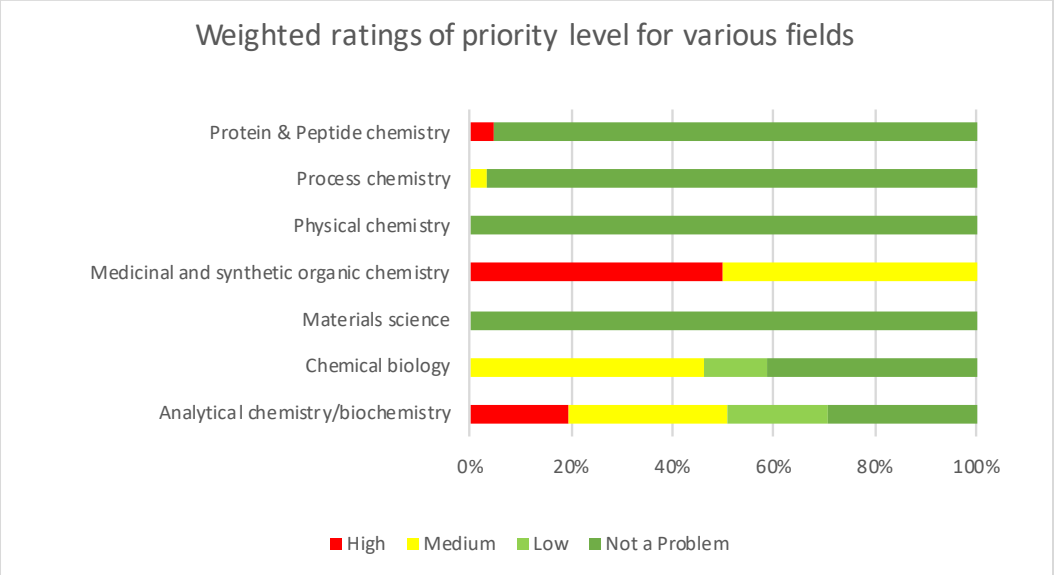
Shortages were seen at all levels – although for analytical chemistry/biochemistry there was a particular shortage of experienced staff.

In the previous survey process chemistry was considered a high priority – this is no longer true.

"We receive a good volume of applications however, these are generally from graduates who do not have relevant industry experience. We require at least 12 months industry experience in analytical."

Survey respondent

Figure 9: Percentage of respondents rating each chemical science discipline as high, medium or low priority or identifying it as 'not a problem'.



Some of these disciplines had a lower response rate, which may account for the appearance of lower priority. However, the 2015 survey also found the chemical science areas to be of lower priority.

We also did not see practical skills flagged as an issue in this area – organic chemistry is a highly practical discipline, so that suggests that training may be sufficiently high quality.

Medicinal and synthetic organic chemistry

Synthetic chemists are involved in making chemical compounds, which are then tested for their potential as new medicines. Medicinal chemists are involved in the design of these compounds. Peptide chemists use synthetic organic chemistry techniques to make, purify and analyse compounds for use as medicines. In medicinal chemistry various techniques are used to design and predict the activity of compounds at a biological target such as a receptor or enzyme, as well as its likely pharmacokinetic profile and safety properties.

Medicinal chemists are likely to have a background in synthetic organic chemistry but may have additional knowledge and skills around molecular understanding of biological systems and processes through application of synthetic, physical, analytical and computational methods. In many organisations, chemists perform the role of both synthetic and medicinal chemist at the same time.

In 2015 medicinal and synthetic organic chemistry came second as a priority to process chemistry, with over 70% considering it a high or medium priority.

Analytical chemistry/biochemistry

Analytical chemists/biochemists work at every stage of development of a medicine, from confirming the structure of a compound that has been made for the first time, to checking the purity of a batch of medicine that is about to be released for sale. Analytical chemists/ biochemists may be involved in investigating biological targets, using biophysical techniques to screen and validate targets and studying how molecular properties affect biological activity. Analytical chemists/biochemists also develop techniques for biomarker identification and detection and probe design (mass spectrometry, PET, SPECT, MRI, labelling).

Process chemistry

Process chemists develop the chemical syntheses for the large-scale preparation of molecules progressing into advanced clinical studies and the synthetic routes for commercial manufacture. In 2008 process chemistry was a medium priority and in 15 a high priority – in the 2018 survey it is no longer a significant priority. This may reflect a low sample size or the success of some of the focus from the Chemistry Growth Strategy Group.

Clinical areas

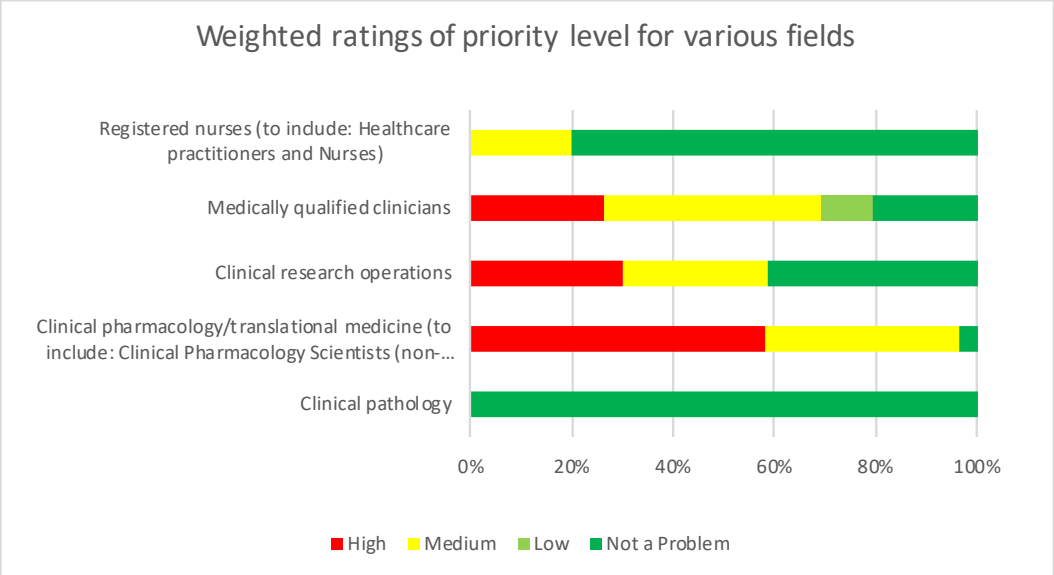
At a glance

- *Clinical pharmacology/translational medicine* has consistently been a top priority since the first ABPI skills survey in 2005. It remains a challenge.
- However, in general we see some progress in *clinical pharmacology/translational medicine* and in other clinical disciplines. We can tentatively conclude that there has been steady progress on skills gaps in this area.

Clinical pharmacology/translational medicine has consistently been a top priority since the first ABPI skills survey in 2005. It remains a challenge, although we do see some progress – in 2015 over 70% considered it a high priority. Today it stands at less than 60% (although sample sizes are not big enough to see this as anything but indicative).

In 2015 all other clinical areas were considered to be medium priority. This is no longer true – *clinical pathology* is no longer considered a challenge, and we see reductions in the prioritisation of all clinical areas. We can therefore tentatively conclude that there has been steady progress on skills gaps in this area.

Figure 10: Percentage of respondents rating each clinical discipline as high, medium or low priority or identifying it as 'not a problem'.



There was a general concern raised by one of our respondents – that the skills base was not keeping pace with technological change.

"Clinical trial design is changing significantly due to:

1. *adaptive/more dynamic trial design & implementation*
2. *The need to address market access (pricing & reimbursement) requirements earlier in clinical development than is traditionally thought about*
3. *The requirement for greater understanding of impact on/measurement of HRQoL throughout clinical development*
4. *The requirement to understand what outcomes may be measured which can later be used in outcomes-based contracting arrangements*

Therefore, those involved in clinical development need to understand these points, and this is seldom the case"

Clinical pharmacology

Clinical pharmacology provides industry with analysis of wanted and unwanted effects of medicines on patients and clinical trial participants. Translational medicine covers the research done at the interface between basic scientific discoveries and patient care through use of medicines. Experts in this area are key for industry, as they provide critical knowledge on both the pharmacokinetic/pharmacodynamic properties of medicines, as well as in-depth expertise on the pathophysiology of diseases. They have a key role in clinical research and their contribution is essential to improve the success rate of early phase trials.

Since the last survey the Association of the British Pharmaceutical Industry, the British Pharmacological Society, the Faculty of Pharmaceutical Medicine and Health Education England joined together to form the Clinical Pharmacology Skills Alliance to develop a long-term, cross-sector action plan. The plan has been designed to develop creative solutions for improving the full clinical pharmacology skills pipeline and the delivery of key competencies in line with priorities across the healthcare sector and the life sciences sector – and in collaboration with other healthcare professionals and scientists. This includes measures to raise visibility of the discipline; practical support in training; partnership to develop an integrated medicines pathway; and developing an NHS workforce strategy.

Clinical research operations

This discipline ensures correct set-up, monitoring, and close-down of clinical trials. This includes developing protocols, identifying trial sites/locations, setting up and monitoring trial progress, ensuring complete documentation throughout the trial and resolving any issues that arise with a view to high quality data being obtained in a timely fashion.

Although not a top priority we still saw some concerns in clinical research operations and a very large number of qualitative inputs.

Medically qualified clinicians

There are many areas where doctors play an important part within the pharmaceutical industry, including clinical development, regulatory affairs, drug safety and clinical pharmacology. They have a key role in supporting clinical research and clinical trials.

On a non-weighted basis this had an extremely high number of respondents indicating deep concern from some companies. It has continued to be flagged as concern since the 2008 ABPI skills survey.

There continue to be concerns about the awareness of roles available for clinicians in the pharmaceutical industry and the way in which medical training communicates how industry works.

"We had a replacement vacancy for an experienced Clinical Pharmacologist. Due to difficulties recruiting and length of time this role was vacant, we are fast tracking an existing employee to develop into this role"

"[we must] improve quality of candidates to ensure modern technologies and imaging techniques [can be used]"

"I would say the number and quality of nurse candidates applying for research jobs in clinical pharmacology is a particular concern"

Pharmacy

At a glance

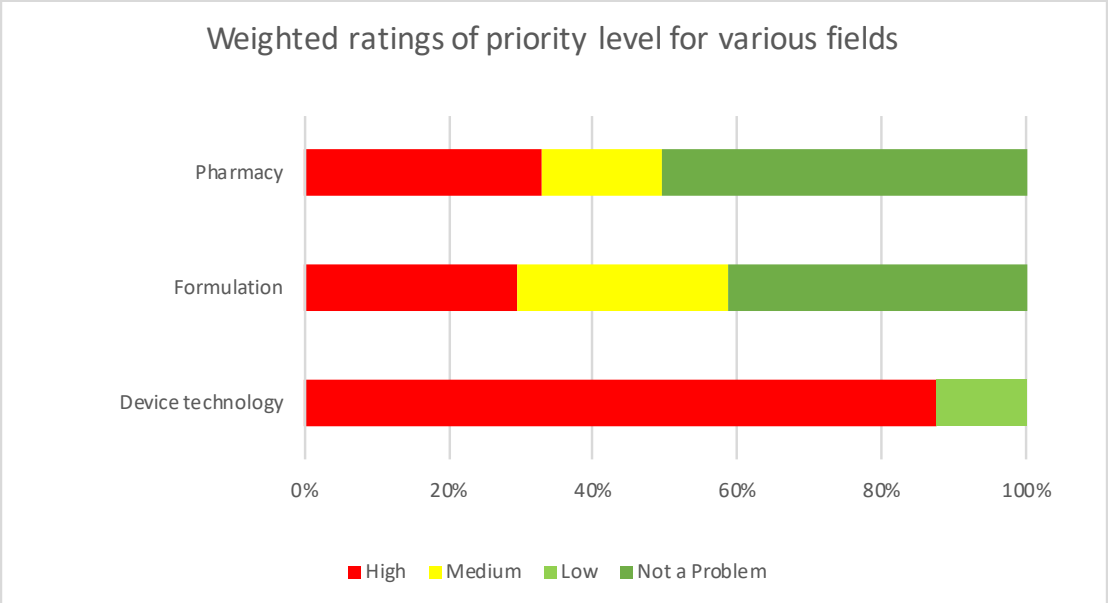
- Device technology is a more serious concern than in the last survey – possibly reflecting an increased focus on diagnostic technologies.

Although none of the disciplines within pharmacy were considered top priorities (due to low response rates) *device technology* was considered a very high priority by those who responded. It was rated as 'requires action' in the previous survey and has become more significant.

Formulation, which was a high priority in the previous survey, has become less of a priority. Meanwhile device technology was rated as 'requires action' in the previous survey and has become more significant.

Problems with quality and quantity were flagged across these disciplines, and concerns over practical skills ranked high.

Figure 11: Percentage of respondents rating each pharmacy discipline as high, medium or low priority or identifying it as 'not a problem'.



Device technology

This is the work related to medical devices which includes drug delivery systems such as inhalers, injections and stents, and also clinical diagnostic tools.

> *"[We have a challenge with the] quantity and quality of candidates in both R&D and GMS – especially with experienced staff"* Survey respondent

It is possible that the increase in focus in this area is because of the rise in diagnostic technologies, their data capturing capabilities, and the desire for their rapid deployment. This may have made the field in higher demand by companies.

Formulation

Formulation involves creation of a dose of a medicine (such as a tablet, capsule or injection) which will deliver the active substance to the correct part of the body, in the right concentration, and at an appropriate rate. For biopharmaceuticals, formulation involves determining the appropriate excipients to add to the drug compound to deliver the desired dose via the desired delivery mechanism to the target organ or system in the body.

A study in 2013 estimated a GVA per employee of £172,000 in formulation technology. Despite this, respondents reported recruitment challenges. This has reduced from the previous survey and may be a result of the work reported in that survey by Cogent to increase training provision and access to qualifications.

> *"It's very difficult to recruit even at trainee level. Lack of practical bench skills are a serious concern"*
>
> *"[We see a] shortage in experienced formulation scientists… we also have salary challenges where candidates applying have large salary expectations"* Survey respondent

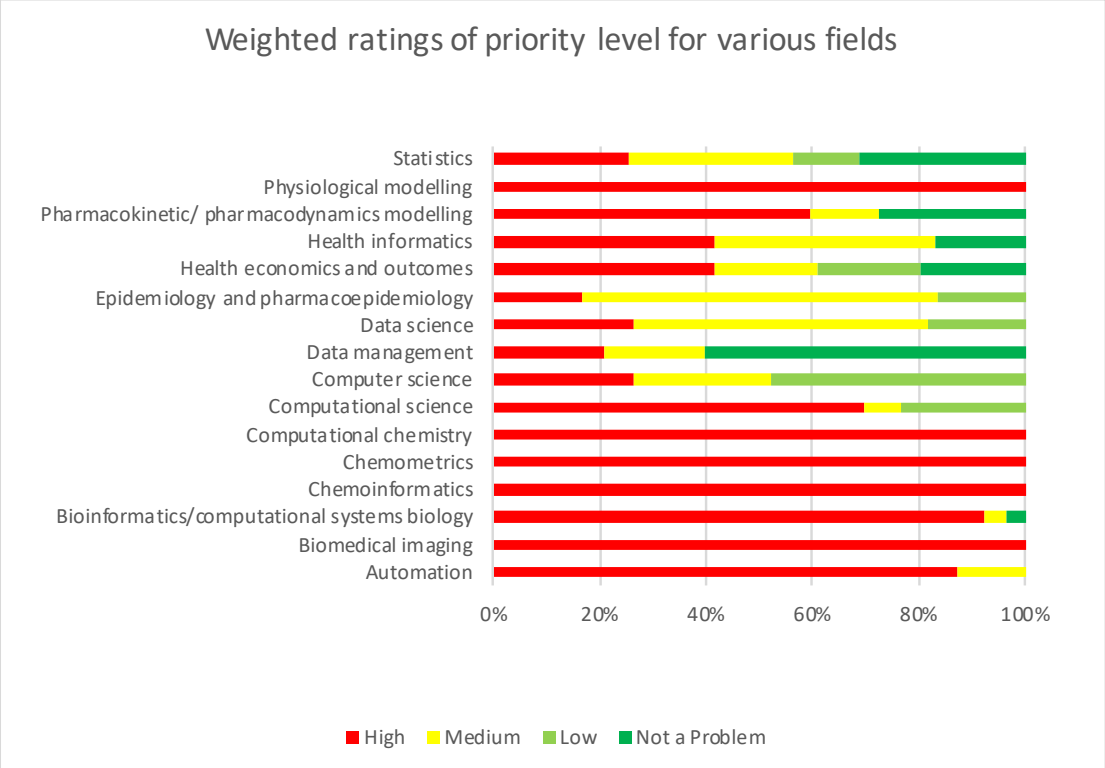
Informatics, Computational, Mathematical and Statistics

At a glance

- Perhaps unsurprisingly this area has become more prominent since the survey in 2015 – mapping to the overall rise in data science across the economy and its use in the pharmaceutical industry.
- We see the most acute concerns in areas of interdisciplinary overlap – such as computational chemistry; chemometrics; and chemoinformatics – compared with more generalist disciplines (such as data management and data science).
- The only disciplines to have lessened in priority are statistics; health informatics; and health economics. However, from the qualitative responses we think this may be because these functions have been moved wholesale out of the UK for some companies – and therefore are still a global priority.

Perhaps unsurprisingly this area has become more prominent since the last survey in 2015 – mapping to the overall rise in data science across the economy and its use in the pharmaceutical industry. In 2015 there was already a major focus in this area – compared to relatively little in 2008 – but it has since intensified.

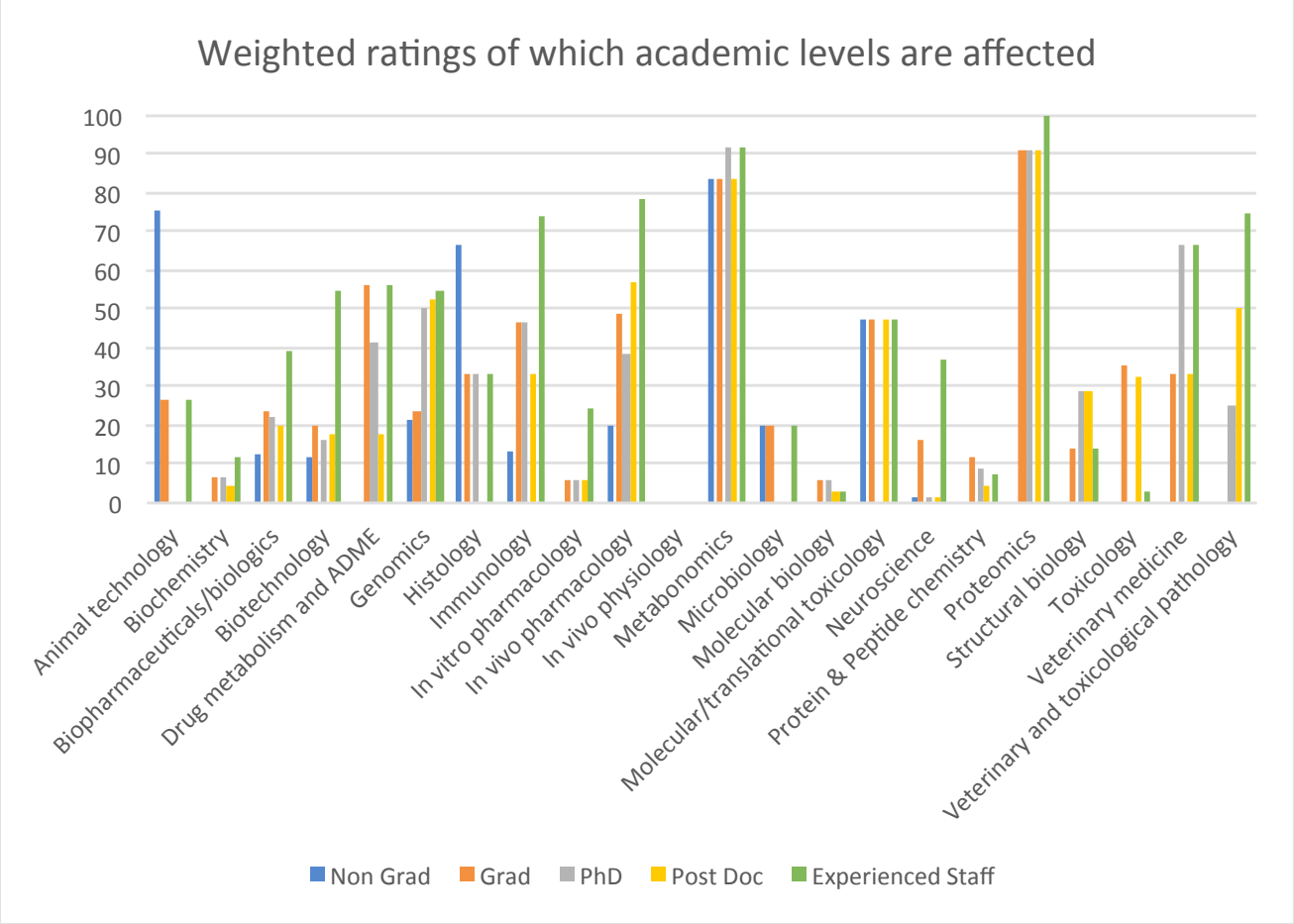
Figure 12: Percentage of respondents rating each informatics, computational, mathematical and statistics discipline as high, medium or low priority or identifying it as 'not a problem'.



We see concerns – each at relatively low volume, but cumulatively startling – in almost every area of this field. Interestingly, they are particularly acute in the areas of interdisciplinary overlap - such as computational chemistry, chemometrics and chemoinformatics – compared with more generalist disciplines (such as data management and data science).

The only disciplines that appear to have lessened to a surprising extent in priority are statistics; health informatics; and health economics. However, from the qualitative responses we think this may be because these functions have been moved wholesale out of the UK for some companies – and therefore, are still a global priority.

Figure 13: Percentage of respondents identifying each qualification level as an issue.



Automation

Laboratory automation is a multi-disciplinary strategy to research, develop, optimize and capitalise on technologies in the laboratory that enable new and improved processes.

This discipline was considered a medium or a high priority by the majority of respondents, with concerns across all levels of recruitment.

Biomedical imaging

Biomedical imaging is increasingly used in the pharmaceutical industry as a non-invasive technique during preclinical studies and clinical studies. 100% of those who responded considered it a high priority – an increase from the previous survey.

Respondents' main concern was with the quality of candidates. It was considered to affect PhD, post-doc and experienced staff.

Bioinformatics/computational systems

Systems biology integrates experimental and computational research to better understand complex biological processes.

This discipline was considered a medium or high priority by 83% of respondents. There was also considered to be a problem with recruiting the quantity of candidates needed. Post-doc and experienced staff seemed particularly affected.

Chemoinformatics

Chemoinformatics involves the application of computational techniques to existing datasets to address a range of chemical problems.

This was an area considered to be a high priority, but also had a low response rate. The respondents considered it to be of a high priority and a problem with the number of candidates. It was considered to affect highly qualified recruitment, including post-doc and PhD. It also affected the recruitment of experienced staff.

Chemometrics

Chemometrics is the science of extracting information from chemical systems by data-driven means using methods such as multivariate statistics, applied mathematics and computer science, in order to address problems in chemistry, biochemistry, medicine, biology and chemical engineering.

This was another area considered to be a high priority, but that also had a low response rate.

The number of candidates was the biggest problem as well as the recruitment of highly qualified workers; both at PhD and post-doc level.

Computational chemistry and computational science

Computational Scientists use mathematical modelling techniques along with information from published literature to build hypotheses for drug targets.

This was unanimously considered to be an area of high priority, with a problem with both the number and quality of the candidates as well as a problem for the future. Recruitment of all staff except graduate/MSc were affected. However, particular emphasis was given to post-doc and experienced staff recruitment.

This area had a relatively low response rate and should be further investigated before any considerable conclusions are drawn from this data set.

Physiological modelling

Physiologically based pharmacokinetic (PBPK) modelling and simulation is a tool that can help predict the pharmacokinetics of drugs in humans and evaluate the effects of intrinsic and extrinsic factors, alone or in combinations, on drug exposure. The use of this tool is increasing at all stages of the drug development process.

100% of those who responded in this area considered it to be a high priority. This is a substantial increase from the previous survey. A problem with the quantity of candidates, particularly at experienced level, was particularly flagged.

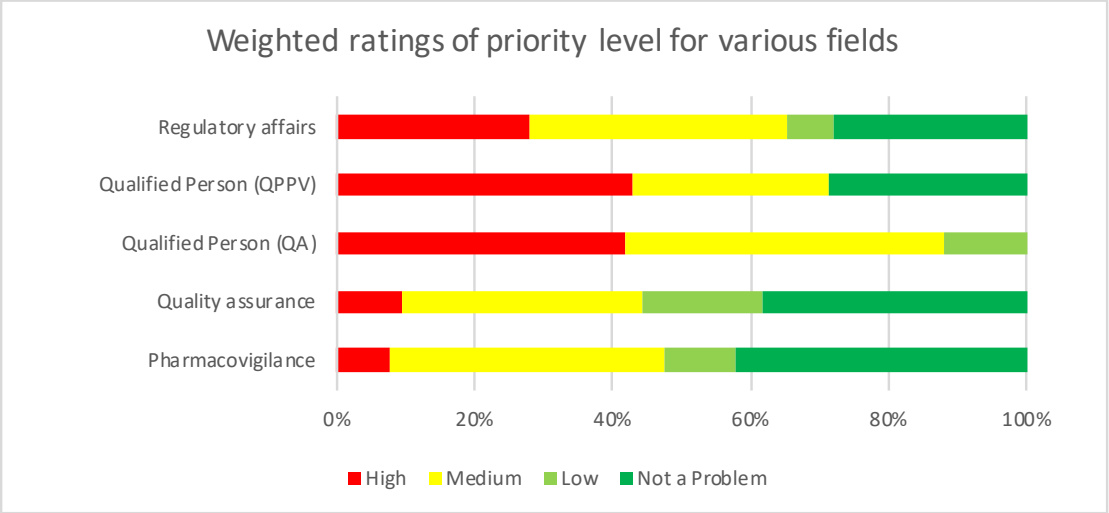
Regulatory areas

At a glance

- Compared with the previous survey, the regulatory areas see a reduction in importance, although over 40% still consider QPPV and QA to be a high priority; and
- In qualitative responses, Brexit appears a major factor producing uncertainty in this field.

Compared with the previous survey all regulatory areas have seen a reduction in importance. In 2015 over 50% of respondents labelled QPPV and QA as a high priority – in 2018 it is less than 50% for both.

Figure 14: Percentage of respondents rating each regulatory discipline as high, medium or low priority or identifying it as 'not a problem'.



Across the regulatory affairs disciplines experienced staff were considered the major shortage.

However, qualitative comments suggested that Brexit was a major swing factor and, in this area,, there were a very high number of comments submitted.

Pharmacovigilance

Pharmacovigilance is the process of collecting, monitoring, researching, assessing and evaluating information from healthcare providers and patients on the adverse effects of medicines, to ensure that drugs on the market are safe for patients, and to identify new hazards associated with the medication.

"Brexit has raised uncertainties"

"Difficult to find the right people with the right experience who wish to work in a permanent role. We frequently see contractors with the right skills but they do not wish to work on a permanent basis for the company as the finances don't work."

"Brexit may bring new challenges. Uncertainties at present with workload expected." Survey respondents

Qualified person (PV and QA)

A QPPV has an essential function in industry, as European PV regulations require each marketing authorisations holder (MAH) to appoint a QPPV to create and maintain its pharmacovigilance system (PV). This system must fulfil the legal obligations regarding product safety and must be adequately resourced.

Qualified Persons working in quality assurance are legally responsible for certifying batches of medicinal products prior to use in clinical trial or release for sale.

Brexit is clearly a major issue in this area since decisions over the deal and future regulatory requirements will change the location and definition of the roles.

"this could be an issue depending on Brexit"

"We recruit QA staff with both GMP and GCP experience. We find it particularly hard to recruit QA employees with GCP experience, from the most junior to senior level."

"Depends on Brexit"

"Brexit contingencies are creating high demand for such roles"

Regulatory affairs

Regulatory affairs professionals ensure regulatory compliance and prepare submissions to regulatory authorities for new medicines and for any change to a marketed medicine.

Here again Brexit was listed as a factor, alongside new innovative therapies changing the regulatory environment and requirements of staff.

"while there are many basic graduates/post grads with regulatory qualifications, they have usually been trained on yesterday's technologies. Looking at innovative therapies such as CART, TCR, gene therapies & gene editing interventions, the type of regulatory strategy requires much greater understanding of how to address the inherent uncertainties when evaluating benefits & risks…this requires a much higher level of capability in regulatory professionals than is usually the case."

"We struggle to find experienced Regulatory Affairs people. We find it especially difficult to find Regulatory professionals with CMC experience."

"Brexit again bringing uncertainty but clearly more local resource is required to maintain / convert UK licences"

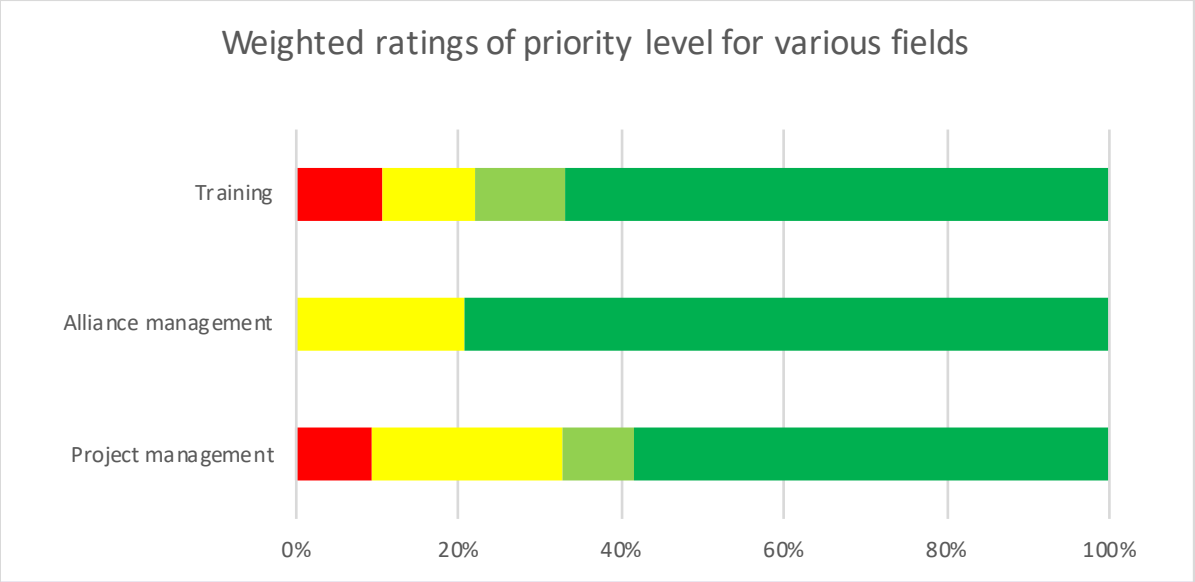
Business areas

At a glance

- This appears to be a relatively low priority area.

These were not asked about in the previous survey, and in this survey, we did not find they were particularly high priorities. Domain specific skills as opposed to generic business skills are a higher priority for the industry.

Figure 15: Weighted ratings of priority level for various fields within business areas.



Core skills

At a glance

- Since the last survey, we have noted a general reduction in the percentage of respondents who see core skills as a concern, with particularly significant reductions in scientific and mathematical knowledge. This may be the result of consistent effort over time to improve the quality of the scientific and maths curriculum in schools
- Application of scientific and maths knowledge is considered to be of the biggest concern, with 63% of respondents marking it as concern.

At the end of the survey respondents were asked to indicate what skills and knowledge they felt were problematic. They were asked to rank the skills on a spectrum ranging from a major concern to not a problem.

Since the last survey, we have noted a general reduction in the percentage of respondents who see core skills as a concern, with particularly significant reductions in scientific and mathematical knowledge. This may be the result of consistent effort over time to improve the quality of the scientific and maths curriculum in schools.

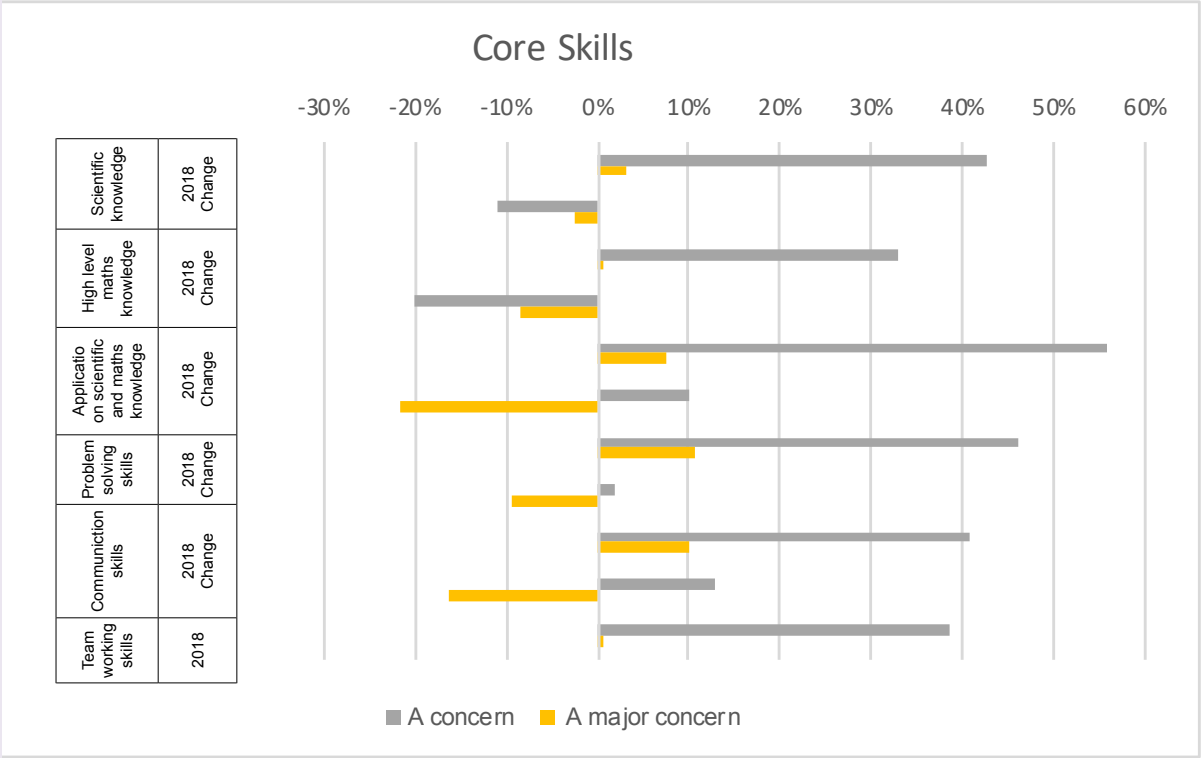
Table 3: Comparison of core skills concerns from 2015 with core skills concerns in 2018.

	Scientific knowledge		High level maths knowledge		Application of scientific and maths knowledge		Problem solving skills		Communication skills		Team-working skills	
	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018	2015	2018
Not a problem	15%	17%	17%	33%	15%	17%	16%	19%	11%	22%	13%	30%
Less of a concern now	25%	25%	21%	20%	10%	11%	20%	12%	35%	18%	41%	19%
A concern	54%	43%	53%	33%	46%	56%	44%	46%	28%	41%	39%	38%
A major concern	6%	3%	9%	1%	29%	8%	20%	11%	26%	10%	7%	0%
Total concern	59%	46%	62%	33%	75%	63%	64%	57%	54%	51%	46%	39%

Application of scientific and maths knowledge was considered to be of the biggest concern, with 63% of respondents marking it as either a major concern or simply a concern. Problem solving skills were also ranked as a high concern by 57% of respondents.

On the other hand, 33% of respondents ranked high level maths knowledge as not a problem and a majority, 67%, considered it either not a problem or less of a concern right now.

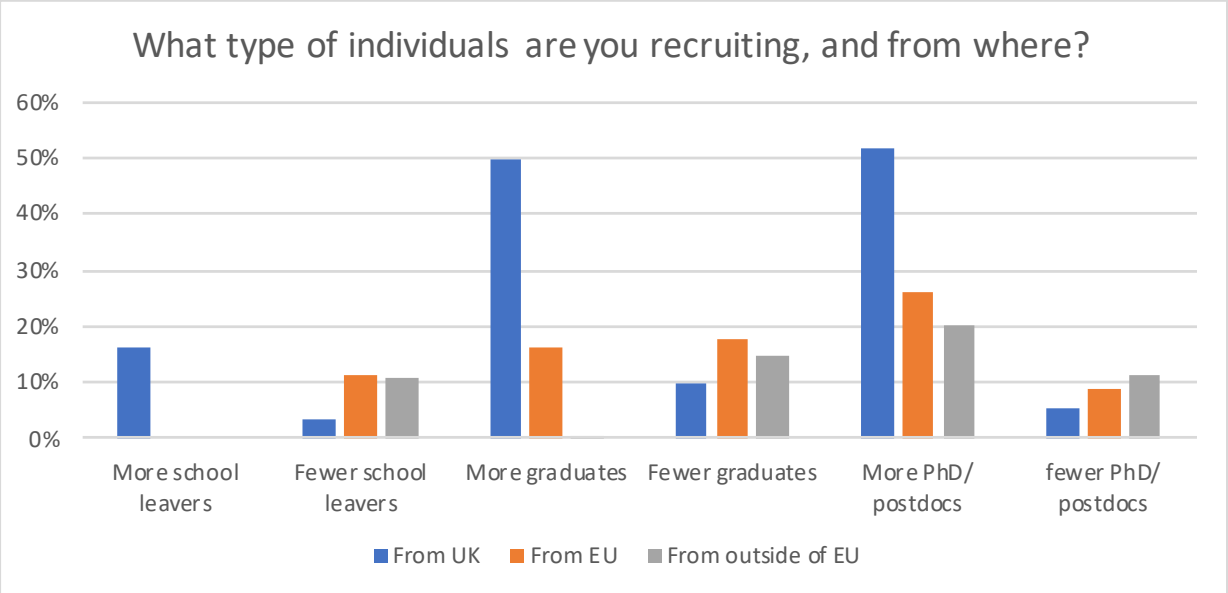
Table 4: Percentage of respondents who rated each core skill area as a major concern or a concern in 2018, with the percentage difference from 2015 ratings.



Recruitment

One survey question sought overview information on the type of individual being recruited; their qualification level; and whether they were from the UK, EU or outside the EU. The responses sought information on whether recruitment of this type of person had increased or decreased in recent years. The chart below summarises these responses. It shows in general a picture of more recruitment, with a particular emphasis on UK graduates and post-docs – perhaps a reflection of Brexit.

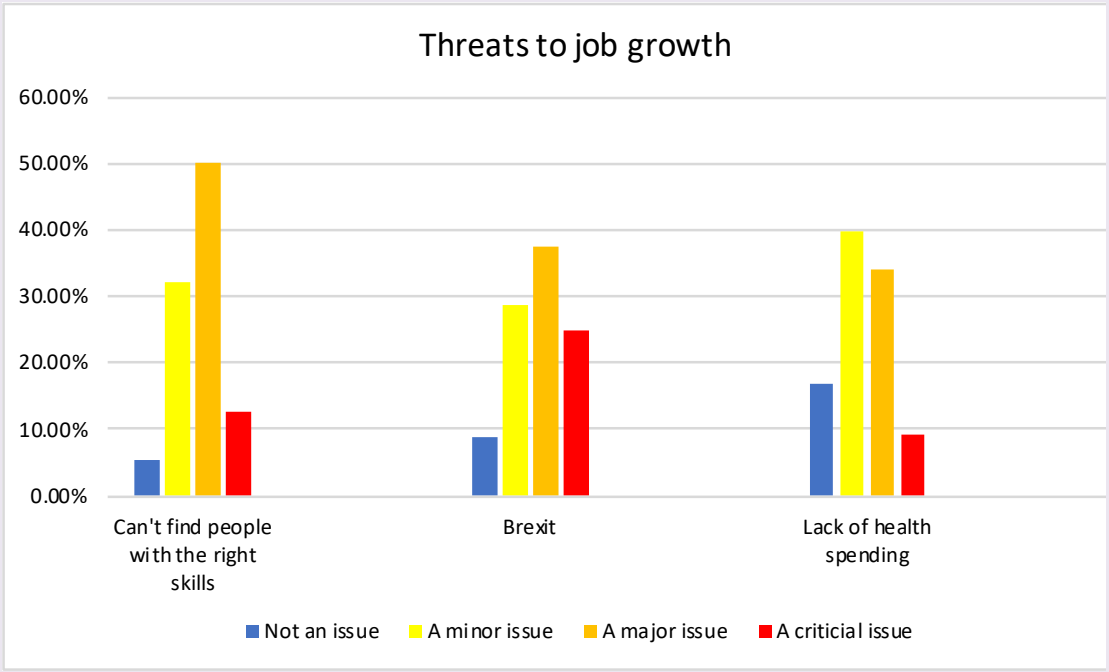
Figure 16: Types of individuals being recruited.



Threats to job growth

Finally, we asked what the major threats to job growth were. Brexit appeared as the most critical issue, with skills shortages second. Most respondents found all of Brexit; skills shortages; and the spending environment, to be threats to job growth.

Figure 17: Threats to job growth



Future issues

We asked respondents which areas they anticipated being of major concern in the future. The areas identified as high concern both now and in the future were:

- Chemoinformatics;
- Chemometrics;
- Metabonomics;
- Computational science and computational chemistry;
- Automation;
- Device technology; and
- Bioinformatics.

The remaining areas, in the table below, are currently not top priorities and should be watched for the future.

Table 4: Summary of areas anticipated as being of major concern in the future.

Discipline	High Priority	Concern for the future
Chemoinformatics	100%	100%
Chemometrics	100%	100%
Metabonomics	83%	100%
Computational science	70%	93%
Computational chemistry	100%	91%
Automation	87%	89%
Device technology	88%	88%
Bioinformatics/computational systems biology	93%	87%
Veterinary and toxicological pathology	0%	75%
Genomics	53%	74%
Pharmacokinetic/ pharmacodynamics modelling	60%	73%
Epidemiology and pharmacoepidemiology	17%	67%
Health economics and outcomes	41%	60%
Immunology	58%	59%
Medically qualified clinicians	27%	59%
Formulation	29%	59%
Qualified Person (QA)	42%	56%
Chemical biology	0%	51%
Medicinal and synthetic organic chemistry	50%	50%

A future concern that has emerged in the 2018 survey that was not considered to be a problem in the 2015 survey is *automation*. The emergence of AI and tech over the last few years has been rapid and has become more ubiquitous in the public domain.

Appendix – list of participating companies

AbbVie UK Ltd

Allergan

Alliance Pharmaceuticals Ltd

Ashfield Healthcare Ltd

AstraZeneca

AZ

Bayer plc

Biogen

Boehringer Ingelheim Ltd

Bristol Myers Squibb

Charles River Laboratories

Chugai Pharma UK

Covance Clinical Research Unit

Eisai

GalbraithWight Ltd

GSK

Gunnels wood Road, Stevenage

Hertfordshire

Ipsen

Janssen UK

MedImmune

Merck Sharp & Dohme

Napp Pharmaceuticals Limited

Novartis

Pfizer Ltd

Quotient Sciences

Roche Products Ltd

Sanofi

Sequani Limited

Servier Laboratories Limited

Takeda Development Centre Europe

Tesaro UKINOR

UCB


MEDICINE
HEALTH
TREATMENT
DOCTOR
SURVEY
RECIPE
MEDICINE

Survey

Section 1 Biological science areas

- Animal technology
- Biochemistry
- Biopharmaceuticals/biologics
- Biotechnology
- Drug metabolism and ADME
- Genomics
- Histology
- Immunology
- *In vitro* pharmacology
- *In vivo* pharmacology
- *In vivo* physiology
- Metabonomics
- Microbiology
- Molecular biology
- Molecular/translational toxicology
- Neuroscience
- Protein & Peptide chemistry
- Proteomics
- Structural biology
- Toxicology
- Veterinary medicine
- Veterinary and toxicological pathology

Section 2 Chemical science areas

- Analytical chemistry/biochemistry
- Chemical biology
- Materials science
- Medicinal and synthetic organic chemistry
- Physical chemistry
- Process chemistry
- Protein & Peptide chemistry

Section 3 Clinical areas

- Clinical pathology
- Clinical pharmacology/translational medicine
- Clinical research operations
- Medically qualified clinicians
- Registered nurses

Section 4 Pharmacy areas

- Device technology
- Formulation
- Pharmacy

Section 5 Informatics, Computational, Mathematical and Statistics areas

- Automation
- Biomedical imaging
- Bioinformatics/computational systems biology
- Chemoinformatics
- Chemometrics
- Computational chemistry
- Computational science
- Computer science
- Data management
- Data science
- Epidemiology and pharmacoepidemiology
- Health economics and outcomes
- Health informatics
- Pharmacokinetic/ pharmacodynamics modelling
- Physiological modelling
- Statistics

Section 6 Regulatory areas

- Pharmacovigilance
- Quality assurance
- Qualified Person (QA)
- Qualified Person (QPPV)
- Regulatory affairs

Section 7 Business skills

- Project management
- Alliance management
- Training

Generic skills issues (to be completed by all respondents)

Rate as 'a major concern', 'a concern', 'less of a concern now', or 'not a problem':

- Scientific knowledge
- High level maths knowledge
- Application of scientific and maths knowledge
- Problem solving skills
- Communication skills
- Team-working skills

The following questions were asked for each discipline selected:

In 2018, is there: *(select as many as appropriate)*

- ☐ A problem with the quality of candidates
- ☐ A problem with the number of candidates
- ☐ A problem for the future
- ☐ Not a problem as far as I am aware (skip logic – no further questions)

Is this: *(select one)*

- ☐ Low priority – an important area to watch
- ☐ Medium priority – requires action
- ☐ High priority – requires immediate action

Does this affect: *(select as many as appropriate)*[19]

- ☐ Non-graduate recruitment
- ☐ Graduate/MSc recruitment
- ☐ PhD recruitment
- ☐ Post-doc recruitment
- ☐ Recruitment of experienced staff

Are practical skills for this discipline[20]

A major concern

A concern

Not a problem

19 In previous surveys, respondents were provided different response options for certain disciplines in clinical areas. In this survey respondents were provided the standard options in their response options for these disciplines.

20 In previous surveys, respondents were only asked about practical skills for certain disciplines. In this survey, respondents were asked this question for all disciplines.

Please provide additional comments if you wish

The final section of the survey for completion by all respondents evaluated core skills:

In previous surveys, the following skills gaps have sometimes been identified across new recruits; please indicate whether they are currently problematic:

Skills issue (✓) *one per line to be ticked*	A major concern	A concern	Less of a concern now	Not a problem
Scientific knowledge				
High level maths knowledge				
Application of scientific and maths knowledge				
Problem solving skills				
Communication skills				
Team-working skills				

Are there other general skills issues we should be aware of?

Skills issue	A major concern (✓)	An increasing concern (✓)

What type of individuals are you recruiting, and from where?

(✓) *can tick up to 3 per line*	More school leavers	Fewer school leavers	More graduates	Fewer graduates	More PhD/ postdocs	Fewer PhD/ postdocs
From UK						
From EU						
From outside of EU						

Are you aware of the Science Industry Partnership (SIP)? (www.scienceindustrypartnership.com)

Yes/No. Please comment on how the SIP helps to address current and future skills needs.

Are there any skills areas that you feel need to be urgently addressed that are not currently part of the SIP?

Survey respondents

Pharmaceutical companies

- AbbVie UK Ltd
- Allergan
- Alliance Pharmaceuticals Ltd
- AstraZeneca
- Bayer plc
- Biogen
- Boehringer Ingelheim Ltd
- Bristol Myers Squibb
- Chugai Pharma UK
- Eisai
- GSK
- Ipsen
- Janssen UK
- MedImmune Ltd
- Merck Sharp & Dohme
- Napp Pharmaceuticals Limited
- Novartis
- Pfizer Ltd
- Quotient Sciences
- Roche Products Ltd
- Sanofi
- Servier Laboratories Limited
- Takeda Development Centre Europe
- Tesaro UKINOR
- UCB

Contract Research Organisations (CROs)

- Charles River Laboratories
- Covance Clinical Research Unit
- Sequani Limited

Other

- Ashfield Healthcare Ltd
- GalbraithWight Ltd

Section summaries

Section 1 - Biological science areas

Figure 8: Percentage of respondents rating each biological science discipline as high, medium or low priority or identifying it as 'not a problem'

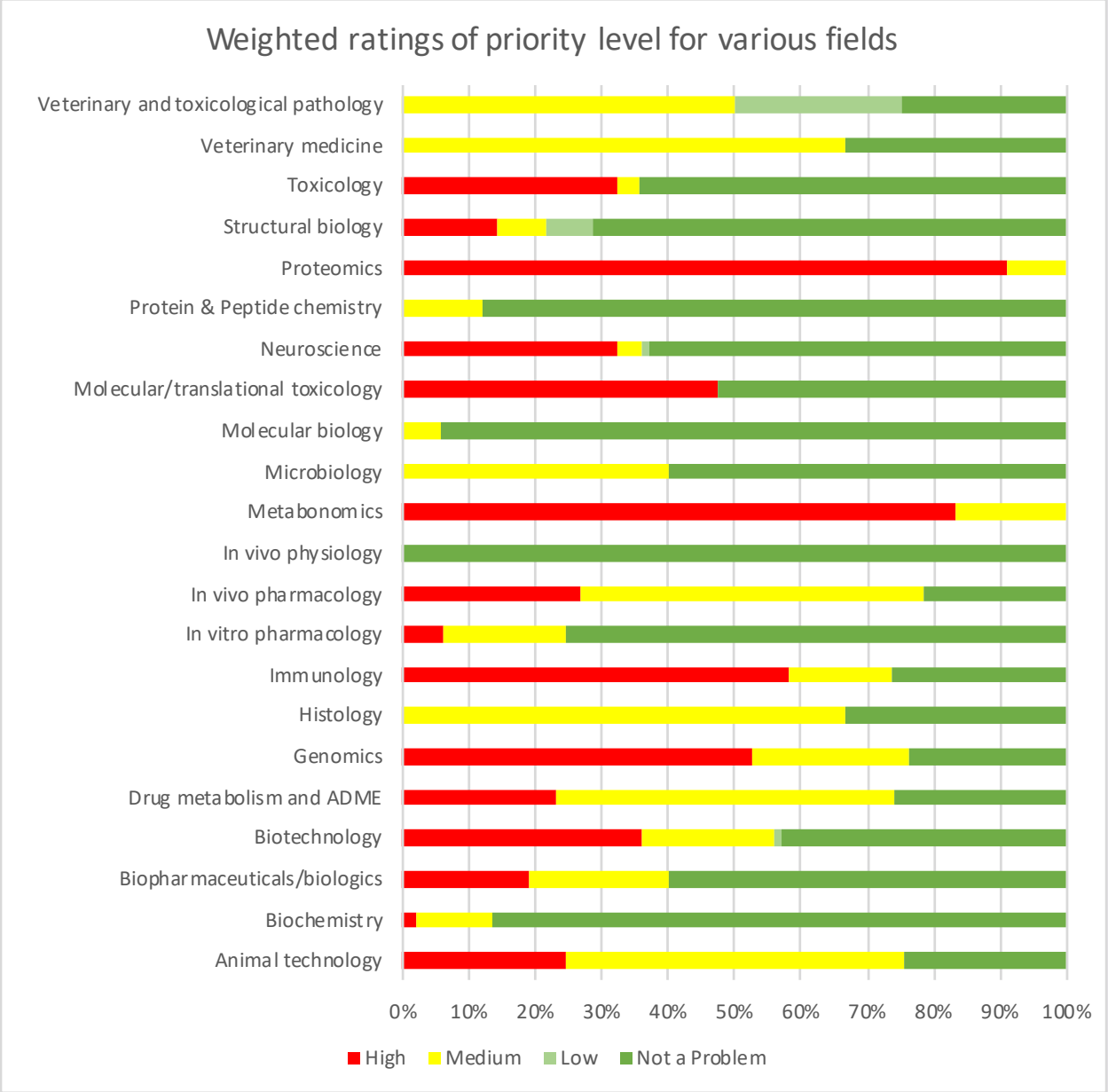


Figure 18: Percentage of respondents identifying each qualification level as an issue within the biological science disciplines

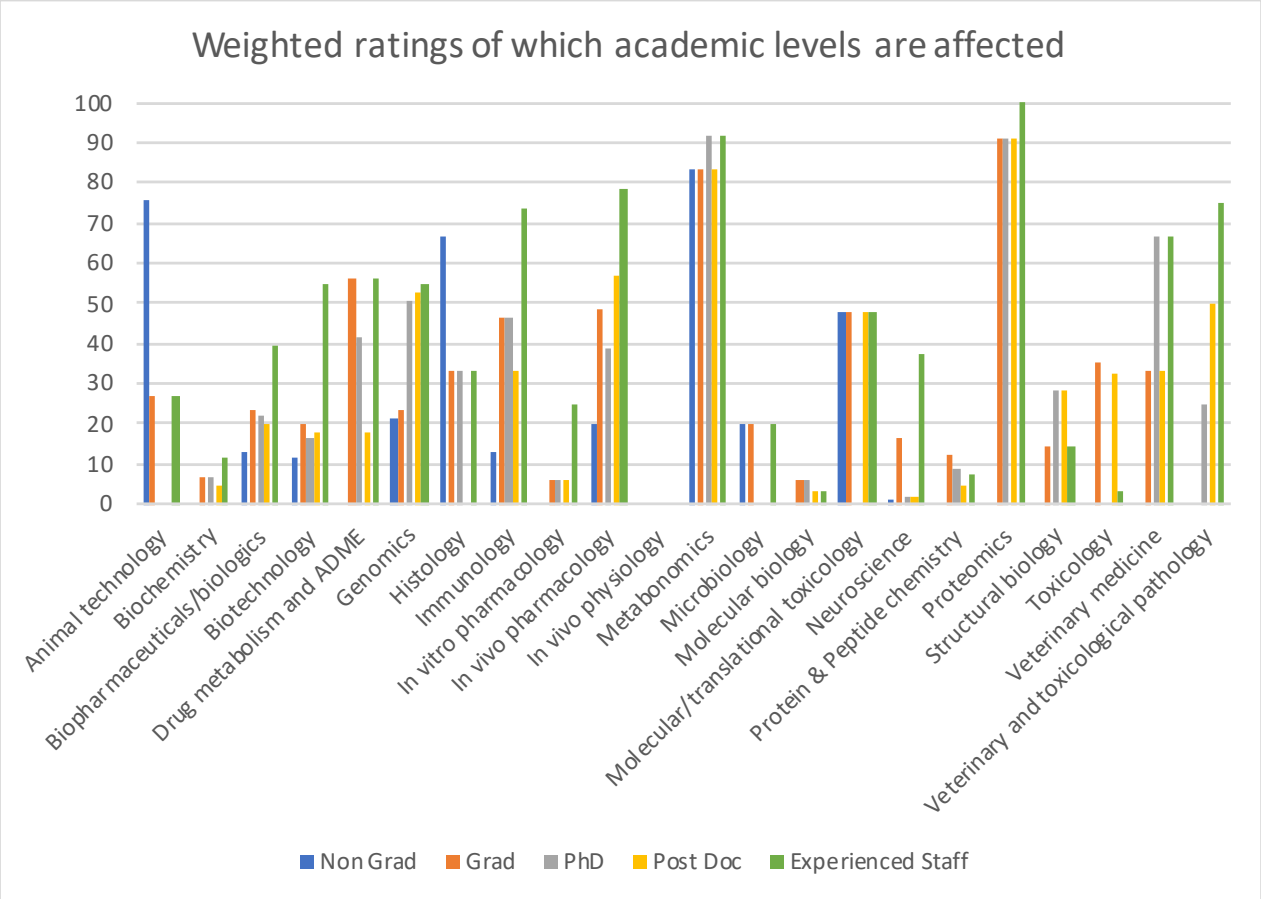


Figure 19: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

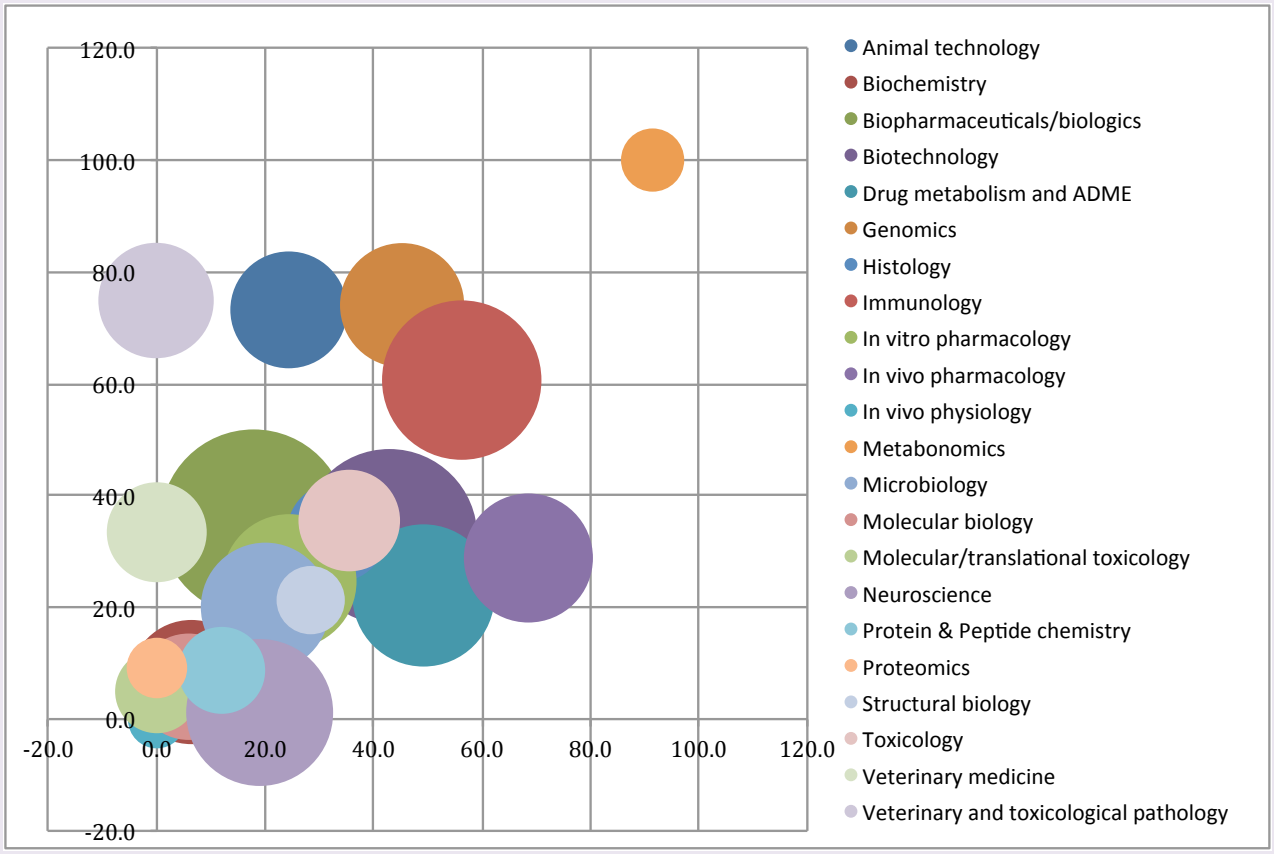


Table 5: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the biological science areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Molecular/translational toxicology	48%	0%	52%
Immunology	39%	33%	26%
Biotechnology	32%	21%	43%
Toxicology	32%	3%	65%
Animal technology	24%	51%	24%
Genomics	22%	55%	24%
Biopharmaceuticals/biologics	20%	21%	60%
Neuroscience	15%	6%	63%
Structural biology	14%	14%	71%
Drug metabolism and ADME	7%	67%	26%
***In vivo* pharmacology**	7%	72%	21%
***In vitro* pharmacology**	6%	18%	75%
Metabonomics	0%	100%	0%
Proteomics	0%	100%	0%
Veterinary and toxicological pathology	0%	75%	25%
Histology	0%	67%	33%
Veterinary medicine	0%	67%	33%
Microbiology	0%	20%	60%
Biochemistry	0%	14%	86%
Protein & Peptide chemistry	0%	12%	88%
Molecular biology	0%	6%	94%
***In vivo* physiology**	0%	0%	100%

Table 6: Detailed biological science results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 7: Detailed biological science results (including previous results)

	2008	2015	2018 weighted	2018 unweighted
Animal technology	Animal technicians are responsible for the day to day welfare of the animals used in in vivo research work. Tasks range from general animal care and husbandry to monitoring the health and development of the animals and ensuring environmental conditions are correct. Qualified animal technicians conduct technical procedures such as administering medicines and collecting clinical data as part of experimental protocols. Additionally, animal technicians are responsible for preparation of samples for pathology and administration of euthanasia.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of PhDs or post-doctorates as a problem.			
Biochemistry	Biochemists study chemical processes in living organisms, looking at the structure and function of biomolecules such as proteins and DNA. In the pharmaceutical industry, biochemists are employed in the area of drug discovery, identifying and validating new drug targets against which new chemicals will be tested in order to identify potential new medicines.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
Biopharmaceuticals/ biologics[21]	Biopharmaceuticals are medicinal compounds produced in cells, usually in bio-fermenters, and purified using a range of upstream and downstream processes to produce purified drug substance. Critical skills involved are cell and fermenter sciences, protein purification and analysis. Biopharmaceuticals are growing rapidly in importance in the pharmaceutical industry and include vaccines, medicines and diagnostic tests.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
Biotechnology[22]	Biotechnology is the combination of biological and microbiological sciences and protein engineering to discover and optimise biologic drug candidates to be medicines or to use biological molecules to perform specific processes to enable their discovery. Use of stem cell biology tools and technologies to assemble biologically relevant, predictive assays and cell models. Bringing cell therapy tools and technologies into clinical practice.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff

21 In 2008 Biopharmaceuticals was linked with Biotechnology

22 In 2008 Biotechnology was linked with Biopharmaceuticals

	2008	2015	2018 weighted	2018 unweighted
Drug metabolism and ADME	This is the study of how the body affects a drug following its administration, through the rate and extent of absorption, distribution, metabolism and excretion (ADME). A good understanding of pharmacokinetics (PK) is crucial to the understanding of whether or not a drug will be safe for use in humans and gives information about dose size and frequency.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
Genomics[23]	Genomics is a discipline where techniques to sequence, assemble and analyse genomes are used to establish their structure and function.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
Histology	Histology is a discipline where daily, routine, and specialised histology techniques and procedures are performed for the benefit of a range of disciplines. Histologists can acquire specialist disease expertise.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of post-doctorates as a problem.			
Immunology	Immunology is often incorporated into roles such biochemists and *in vivo* pharmacologists, with more senior positions being recruited as specialist immunologists.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff

23 In 2008 the 'omics' disciplines were merged into a single area

	2008	2015	2018 weighted	2018 unweighted
In vitro pharmacology	*In vitro* pharmacology is the study of how medicines interact with cells and tissues, with the aim of predicting what effects a medicine might have in humans. All experiments are carried out in a controlled environment outside a living organism. This work is essential to develop an understanding of how compounds that have the potential to become medicines act at both the cellular and molecular level.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
In vivo pharmacology	*In vivo* pharmacology is the study of how medicines interact with living organisms, with the aim of predicting what effects a medicine might have in humans. In vivo pharmacologists investigate how effective a compound is in living biological systems (pharmacodynamic effects) and establish whether a new compound could produce side effects (safety pharmacology).			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
In vivo physiology	*In vivo* physiology is the study of the physical, chemical and biochemical properties of the functions of living organisms. In the pharmaceutical industry in vivo physiologists work to set up new animal models to understand the disease processes, helping to identify sites for therapeutic intervention and to elucidate the desired and undesired mechanisms of action of potential drugs.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	The only respondent to this discipline identified it as not a problem.			
Metabonomics[24]	Metabonomics looks at changes in the metabolites present in a cell or organism and can be used to determine the toxicity of potential new drug targets.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	After weighting, quality of candidates is a very high priority (+90%), but before weighting 67% of responses indicated such. Responses unanimously ranked quantity of candidates as a problem. PhD and experienced staff were regarded as very high priority (+90%) after weighting, though again before weighting moderately high priority (67%).			

24 In 2008 the 'omics' disciplines were merged into a single area

	2008	2015	2018 weighted	2018 unweighted
Microbiology	The study of microscopic organisms. It includes the sub-disciplines of virology, mycology, parasitology and bacteriology.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of PhDs or post-doctorates as a problem.			
Molecular biology[25]	Molecular biology is the study of biology at a molecular level, particularly looking at the way in which various systems within a cell interact and how they are regulated. In the pharmaceutical industry, molecular biologists and bio-scientists are employed in the area of drug discovery, identifying and validating new drug targets against which new chemicals will be tested in order to identify potential new medicines to go into development.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
Molecular/ translational toxicology	Molecular and translational toxicologists study the adverse effects that drugs can have on living organisms, from the level of molecules and cells to whole organs. Their work increases the understanding of the safety of a drug before it is trialled in humans. This discipline does not include animal-based toxicology.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the quality of candidates to be a problem, or the finding of PhDs.			
Neuroscience	Neuroscientists tend to work in teams, collaborating as part of that team, and possessing transferable skills which support therapeutic advances. Neuroscientists will often start their career as a bench scientist in R&D.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff

25 In 2008 Molecular biology was linked with Bioscience

	2008	2015	2018 weighted	2018 unweighted
Protein & Peptide chemistry	Protein and peptide chemists are very important within the biological science areas, though often work in multidisciplinary groups. Protein and peptide chemists develop and execute analytical methods alongside characterisation of techniques and development and validation of methodologies.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
Proteomics[26]	This is the large-scale study of the structure and function of proteins. Proteomics can be used to identify new bio-markers of disease as well as potential new drugs and drug targets.			
	Q: Non-graduate N: Graduate, PhD, Post-doc	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No responses indicated the quality of candidates to be a problem. After weighting all except non-graduate (which itself received no responses identifying finding candidates at that level as a problem) were identified as very high priority (90%+). Responses that finding experienced staff was a problem were unanimous.			
Structural biology	This involves the determination of the molecular structure of biological macromolecules, especially proteins and nucleic acids, as well as the structure of compounds complexed to these macromolecules. This information can be used in compound design by medicinal and computational chemists, as well as in developing an understanding of the relationship between structure and biological function.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No responses indicated the finding of non-graduates as a problem.			
Toxicology	Toxicologists study the adverse effects of chemicals on living organisms. Compounds that have the potential to become medicines are assessed for toxicity in both in vitro and in vivo experiments that are required by law for pre-clinical studies.			
	Q: Non-graduate N: Graduate, PhD, Post-doc	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No responses indicated the finding of non-graduates or PhDs as a problem.			

26 In 2008 the 'omics' disciplines were merged into a single area

	2008	2015	2018 weighted	2018 unweighted
Veterinary medicine[27]	In industry, vets advise on animal health and welfare, ensuring that all procedures requiring the use of animals are compliant with the principles of humane experimentation (the '3Rs' – refinement, reduction and replacement). Vets monitor animal health and will often advise scientists on techniques to minimise or prevent any pain, suffering or distress to the animals.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the quality of candidates as a problem, or the finding of non-graduates.			
Veterinary and toxicological pathology[28]	Pathology is the study of the nature of disease and the structural and functional changes it causes. In industry pathologists work to establish disease models to assess potential therapies, and to characterise the structural changes in the disease state that occur in response to medicines. Veterinary pathologists examine histopathological evidence from routine toxicity studies to establish whether changes seen in tissues are due to normal variation and spontaneous natural disease processes or may have arisen due to the substance under test.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the quality of candidates as a problem, or the finding of those at the non-graduate or graduate/MSc level.			

27 In 2008 this area was merged with Veterinary science

28 In 2008 this area was described as Pathology

Section 2 - Chemical science areas

Figure 9: Percentage of respondents rating each chemical science discipline as high, medium or low priority or identifying it as 'not a problem'.

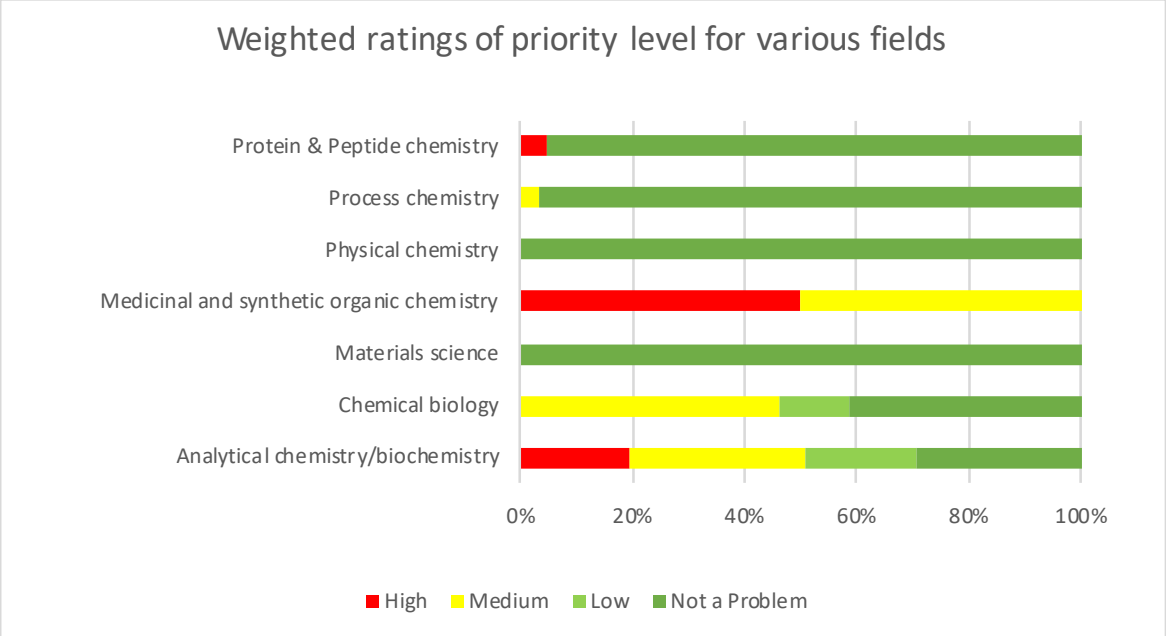


Figure 20: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

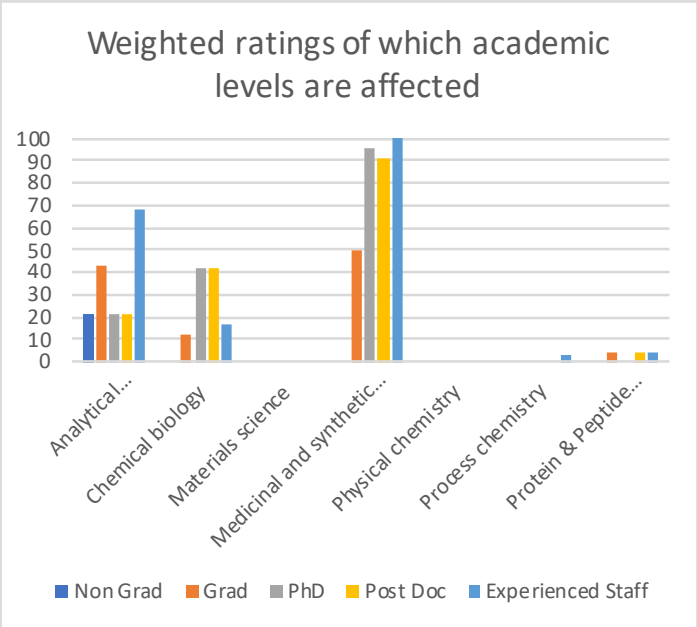


Figure 21: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

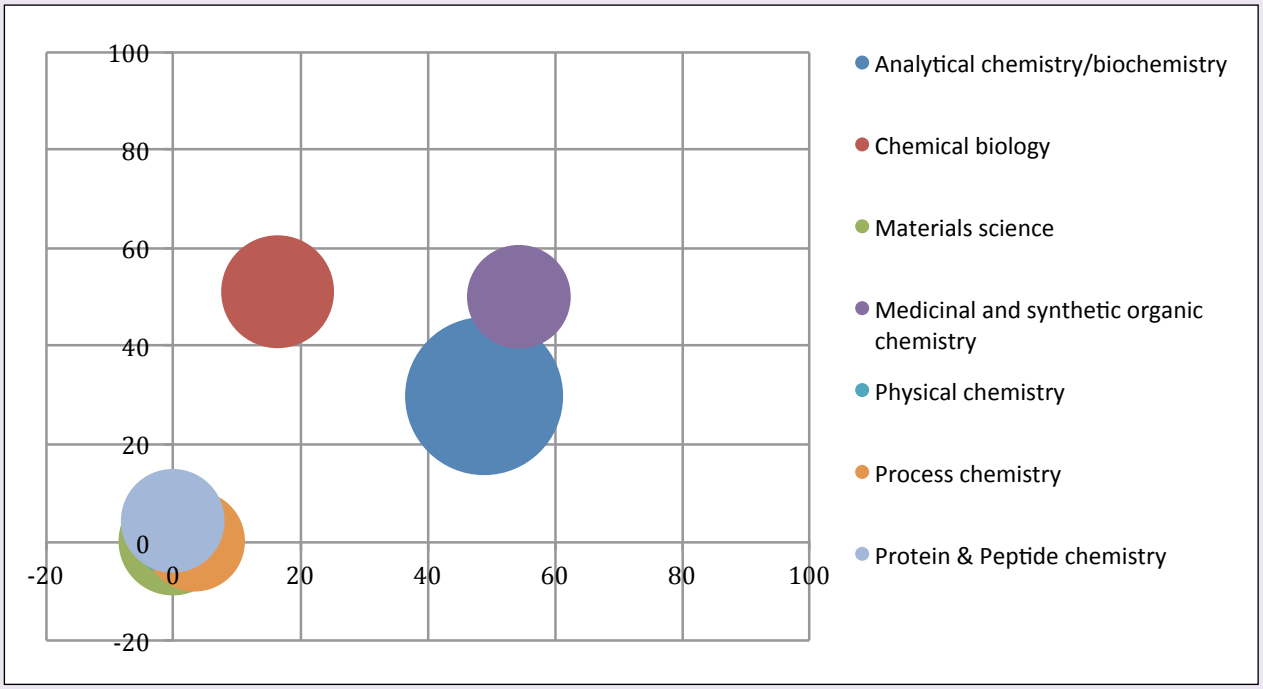


Table 8: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the chemical science areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Medicinal and synthetic organic chemistry	5%	95%	0%
Analytical chemistry/biochemistry	0%	51%	49%
Chemical biology	0%	42%	54%
Protein & Peptide chemistry	0%	5%	95%
Process chemistry	0%	3%	97%
Materials science	0%	0%	100%
Physical chemistry	0%	0%	100%

Table 10: Detailed chemical science results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 11: Detailed chemical science results (including previous results)

	2008	2015	2018 weighted	2018 unweighted
Analytical chemistry/ biochemistry[29]	Analytical chemists/biochemists work at every stage of development of a medicine, from confirming the structure of a compound that has been made for the first time, to checking the purity of a batch of medicine that is about to be released for sale. Analytical chemists/biochemists may be involved in investigating biological targets, using biophysical techniques to screen and validate targets and studying how molecular properties affect biological activity. Analytical chemists/biochemists also develop techniques for biomarker identification and detection and probe design (mass spectrometry, PET, SPECT, MRI, labelling).			
	Q N Non-graduate Graduate PhD Post-doc	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff
Chemical biology	Chemical biology uses chemical techniques and tools, and compounds synthesised by chemists, to understand the biological processes that cause disease.			
	In 2008 this area was not rated.	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff
	No responses indicated the finding of those at the non-graduate level as a problem.			
Materials science	Materials science is an interdisciplinary field which deals with the discovery and design of new materials to meet a specific need. Pharmaceutical materials science applies physical principles from materials science to challenges in such areas as drug delivery, control of drug form, manufacture and processing of nanoscopic and microscopic particle systems, and the structure and properties of bulk powders and creation of dosage forms such as tablets or capsules.			
	In 2008 this area was not rated.	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff
	Respondents unanimously identified materials science as not a problem.			

29 In 2008 this was merged with Physical chemistry

	2008	2015	2018 weighted	2018 unweighted
Medicinal and synthetic organic chemistry[30]	Synthetic chemists are involved in making chemical compounds, which are then tested for their potential as new medicines. Medicinal chemists are involved in the design of these compounds. Peptide chemists use synthetic organic chemistry techniques to make, purify and analyse compounds for use as medicines. In medicinal chemistry various techniques are used to design and predict the activity of compounds at a biological target such as a receptor or enzyme, as well as its likely pharmacokinetic profile and safety properties. Medicinal chemists are likely to have a background in synthetic organic chemistry but may have additional knowledge and skills around molecular understanding of biological systems and processes through application of synthetic, physical, analytical and computational methods. In many organisations chemists perform the role of both synthetic and medicinal chemist at the same time.			
	Q / N: Non-graduate / Graduate / PhD / Post-doc	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff
	No responses indicated the finding of those at the non-graduate level as a problem. Respondents unanimously identified finding experienced staff as a problem.			
Physical chemistry[31]	Physical chemists generate high quality physicochemical property data on compounds prepared as part of a drug discovery programme. This data is used by medicinal chemists in compound design. Structural chemists try to elucidate the structures and shapes of molecules. This approach can be used in the design of new medicines.			
	Q / N: Non-graduate / Graduate / PhD / Post-doc	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff
	The only respondent to this discipline identified it as not a problem.			
Process chemistry[32]	Process chemists design suitable chemical syntheses for the large scale preparation of molecules that are being progressed to advanced clinical studies as potential drugs. For approved drugs, process chemists will have devised the synthetic route that will be used in commercial manufacture.			
	Q / N: Non-graduate / Graduate / PhD / Post-doc	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff
	No responses identified quantity of candidates as a problem, or for any recruitment level other than experienced staff as a problem.			
Protein & peptide chemistry	Protein and peptide chemists are very important within the chemical science areas, though invariably work in multidisciplinary groups. Protein and peptide chemists develop and execute analytical methods alongside characterisation of techniques and development and validation of methodologies.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff	Q / N: Non-graduate / Graduate/MSc / PhD / Post-doc / Experienced staff
	No responses identified quality of candidates as a problem, or the finding of graduate/MSCs or PhDs as a problem.			

30 In 2008 this was merged with Process chemistry

31 In 2008 Physical chemistry was merged with Analytical chemistry

32 In 2008 this was merged with Medicinal or Synthetic organic chemistry

Section 3 - Clinical areas

Figure 10: Percentage of respondents rating each clinical discipline as high, medium or low priority or identifying it as 'not a problem'.

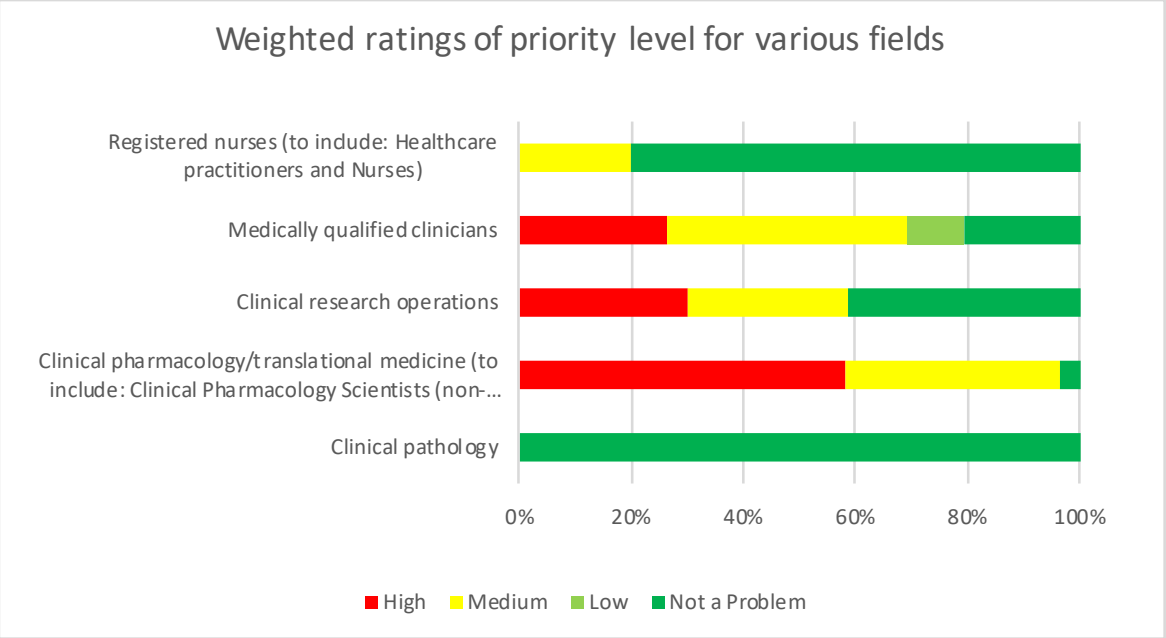


Figure 22: Percentage of respondents identifying each qualification level as an issue within the clinical disciplines

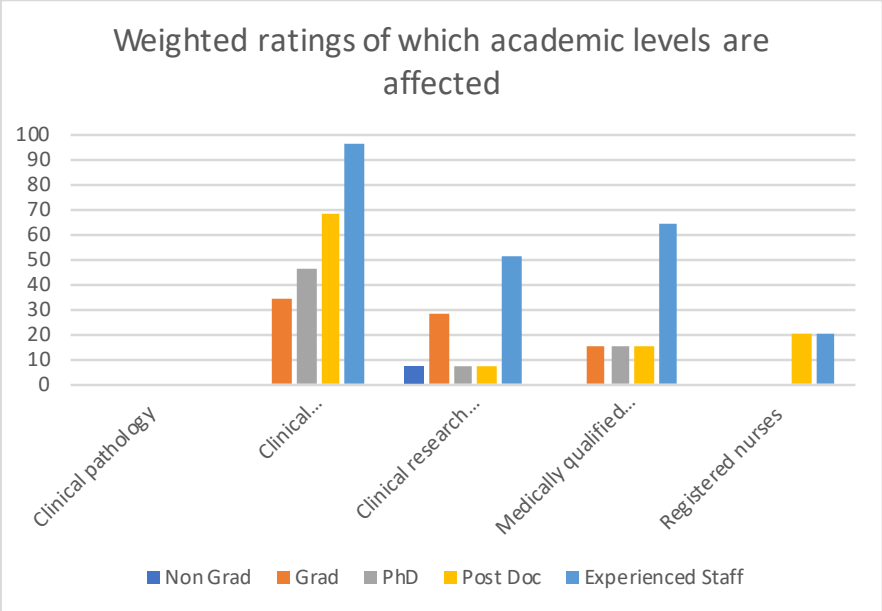


Figure 23: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

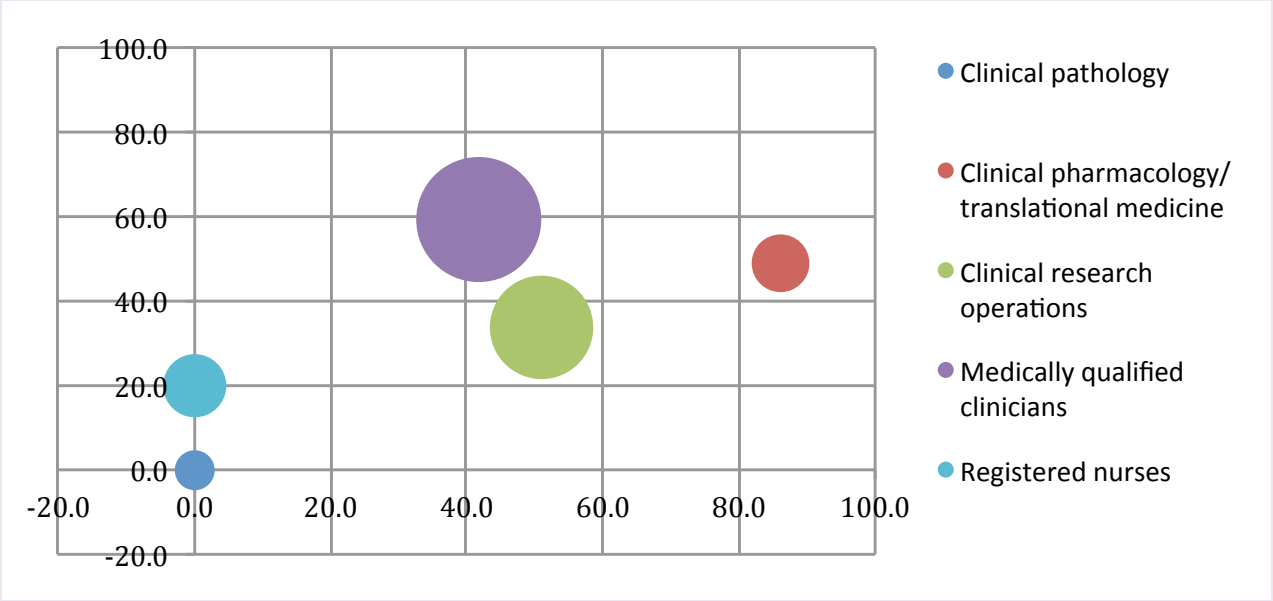


Table 12: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the clinical areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Clinical pharmacology/ translational medicine	37%	60%	3%
Medically qualified clinicians	16%	53%	31%
Clinical research operations	15%	44%	42%
Clinical pathology	0%	0%	100%
Registered nurses	0%	0%	100%

Table 13: Detailed clinical results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 14: Detailed clinical results (including previous results)

	2008	2014/	2018 weighted	2018 unweighted
Clinical pathology[33]	Clinical pathology is the study of the nature of disease and the structural and functional changes it causes. In industry pathologists work to establish disease models to assess potential therapies, and to characterise the structural changes in the disease state that occur in response to medicines.			
	Q N Non-graduate Graduate PhD Post-doc	Q N Non-graduate Graduate/MSc PhD Post-doc MD MD/PhD Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff
	Respondents unanimously identified clinical pathology as not a problem.			
Clinical pharmacology/ translational medicine	Clinical pharmacology is the study of drugs and their clinical use. Clinical pharmacologists carry out work involving the analysis of the effects of medicines on people within clinical trial studies. Translational Medicine is a discipline that aims to bridge the divide between basic scientific research and patient care through translating scientific discoveries into real therapies and medicines (also known as "bench to bedside"). This section is to include: Clinical Pharmacology Scientists (non-medical); Physician Pharmacologists; Pharmacometricians (modellers).			
	Q N Non-graduate Graduate PhD Post-doc	Q N Non-graduate Graduate/MSc PhD Post-doc MD MD/PhD Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff	Q N Non-graduate Graduate/MSc PhD Post-doc Experienced staff
	After weighting respondents identified experienced staff as a very high priority (90%+). No respondents identified finding candidates at the non-graduate level as a problem.			

33 In 2008 this area was merged with Toxicological and veterinary pathology

	2008	2014/	2018 weighted	2018 unweighted
Clinical research operations	This discipline involves working operationally in the field of clinical research trials, to ensure correct set-up monitoring and close-down of clinical trials. This includes developing protocols, identifying trial sites/locations, setting-up and monitoring trial progress, ensuring complete documentation throughout the trial and resolving any issues that arise with a view to high quality data being obtained in a timely fashion. Job titles include Project/Study Managers, Clinical Research Associates (CRAs) and Clinical Trial Assistants (CTAs).			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, MD, MD/PhD, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
Medically qualified clinicians[34]	There are many areas where doctors play an important part within the pharmaceutical industry, including clinical development, regulatory affairs, drug safety, and clinical pharmacology. They have a key role in supporting clinical research and clinical trials.			
	Q: Non-graduate N: Graduate, PhD, Post-doc	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, MD, MD/PhD, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No respondents identified finding candidates at the non-graduate level as a problem.			
Registered nurses[2]	This section includes Healthcare practitioners and Nurses. There are numerous and diverse job roles within the Pharmaceutical industry for those with nursing experience who can apply knowledge of healthcare or healthcare systems – such roles for example, can be within Pharmacovigilance or Drug Safety disciplines.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	No responses indicated the quality of candidates as a problem, or non-graduate, graduate/MSc or PhD recruitment levels as a problem.			

34 In 2008 and 2015, medically qualified clinicians were surveyed as clinicians.

Section 4 - Pharmacy

Figure 11: Percentage of respondents rating each pharmacy discipline as high, medium or low priority or identifying it as 'not a problem'.

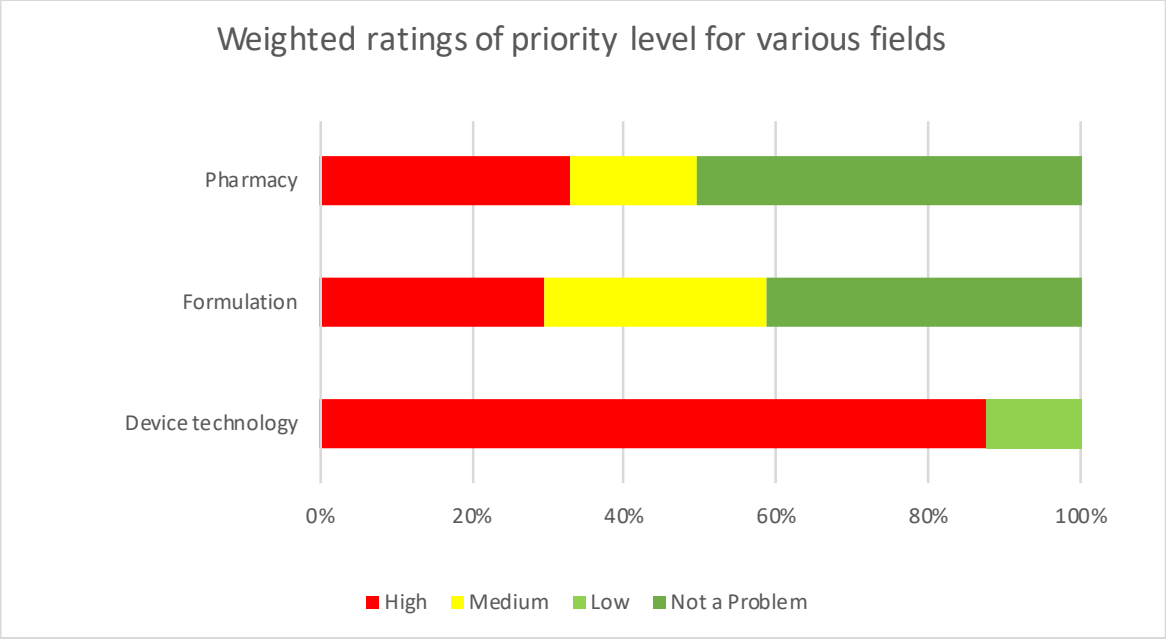


Figure 24: Percentage of respondents identifying each qualification level as an issue within the pharmacy science disciplines

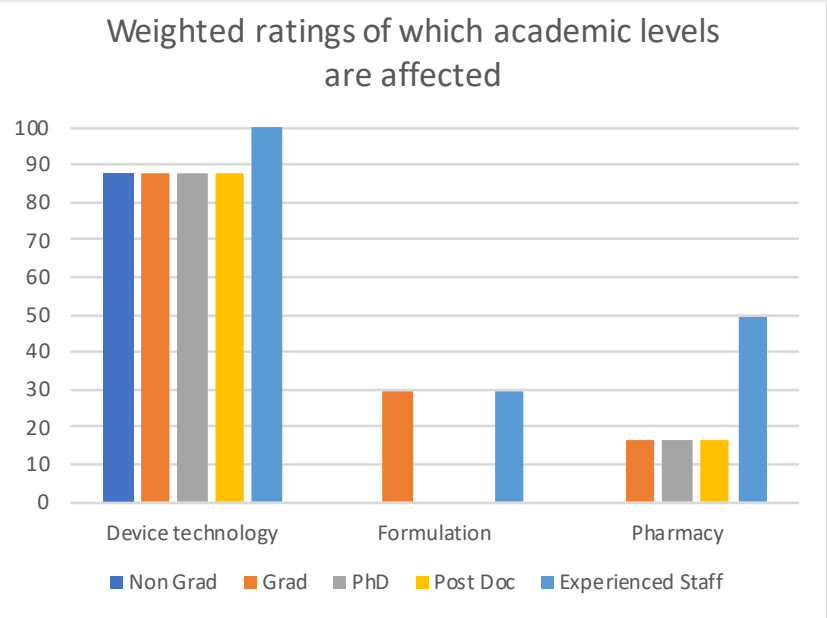


Figure 25: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

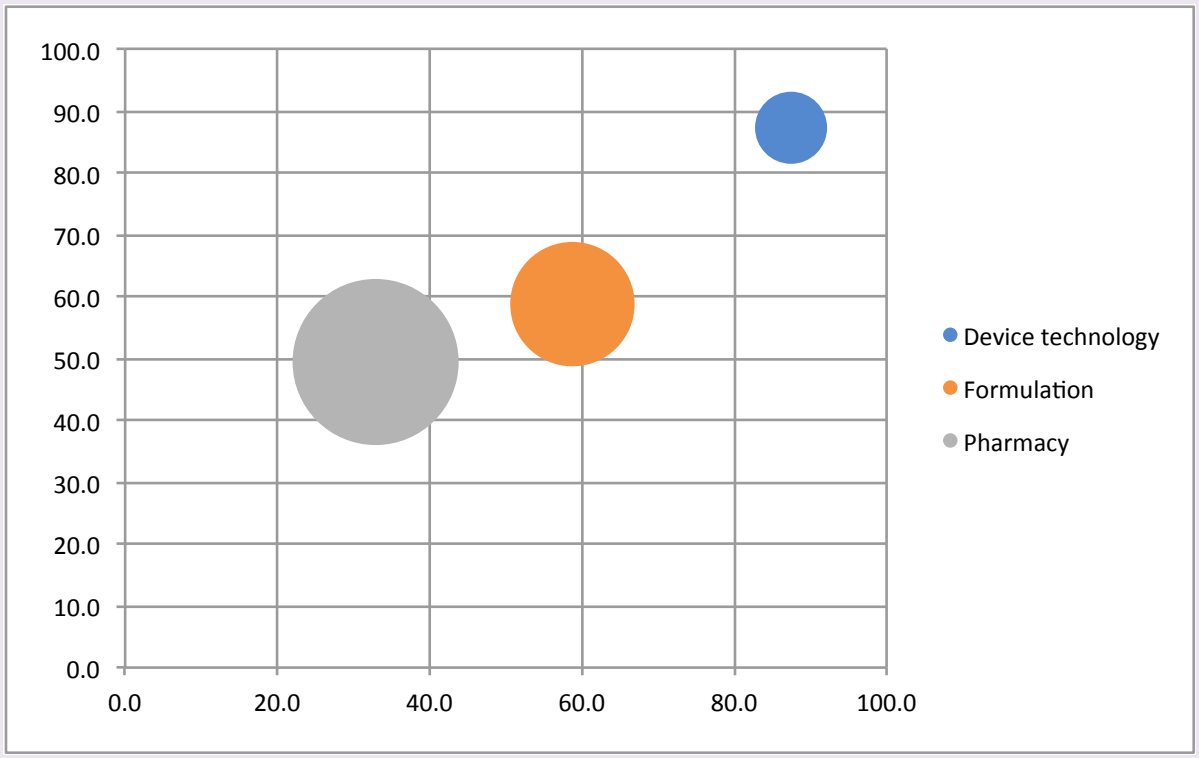


Table 15: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the pharmacy areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Device technology	88%	0%	6%
Pharmacy	33%	16%	51%
Formulation	29%	29%	41%

Table 16: Detailed pharmacy results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 17: Detailed pharmacy results (including previous results)

	2008	2015	2018 weighted	2018 unweighted
Device technology	Medical devices include drug delivery systems such as inhalers, injections and stents, and also clinical diagnostic tools.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	Respondents unanimously identified finding experienced staff as a problem.			
Formulation	This involves creation of a dose of a medicine (such as a tablet, capsule or injection) which will deliver the active substance to the correct part of the body, in the right concentration, and at an appropriate rate. For biopharmaceuticals formulation involves determining the appropriate excipients to add to the drug compound to deliver the desired dose via the desired delivery mechanism to the target organ or system in the body.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding candidates at the non-graduate, PhD or post-doctoral level as a problem.			
Pharmacy	Pharmacists work across the industry in areas such as the assessment of safety and efficacy of new medicines and the formulation of medicines and could be responsible for the release of medicines to the market.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding candidates at the non-graduate level as a problem.			

Section 5 - Informatics, Computational, Mathematical and Statistics areas

Figure 12: Percentage of respondents rating each informatics, computational, mathematical and statistics discipline as high, medium or low priority or identifying it as 'not a problem'.

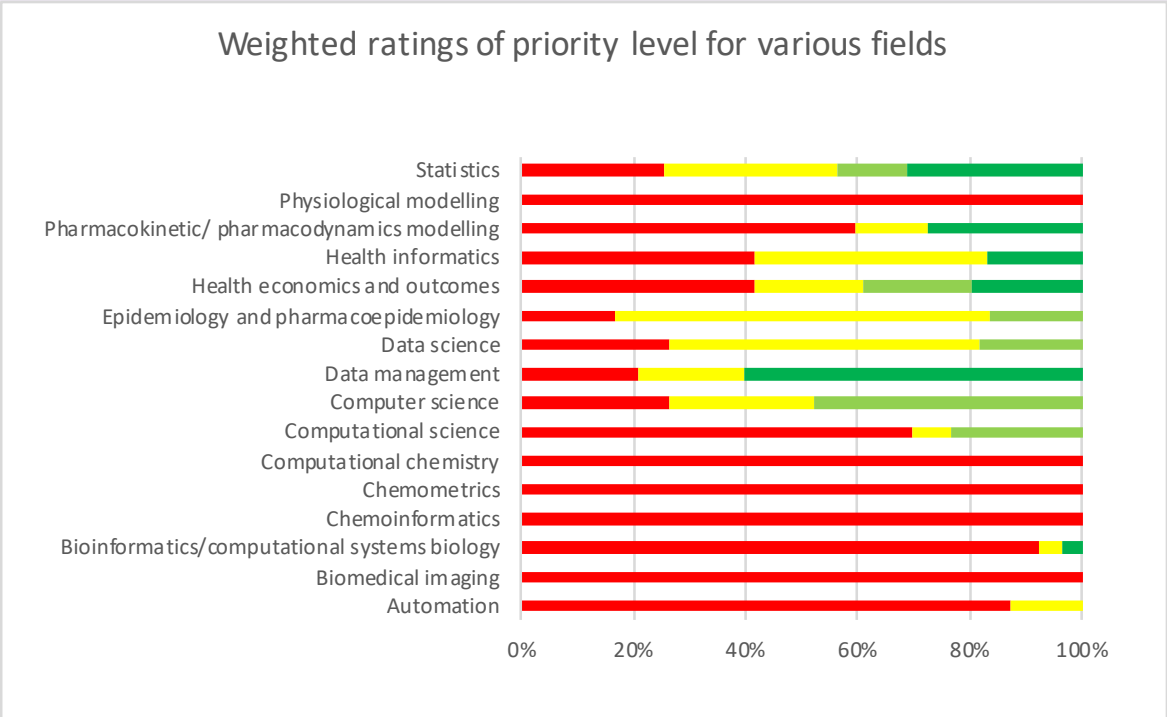


Figure 13: Percentage of respondents identifying each qualification level as an issue.

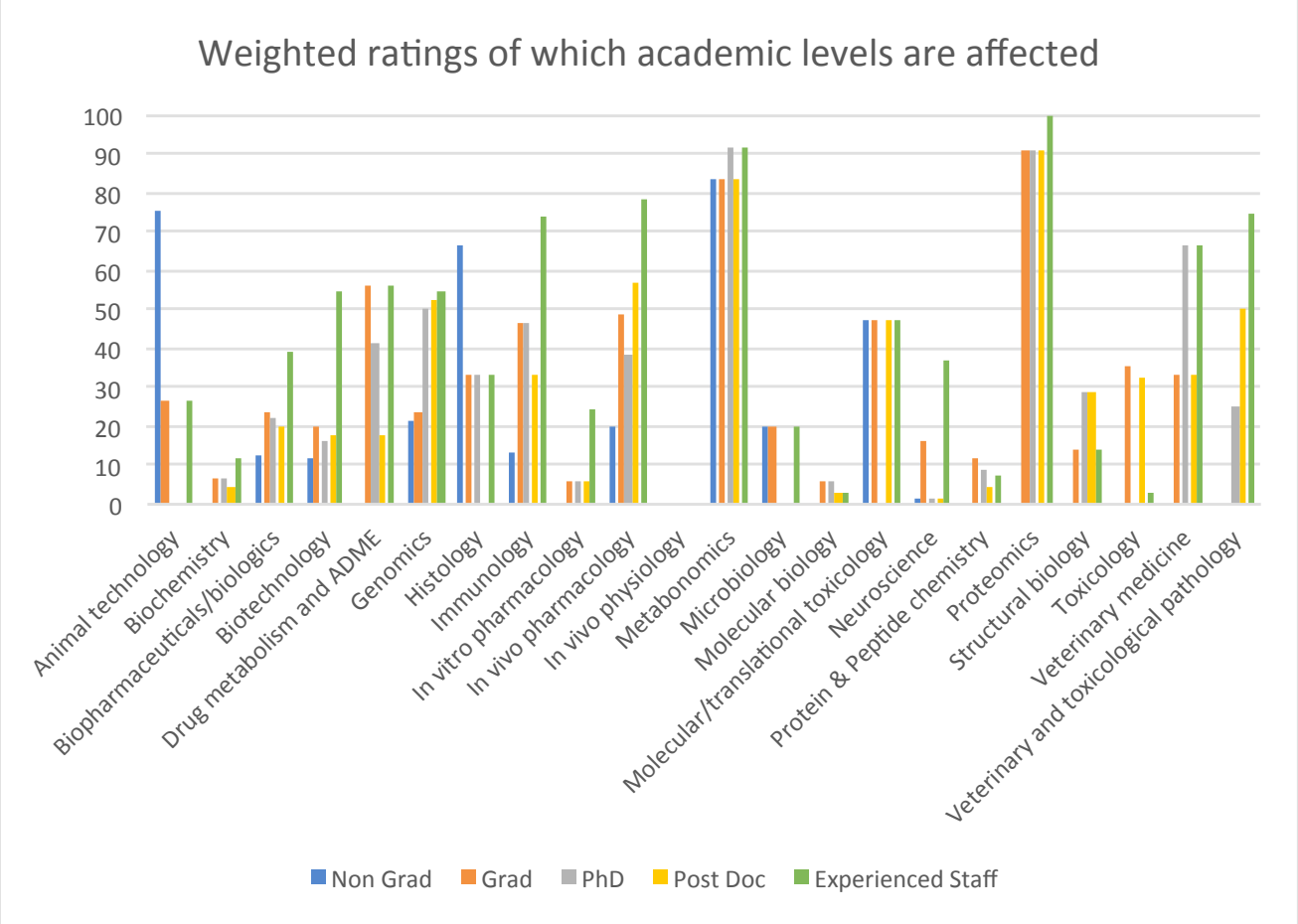


Figure 26: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

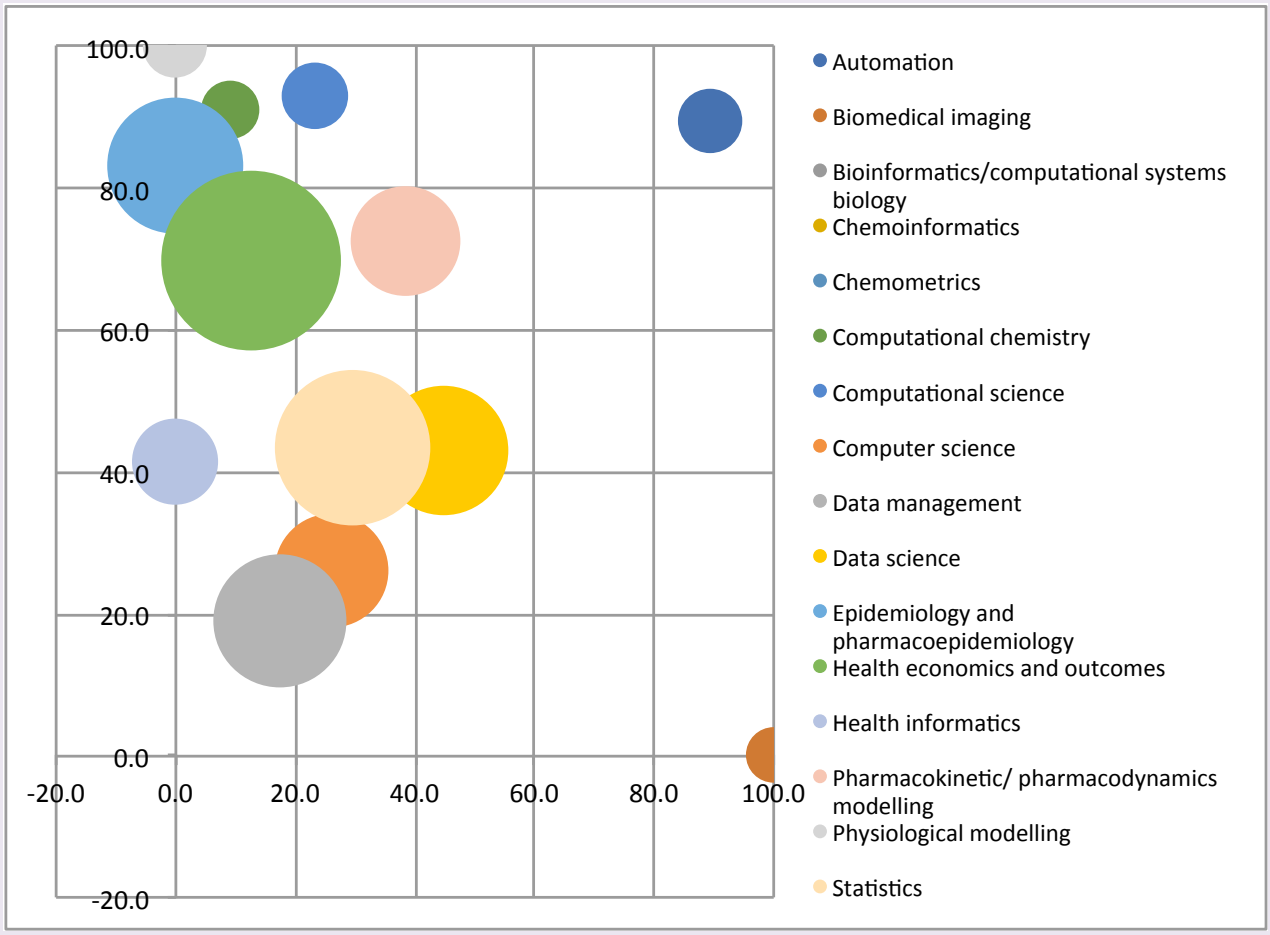


Table 18: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the informatics, computational, mathematical and statistics areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Automation	82%	13%	5%
Statistics	26%	43%	31%
Physiological modelling	25%	0%	0%
Bioinformatics/computational systems biology	23%	70%	4%
Health economics and outcomes	22%	29%	39%
Computational chemistry	9%	91%	0%
Pharmacokinetic/ pharmacodynamics modelling	9%	64%	27%
Data management	3%	35%	62%
Computer science	2%	74%	24%
Data science	2%	80%	18%
Biomedical imaging	0%	100%	0%
Chemoinformatics	0%	100%	0%
Chemometrics	0%	100%	0%
Computational science	0%	100%	0%
Epidemiology and pharmacoepidemiology	0%	67%	17%
Health informatics	0%	46%	17%

Table 19: Detailed informatics, computational, mathematical and statistics results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 20: Detailed informatics, computational, mathematical and statistics results (including previous results)

	2008	2015	2018 weighted	2018 unweighted
Automation	Laboratory automation is a multi-disciplinary strategy to research, develop, optimize and capitalise on technologies in the laboratory that enable new and improved processes.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	Respondents were unanimous that finding experienced staff is a problem.			
Biomedical imaging	Biomedical imaging is increasingly used in the pharmaceutical industry as a non-invasive technique during preclinical studies and clinical. It can be used, for example, to evaluate whether or not a medicine has had a biological effect, or if it reaches the target organ. Imaging techniques can also provide data on biomarkers of disease, providing an efficient way to accurately evaluate the effectiveness of some new medicines.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	The single respondent answering in this discipline identified biomedical imaging as high priority.			
Bioinformatics/ computational systems biology[35]	Systems biology integrates experimental and computational research to better understand complex biological processes. Bioinformatics and computational systems biology use statistical techniques, including Bayesian methods, to interpret large sets of biological data. Modelling and simulation of biological systems are used as an aid to predicting activity of potential medicines.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	After weighting, finding post-doctorates and experienced staff is a very high priority (+90%).			
Chemoinformatics	Chemoinformatics involves the application of computational techniques to existing datasets to address a range of chemical problems. Chemoinformatics toolkits allow virtual screening, chemical database mining and structure-activity studies.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	The single respondent answering in this discipline identified chemoinformatics as high priority.			

35 In 2008 Computational chemistry was merged with Structural chemistry

	2008	2015	2018 weighted	2018 unweighted
Chemometrics	Chemometrics is the science of extracting information from chemical systems by data-driven means using methods such as multivariate statistics, applied mathematics and computer science, in order to address problems in chemistry, biochemistry, medicine, biology and chemical engineering.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	The single respondent answering in this discipline identified chemometrics as high priority.			
Computational chemistry[36]	This discipline involves the use of computational approaches in drug design and in lead identification. The properties of molecules and target proteins are modelled to predict and gain insight into how these will interact. Computational chemists often work with structural chemists who in turn try to elucidate the structures and shapes of molecules, protein targets and protein-molecule complexes. These approaches are widely used in the design of new medicines.			
	Q: Non-graduate N: Graduate, PhD, Post-doc	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	After weighting, quantity of candidates is a very high priority (+90%), as was the problematic nature of finding non-graduates and PhDs. No responses identified finding graduate/MSc as a problem, while respondents were unanimous that finding post-doctorates and experienced staff is a problem.			
Computational science[37]	Computational Scientists use mathematical modelling techniques along with information from published literature to build hypotheses for drug targets. The use of computational science allows large data sets to be collected and analysed quickly.			
	Q: Non-graduate N: Graduate, PhD, Post-doc	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	Prior to weighting responses were split evenly between computational science being a high priority, a medium priority or a low priority. After weighting, quantity of candidates is a very high priority (+90%). No responses identified finding PhDs as a problem.			
Computer science	Computer Scientists within the pharmaceutical industry play a vital role within key growth areas of software development, app development, AI and coding.			
	In 2008 this area was not rated.	In 2015 this area was not rated.	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff	Q: Non-graduate N: Graduate/MSc, PhD, Post-doc, Experienced staff
	Prior to weighting responses were split evenly between computer science being a high priority, a medium priority or a low priority.			

37 In 2008 Computational science was linked with Bioinformatics

	2008	2015	2018 weighted	2018 unweighted
Data management	Broadly this involves the development, execution and supervision of plans, policies, programmes and practices that control, protect, deliver and enhance the value of data and information assets. Clinical research data management is the application of informatics theories and methods to the definition, collection and processing of data for clinical studies and the design of associated work and data flow.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
Data science[38]	The process of analysing data to find correlations or patterns in large sets of data, possibly from multiple sources.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	After weighting, the problematic nature of finding experienced staff was identified as a very high priority (+90%).			
Epidemiology and pharmacoepidemiology	Epidemiology is the study of health and disease conditions in a defined population to identify patterns. Pharmacoepidemiology uses these techniques to study the uses and effects of medicines in large, well defined, populations.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses identified the quality of candidates as a problem, or finding non-graduates as a problem.			
Health economics and outcomes	Health economics is a branch of economics concerned with issues relating to the allocation of health and healthcare. Health economists study factors that affect the supply and demand for healthcare and the market equilibrium, and look at healthcare system design and reform as well as aspects of financing, expenditure and purchasing.			
	Q: Non-graduate N: Graduate PhD Post-doc	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding non-graduates as a problem.			

38 In 2008 and 2015, data science was rated as data mining.

	2008	2015	2018 weighted	2018 unweighted
Health informatics	Health informatics deals with the resources, devices, and methods required to optimise the acquisition, storage, linkage, retrieval, and use of health-related data to improve health care outcomes and optimise the development and use of medicines.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified the quality of candidates as a problem, or finding non-graduates as a problem.			
Pharmacokinetic/ pharmacodynamics modelling	Pharmacokinetics (PK) focuses on how the body processes a drug, resulting in a drug concentration. Pharmaco-dynamics (PD) is concerned with how the drug acts on the body, resulting in a measurable drug effect. Through PK/PD modelling and simulation, which combines the two disciplines, pharmaceutical scientists acquire an earlier understanding of the link between drug and response, and can better characterise a drug's absorption, distribution, and elimination properties.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding non-graduates as a problem.			
Physiological modelling	Modelling and simulation at the pre-clinical stage of drug development involves integration of data on physicochemical properties, pharmacokinetics, pharmacodynamics, formulation and safety. Physiologically based pharmacokinetic (PBPK) modelling and simulation is a tool that can help predict the pharmacokinetics of drugs in humans and evaluate the effects of intrinsic and extrinsic factors, alone or in combinations, on drug exposure. The use of this tool is increasing at all stages of the drug development process.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	Respondents were unanimous in their responses in this discipline.			
Statistics	Statisticians are a fundamental part of a drug development project team across the whole lifecycle of a pharma-ceutical product – from laboratory work through to trials in humans (clinical trials) and finally to manufacturing and marketing. Pharmaceutical statisticians are closely involved with activities such as experimental design, sample size calculations, data collection, and the analysis, interpretation and presentation of results.			
	Q Non-graduate N Graduate PhD Post-doc	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding non-graduates as a problem.			

38 In 2008 and 2015, data science was rated as data mining.

Section 6 - Regulatory areas

Figure 14: Percentage of respondents rating each regulatory discipline as high, medium or low priority or identifying it as 'not a problem'.

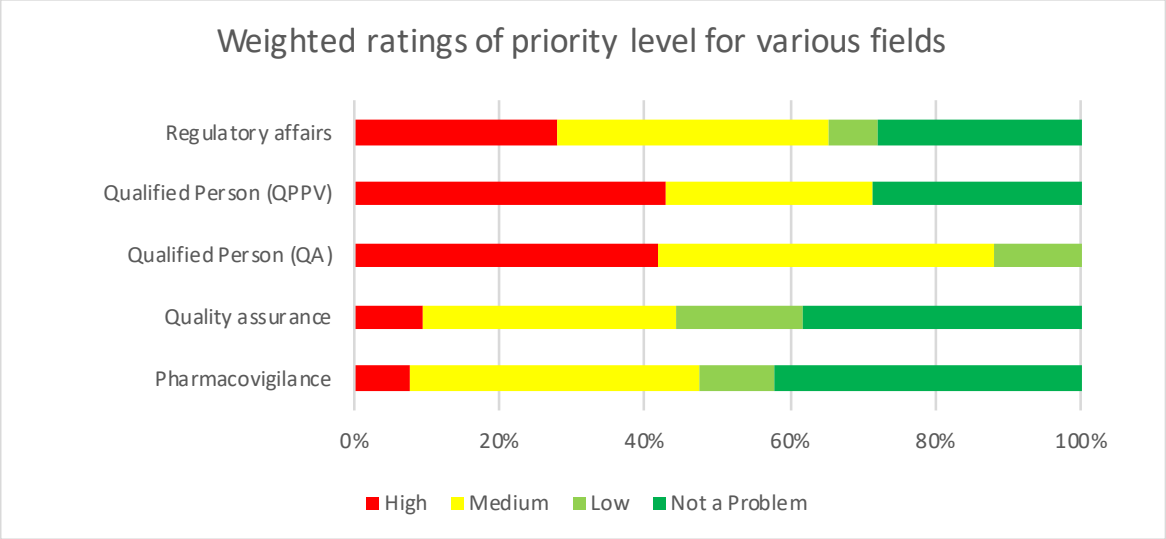


Figure 27: Percentage of respondents identifying each qualification level as an issue within the regulatory disciplines

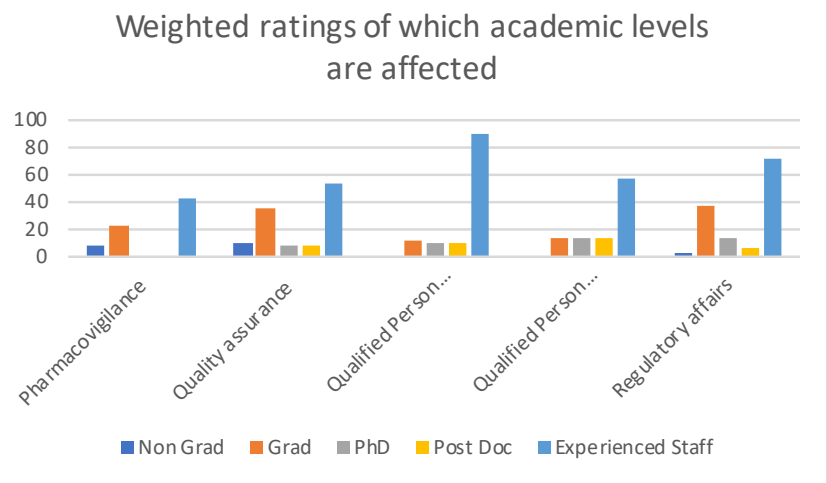


Figure 28: Percentage of respondents identifying a concern with the number vs. quality of candidates. Size of bubbles represents the number of respondents in each area.

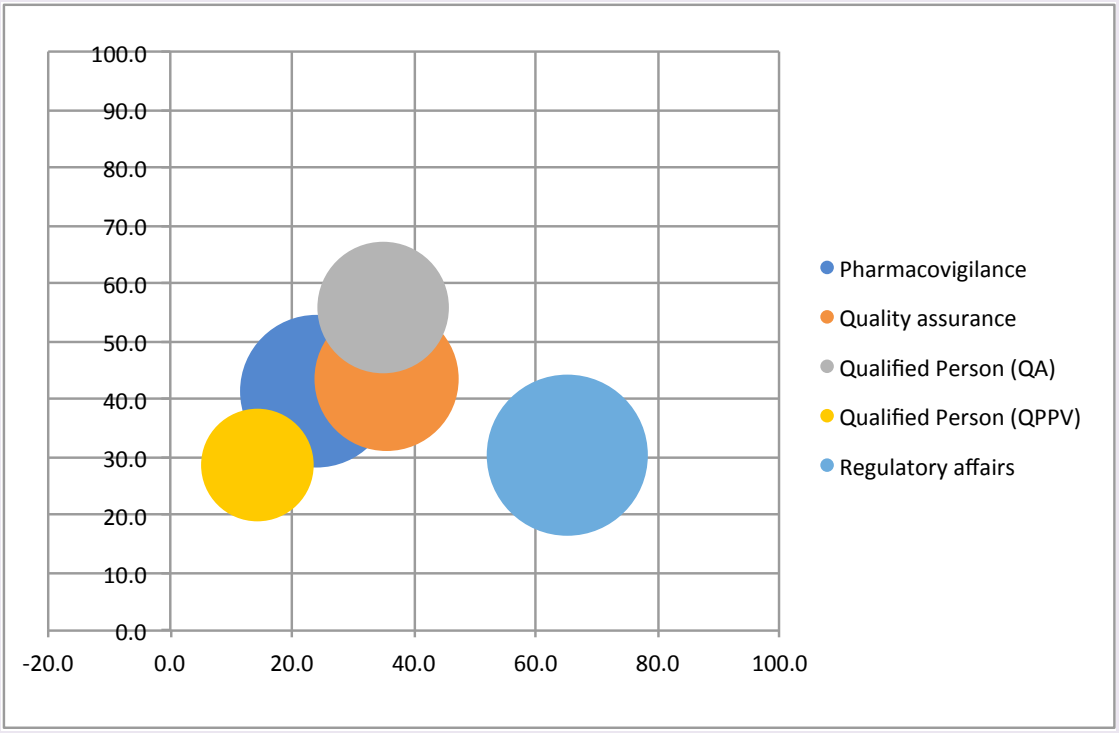


Table 21: Percentage of respondents identifying practical skills as a 'major concern', 'concern' or 'not a problem' within the regulatory areas (numbers may not total 100% due to rounding)

	Major Concern (%)	Concern (%)	Not a Problem (%)
Qualified Person (QA)	42%	36%	11%
Qualified Person (QPPV)	29%	43%	29%
Regulatory affairs	21%	51%	28%
Quality assurance	0%	62%	38%
Pharmacovigilance	0%	58%	42%

Table 22: Detailed regulatory results (including previous results)

	Low priority – an important area to watch
	Medium priority – requires action
	High priority – requires immediate action
	Not applicable or not rated

Q = Quality of candidates, N = Number of candidates

- Q, N, and recruitment level colour-coded according to the percentage of respondents identifying it as a concern (0 – 30% respondents considered low priority, 30 – 60% respondents considered medium priority and 60 – 100% respondents considered high priority)
- Overall priority band colour-coded according to the priority level with the greatest percentage of respondents

Table 23: Detailed regulatory results (including previous results)

	2008	2015	2018 weighted	2018 unweighted
Pharmacovigilance	Pharmacovigilance is the process of collecting, monitoring, researching, assessing and evaluating information from healthcare providers and patients on the adverse effects of medicines, to ensure that drugs on the market are safe for patients, and to identify new hazards associated with the medication.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding PhDs or post-doctorates as a problem.			
Quality assurance	Quality needs to be built into the product. The information and knowledge gained from pharmaceutical development studies provide scientific understanding to support the establishment of specifications and manufacturing controls which will enable to ensure a pharmaceutical product's quality throughout its life cycle. GLP, GCP and GMP guidelines ensure that appropriate standards are adhered to.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
Qualified Person (QA)	The primary legal responsibility of the Qualified Person is to certify batches of medicinal products prior to use in a clinical trial or prior to release for sale and placing on the market.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding non-graduates as a problem. Prior to weighting, finding experienced staff was identified as a very high priority (+90%).			
Qualified Person (QPPV)	Under European Pharmacovigilance regulations, each marketing authorisation holder (MAH) is required to appoint a QPPV. The QPPV is responsible for creating and maintaining the MAH's Pharmacovigilance system. The system must fulfil the legal obligations regarding product safety and must be adequately resourced.			
	In 2008 this area was not rated.	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff	Q Non-graduate N Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding non-graduates as a problem.			

	2008	2015	2018 weighted	2018 unweighted
Regulatory affairs	Regulatory affairs professionals ensure regulatory compliance and prepare submissions to regulatory authorities for new medicines and for any change to a marketed medicine.			
	In 2008 this area was not rated.	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff	Q: Non-graduate N: Graduate/MSc PhD Post-doc Experienced staff
	No responses identified finding PhDs or post-doctorates as a problem.			