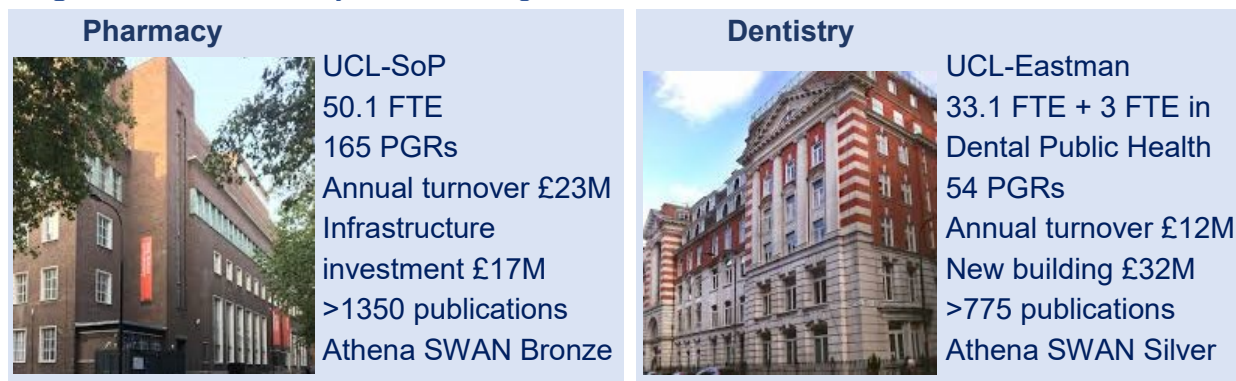


<b>Institution: University College London (UCL)</b>
<b>Unit of Assessment: 3 (Pharmacy and Dentistry)</b>
<p><b>1. Unit overview</b></p> <p>UCL's research in pharmacy and dentistry seeks to deliver transformative therapeutic advances in the discovery, delivery and administration of medicines and to accelerate the prevention and treatment of oral disease for patient benefit. The 86.2 FTE staff returned in this Unit of Assessment generate world leading basic, clinical and translational research, transfer knowledge throughout society and train the next generation of researchers. Our staff are engaged in UCL-wide, national and international collaborations, enriching our science at all levels.</p> <p>This submission comprises research activity within two major units to which staff are affiliated; the UCL School of Pharmacy (<b>UCL-SoP</b>; 50.1 FTE), and the UCL Eastman Dental Institute (<b>UCL-Eastman</b>; 36.1 FTE), which includes the research activity of the Dental Public Health team (3 FTE) employed within UCL Population Health. UCL-SoP and UCL-Eastman are part of the UCL School of Life and Medical Sciences (SLMS). In the 2020 World QS rankings UCL-SoP is ranked 5<sup>th</sup> in Pharmacy and Pharmacology and UCL-Eastman is 16<sup>th</sup> in Dentistry. UCL-SoP and UCL-Eastman have a long-standing collaborative relationship integrating research activities; for example, they jointly manage a major EPSRC Centre for Doctoral Training and collaborate to lead major international strategic development projects including creation of new Departments of Pharmacy and Dentistry at New Giza University, Egypt.</p> <p>The vitality and sustainability of our research is driven by the world-class research environment, research culture and facilities of UCL (ranked 8<sup>th</sup> in the world; QS 2020). The environment has provided both major investment and extensive support over the assessment period, allowing us to deliver:</p> <ul style="list-style-type: none"> <li>• Research grant income (£39M)</li> <li>• Investment in outstanding unit-specific infrastructure and facilities (£49M)</li> <li>• Significant strategic research funding (&gt;£10M)</li> <li>• Highly productive relationships with industry (e.g. £8.2M in consultancy income)</li> <li>• Recruitment activity at all levels of seniority (22 appointments)</li> <li>• Diverse clinical collaborations (including 19 current clinical trials)</li> <li>• Growth in successful spinout companies (currently 13 associated with the unit)</li> </ul> <p>All parts of the unit enjoy collaborations with world-leading partners and international scientific communities (in a survey of unit staff, 76% were involved in international collaborative research), highlighting the global reach of our research.</p> <p><b>1.1 Overview of UCL-SoP</b></p> <p>UCL-SoP is a Division within the Faculty of Life Sciences with an annual turnover of ~£23M. It is led by a Director (Prof. Duncan <b>Craig</b>) and Divisional Executive Team and consists of four Research Departments, (Pharmaceutics, Pharmaceutical &amp; Biological Chemistry, Practice and Policy, Pharmacology), each with a Head of Research Department who manages the academic and support staff. Associate Director of Research <b>Rahim</b> has the combined role of promoting research strategy and mentoring scientists at all levels of seniority. Research Clusters within UCL-SoP promote research interactions between Departments and throughout UCL. As one of the three international PharmAlliance partners, we form a tri-continental centre of excellence in collaboration with the Schools of Pharmacy at Monash University and the University of North</p>

Figure 1. UCL UoA3 key metrics at a glance



Carolina. UCL-SoP is also a member of ULLA, a cross-European confederation of pharmacy schools supporting EU grant applications and postgraduate training.

During the assessment period, UCL has invested over £17M in new research infrastructure including fume cupboards, laboratory refurbishments and upgrades, heating, water handling facilities and improvements to the Biological Services Unit (BSU). UCL-SoP occupies an eight storey building on Brunswick Square plus clinical research facilities within the nearby British Medical Association complex. UCL-SoP has a dedicated library, IT suite, refectory, common room, and BSU as well as a wide range of dedicated analytical, synthetic, spectroscopic, microscopic and tissue culture facilities with technical support teams.

UCL-SoP provides a thriving and opportunity-laden environment for researchers at all levels, evidenced in the assessment period by: the recruitment of 15 new permanent academic staff (73% female); creation of two EPSRC Centres for Doctoral Training (CDT) in partnership with Nottingham School of Pharmacy with an EPSRC contribution of £11M; managing the Maplethorpe Fellowship scheme with King's College School of Pharmacy to fund young and promising pharmaceutical scientists; and, recently, the £1M Thomas Marns Fund to support PhD students from disadvantaged and ethnically under-represented backgrounds. In the assessment period UCL-SoP staff published >1350 peer-reviewed research articles; these were cited nearly 20,000 times and included 50 highly-cited documents (top 1% of their field). Two researchers (**Basit, Gaisford**) were recognised two years in a row (2019, 2020) as Web of Science Clarivate Highly Cited Researchers. Over 55% of published articles included international collaborators, highlighting the global reach of our work.

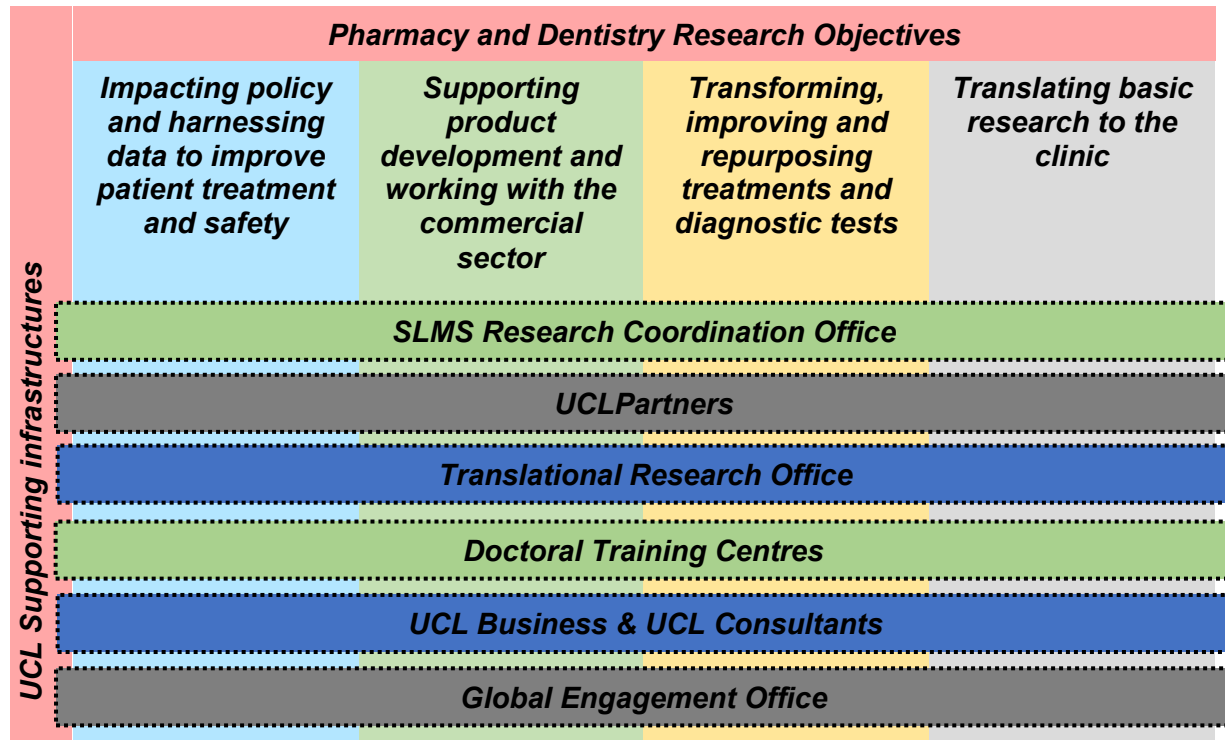
UCL-SoP was awarded Athena SWAN Bronze status in 2014, and is in the progress of applying for silver (delayed by COVID-19). Our Equality, Diversity & Inclusion (EDI) Committee are represented at all management committees within UCL-SoP, and we have a highly active BAME awareness and support group.

## 1.2 Overview of UCL-Eastman

UCL-Eastman is a Division within the Faculty of Medical Sciences with an annual turnover of ~£12M. It is led by an Institute Director (Prof. Stephen **Porter**) and Institute Manager, supported by the Institute Management Board, and consists of three Research divisions, (Microbial Disease (MD), Biomaterials and Tissue Engineering (BTE) and Clinical Research (CR), plus four Teaching divisions.

Following UCL capital investment of £32M during the assessment period, UCL-Eastman has moved into two major purpose-built facilities. Firstly, the UCL Rockefeller Building now houses a state-of-the-art Clinical Research Facility (Eastman Clinical Investigation Centre, ECIC) as well as upgraded offices and IT/AV facilities for research. It is adjacent to the UCL Bloomsbury campus and the new Eastman Dental Hospital (opened 2020), thereby accelerating translational research, widening collaborations and facilitating knowledge transfer. Secondly, the UCL Campus at the Royal Free Hospital (RFH) now houses UCL-Eastman's laboratory-based research facilities supporting Microbial Disease and Biomaterials and Tissue Engineering,

**Figure 2.** How UCL infrastructure supports research objectives in UoA3



building on UCL-Eastman’s established research collaborations with UCL Divisions based in the RFH (Medicine, Surgical Sciences and Infection and Immunity). In addition to research facilities, the new accommodation provides excellent infrastructure support (library, office, social spaces, catering and IT). In the assessment period >775 peer-reviewed research articles were published; these were cited nearly 12,000 times and included 28 highly-cited documents (top 1% of their field). Over 50% of published articles included international collaborators, highlighting the global reach of our work.

As with UCL-SoP, UCL-Eastman provides a thriving environment that ensures all researchers can flourish. Examples during the assessment period include the recruitment of 7 (29% female) permanent academic staff and major growth in our portfolio of NIHR IAT Academic Clinical Lecturers (5, 80% female). Reflecting the strength of the collaborations with the NHS (particularly the UCLH Eastman Dental Hospital, part of UCLH NHS Trust), UCL-Eastman secured £2.1M funding to create a new Oral Health & Disease Theme within the UCL/UCLH NIHR Biomedical Research Centre. This Theme now supports 15 staff delivering one of the highest numbers of NIHR Oral & Dental Portfolio trials in secondary care nationally.

The Dental Public Health Group is based in the multidisciplinary Department of Epidemiology and Public Health where their research and teaching activities are integrated with broader public health agendas and with clinical colleagues at the Eastman.

UCL-Eastman was awarded Athena SWAN Silver status in 2015, and has an effective Equality, Diversity Inclusion (EDI) Committee that, together with the Institute Manager and Human Resource Officer, ensures robust support for staff and students as evidenced by regular staff surveys.

**1.3 Strategy for facilitating the achievement of impact from research**

Our major research and impact objectives are in §1.4 and **Figure 2**. Strategies to ensure that our discovery research achieves commercial and clinical impacts include:

1. **Accelerating research translation for patient benefit**, evidenced in this REF period through establishing a new clinical research facility (current portfolio of 19 clinical trials).
2. **Establishing influential links to policy-making bodies**, including informing MHRA on the recent COVID-19 vaccine.

3. **Promoting active collaboration with commercial partners** as evidenced by the number of spinouts (13 from the unit) and consultancies within the unit (attracting >£8M in income).
4. **Forging international networks to track and harness 'big data'** to inform health policy, harnessing datasets covering >100M patients globally.
5. **Recruiting, developing and retaining a diverse team of researchers**; during the period our new open-contract appointments were >50% (10) female and 47% (9) self-identify as BAME.
6. **Creating and delivering state-of-the-art PhD training programmes** incorporating strong links to industry (our 2x EPSRC-funded CDT programmes have an intake of 60 students joint with Nottingham University).
7. **Harnessing major UCL infrastructure and partnerships** including collaborations with UCLPartners and access to >1800 pieces of shared equipment through the UCL Research Equipment Catalogue.

#### 1.4 Research objectives for the next 5 years

Our goals for the next period cluster into four broad aims that link basic scientific innovation with clinical benefits.

##### 1.4.1 Impacting policy and harnessing data to improve patient treatment and safety

Our goal is to deliver research that improves patient treatment and safety as well as influencing national and international policy, ranging from medicines safety to orthodontic care. We have established many effective collaborations that have delivered outputs and impacts: see Impact Case Studies from **Franklin, Horne, Watt**.

##### Underpinning activity:

- Establishment (in 2019) of a designated World Health Organisation Collaborating Centre of Oral Health Inequalities and Public Health; this allows researchers to influence policy on global standards for dental health and input into forthcoming WHO Global Oral Health Report (**Watt**).
- Establishment (in 2018) of the Neurological and Mental Health Global Epidemiology Network (NeuroGEN) to address evidence-gaps in the treatment of neurological and mental health disorders. This brings together researchers from Australia, Asia, Europe and North America, with combined databases covering >100 million patients (**Brauer, Lau, Wei, Wong** and PharmAlliance partners).
- Establishment (building on a long-term relationship) of a joint UCL-Korea Dental Medicine Innovation Centre, funded by the Korean National Research Foundation and with a current portfolio of ~15 patents (**Knowles**).
- Structured senior leadership contributions to the external scientific community in medicines usage, including: membership of both the Commission on Human Medicines (CHM) and the CHM COVID-19 Vaccines Benefit Risk Expert Working Group involving the MHRA's approval process for COVID-19 vaccines (**K Taylor**); co-authorship of the 2017 global classification of periodontal and peri-implant disorders (**Needleman**); senior editorship of BMJ Quality and Safety (**Franklin**); authorship of PHE guidelines of Oral Medicine care during the COVID pandemic (**Porter, Fedele**).

**Supporting infrastructure:** this involves building extensive collaborations with UCLPartners, the largest academic health science system in the world, responsible for treating more than 6 million patients per annum with an annual turnover of ~£2bn, close relationships with UCLH NHS Foundation Trust (which includes the Eastman Dental Hospital) and with Imperial College Healthcare Trust. In addition, the unit has created close links with the World Health Organisation and the International Pharmaceutical Federation (FIP).

### 1.4.2 Supporting product development and working with the commercial sector

Since 2014 we have accelerated our commercial involvement as we have encouraged researchers to engage with industry (62% of staff submitted in the unit have been involved in collaborative research with industry), and this is also delivering impacts, see Impact Case Studies for **Basit, Neidle**. This is an area of considerable scientific trajectory as we have a growing number of early phase companies and commercial partnerships as well as well-established activities leading to marketed products.

#### Underpinning activity:

- Harnessing 3D printing to develop medicines and biomaterials; this activity started as basic research but has now resulted in two spinouts, including FaBRx which was awarded > €5M with collaborators through the Interreg 2 Seas programme and £650k (InnovateUK) towards advancing healthcare aims to improve oral drug delivery (**Gaisford, Basit**).
- Creation of the spinout company Nanomerics, specialising in developing chitosan-based nanotherapeutics and supported by UCL Business. The company won the 2016 APS Innovative Science Award and the Royal Society of Chemistry's 2017 Emerging Technologies Award (**Uchegbu, Shatzlein**).
- Development and commercialisation (by the spin-out company Intract) of Phloral, a dual-mechanism coating to allow drug targeting to the colon, currently being used for the treatment of Crohn's and other bowel diseases (**Basit**).
- Collaboration with AFYX to develop a revolutionary drug-delivery system for the treatment of chronic inflammatory disease of the oral mucosa (**Fedele**).
- Collaboration with SALIWELL Ltd to develop an intra-oral electrostimulation device for salivary gland dysfunction (**Porter**).

**Supporting investment:** this takes advantage of UCL's extensive funding schemes for translational, consultancy and start-up projects (§3.2). Staff are supported to engage in knowledge transfer and consultancy, which has dedicated professional support from UCL Consultants. We encourage researchers in this unit to dedicate up to 40 days per year to national and international consultancy and knowledge exchange. The achievements of our researchers in enterprise and external engagement are recognised in appraisal and promotion processes and thus these activities are encouraged for all staff.

### 1.4.3 Transforming, improving and repurposing treatments and diagnostic tests

Major investments to support researchers developing novel and world-leading approaches to treatments and diagnosis support delivery of this aim as it improves clinical trials and delivers clinical and therapeutic benefits to patients. Several Impact Case Studies (**Wei, Tuleu**) highlight the progress in this aim. Innovating to improve approaches via clinical, computational, statistical and policy-driven approaches is a growing component of our portfolio.

#### Underpinning activity:

- A major investment supporting translation of treatments and diagnostics is the ECIC, allowing extension of trials of novel devices, including: neuro-electrostimulation devices in the treatment of Sjögren's syndrome (SALRISE study); novel approaches to diagnosis, including of oral cancer (LEGEND study); the first UK trial for repurposing sodium valproate in epigenetic reprogramming of high-risk epithelial dysplasia in the chemoprevention of oral cancer (SAVER trial); and, repurposing pentoxifylline/tocopherol for soft tissue fibrosis of head and neck radiotherapy (**Fedele, Porter**).
- With Yale University School of Medicine, we are developing innovative diagnostic computational models increasingly used clinically to predict patient outcomes and plot treatment pathways in rare diseases such as sporadic congenital hydrocephalus (**Haider**).

- In response to the COVID-19 pandemic, we are collaborating with an international consortium led by the National Research Council in Italy to optimise clinical trial design for treatments by applying virtual pharmacokinetic models to develop appropriate dosing regimens (**Della Pasqua**).
- Collaborating with Dundee University, **Wei** (see Impact Case Study) revealed the impact of sodium content in medicines leading to changes in European Medicines Agency and NHS guidelines and altered prescribing habits to reduce risks to patients with predisposition to cardiovascular conditions.

**Supporting investment:** This objective is a high priority for the university, as evidenced by £0.45M investment creating six dedicated Therapeutic Innovation Networks (TINs), run by the Translational Research Office, and recently awarded an additional £1M from Wellcome. TINs promote internal collaboration across six priority areas and provide funding opportunities and connections with external partners. Staff in this unit chair the Drug Repurposing TIN (**Della Pasqua**), and co-chair the Regenerative Medicine TIN (**Knowles**).

#### 1.4.4 Translating basic research to the clinic

We seek to link our research from fundamental discovery science through to clinical translation and clinic-ready treatments. In the previous REF period we laid the groundwork for multiple clinical treatments, including ATMPs and nerve engineering; in this assessment period we have made considerable advances in this area and are poised to deliver significant clinical impacts.

##### Underpinning activity:

- Our work in Advanced Therapy Medicinal Products (ATMPs) has been awarded MRC-DPFS funding to support pre-clinical translation and first-in-human gene therapy trials for Gaucher Disease (£0.79M; **Rahim**) and epilepsy (£1.8M; **Schorge**). Momentum is evidenced by new funding since August 2020 for treatment of Neimann-Pick disease (£2M DPFS, **Rahim**), and further investment of >£3.5M from UCL Technology fund for projects with partners in the unit now progressing to clinical trials (§3.2).
- GeneTxNeuro, a self-contained gene therapy facility allowing synthesis of gene therapy vectors funded by UCL (SLMS-CEF, £99k) and a two-year research fellowship (£117k) in collaboration with UCL-Institute for Child Health and the Great Ormond Street Hospital for Children NHS Foundation Trust (GOSH) NIHR Biomedical Research Centre (BRC) (**Schorge, Rahim**).
- We established the London Centre for Nerve Engineering (supported by a £1.1M EPSRC award), in 2018 to develop and translate engineered tissue towards clinical trials in nerve injury (**Phillips**).
- Completion of proof-of-concept clinical trial of novel, UCL-Eastman developed “SMART” restorative dental materials assuring strong retention, promotion of remineralisation and avoidance of the need for aerosol-generation making them safe for use during COVID-19 (**Young, Ashley**).
- Establishment of a new theme (2016, £2.1M investment) within the UCL/UCLH NIHR BRC in Oral Health and Disease to develop new treatments for significant oral disease (**Fedele, D’Aiuto, Young**).
- Appointment of a founding member of open source drug discovery (**Todd**) to the unit. The Open Source Malaria (OSM, with MMV (Geneva)), Open Source Mycetoma (MycetOS, with DNDi (Geneva)) and Open Source Antibiotics consortia are now led by the unit, as is the broader Open Source Pharma movement.

**Supporting investment:** During the assessment period, we have secured £10.7M for clinical trials including those conducted in the Eastman Clinical Investigation Centre (part of the UCL/NIHR UCLH BRC award), the Leonard Wolfson Experimental Neurology Centre and the NIHR UCLH Clinical Trial Facility, all of which have been used by researchers in this

submission. In addition, a UCL Translational Research Office **Drug Discovery Unit** is now embedded in UCL-SoP (£2.5M investment).

## 1.5 Delivery of strategy outlined in REF2014

### 1.5.1 Global healthcare

Our considerable success in delivering this aim is now underpinning our first objective for the coming period (§1.4.1). In particular, our commitment to reducing global oral health inequality led to the creation of a WHO Collaborating Centre, and the award of £2M to the Oral Health & Disease Theme of the NIHR UCLH Biomedical Research Centre (**Watt**). Watt also now co-chairs the Lancet Commission on Oral Health, established in 2020 in light of the neglect of oral diseases in global health agendas, and his continuing impact is highlighted in our Impact Case Study on the social causes of oral health inequalities.

Our strengths are exemplified by leading roles guiding international policy. The Impact Case Study of **Wei** describes research leading to development of international guidelines for safe salt intake from medicines. **Franklin** advised WHO guidelines on medicines safety. **Bates** serves as Director of Education Development for the International Pharmaceutical Federation (FIP) and his instrumental role in developing the Global Strategic Framework for Workforce Development. This Framework has now been adopted worldwide as a guide to education of existing and future pharmacists, and our work here is supported by the appointment of **Mills**. Additional appointments of **Whittlesea** and **F Smith** expand our research into the role of community pharmacies in public health, including in low-income countries.

**Fedele** contributed to the European Association of Oral Medicine consensus guidelines on the management of oral lichen planus. **Needleman** and **Ashley** proved the importance of oral health to athletic performance, influencing national and international health policies in sport at any level (e.g. International Olympic Committee) and promoted these principles through many media outlets (e.g. BBC).

Our investment in promoting safe medicines has led to academic teaching staff developing influential roles, including: in the internationally recognised Fight the Fakes Campaign against counterfeit medicines (led by Pyzik); broadcasting on COVID-19 developments for the BBC, Sky News and other media outlets; a UCL Global Ambassador with particular interests in female education in Pakistan and promoting inclusion of pharmacists in the doctHERs female health care promotion programme (led by Bukhari).

### 1.5.2 Medicines for children

Our research developing medicines for children is having global impacts through the work of **Tuleu**, who developed the Safety and Toxicity of Excipients for Paediatrics (STEP) database, a free global resource that compiles toxicity information on excipients for children's medicines (§1.4.3, and Impact Case Study). In addition, a diamorphine treatment for severe emergency pain in children, Ayendi, was developed by Therakind, the company co-founded by **Wong**.

A new initiative is the pre-clinical success of gene therapies for rare childhood diseases, which are in preparation for clinical trials, offering new hope to children with devastating disorders (**Rahim**). This work represents our growing strategy in translational research (§1.4.4). We are also pushing the boundaries of understanding of rare disease mechanisms by modelling genetic mutations leading to cerebral palsy, opening the door to rational treatments (**Haider**, *Nature Genetics*). The appointment of **Haider** from a fellowship to a permanent contract will allow continued support for this objective.

This initiative is now being united with our work in global policy and medicines safety (§1.4.1) by **Lau** (appointed in this period) who has used global epidemiology data to reveal the increased risk of seizures upon starting treatment for attention deficit hyperactivity disorder (ADHD) in adolescents (*Lancet Child and Adolescent Health*).

### 1.5.3 Nanofabrication

Facilitation of enterprise and commercialisation of research (§1.4.1) has been critical for advanced manufacturing techniques and their roll out to clinical trials. The sophisticated film coats for colonic delivery developed by **Basit** has passed phase III clinical trials, been licenced, and launched globally, offering effective treatment for irritable bowel disease affecting 7 million people worldwide (see Impact Case Study, **Basit**). Our investment in 3D printing techniques supports multiple spinout companies (**Gaisford, Basit, Hilton**) and a major EPSRC funded collaboration (£0.82M to UCL-SoP) with Cambridge University (**Gaisford**).

We continue to lead in the development of new nanofabrication techniques, an area that underpins our objective to transform treatments (§1.4.2): **Williams** published the seminal monograph (UCL Press, 2018) on pharmaceutical applications of electrospinning (2,525 downloads from 89 countries). Our world-leading expertise has led to key roles in large collaborative efforts to advance nanofabrication techniques. **Knowles**, has won EPSRC funding (£1.6M total, £1.14M to UCL) and established a collaboration with UCL Mechanical Engineering and Oxford University to develop core-shell nanoparticles for enhanced effectiveness for the treatment of oral cancers. **Craig** is part of a major INTERREG EU consortium (IMODE, €6.0M total, £0.2M to UCL-SoP), developing nanofabricated gene delivery systems, and two EPSRC grants (combined total £0.92M total, £0.47M to UCL-SoP) with UCL Mechanical Engineering to develop innovative nanofiber manufacturing approaches.

To maintain our leading expertise in nanofabrication and support delivery of objectives §1.4.2 and §1.4.3 we recruited three new academic staff: **Parhizkar** (nanofibers and electrohydrodynamics), **Buanz** (developing printing methods) and **Carruga** (acoustofluidic devices to develop ultrasound-responsive drug delivery vehicles).

### 1.5.4 Microbial diseases

Our research into the cause and treatment of microbial diseases has global impact; indeed, it has an impact beyond the planet as **P Taylor** advises NASA on the development of microbial resistance on space flights. Globally, **Della Pasqua** provides guidance to the WHO on the pharmacokinetics of drugs used in TB. We have also identified a promising new treatment for *C. difficile*, the Impact Case Study by **Neidle** outlines research and commercial collaboration that led to a Phase III clinical trial of ridinilazole.

A less expected advance in our microbial work reflects the growing understanding of the importance of healthy microbiomes; **A Smith** showed that the environment rather than genetics shapes the structure and development of the oral microbiome, and led the expansion of the NIHR-funded (£0.3M) impact of the mouth-gut microbial interactions. Work in this area was also expanded by the recruitment of **Evangelopoulos** with expertise in microbial resistance.

### 1.5.5 Chemical biology informing drug discovery

Since 2014, we have recruited five new staff to support this strategy (**Todd, Browne, Dickman, Woon and Waller**). **Todd** leads on Open Source Drug Discovery as described above, while **Browne** develops novel catalysis and manufacturing approaches to drug synthesis, **Dickman** synthesises and evaluates antimicrobial peptides, **Woon** is identifying novel epigenetic disease targets, and **Waller** studies drug-nucleic acid interactions for the treatment of cancer and infections. In the past 10 years the TRO Drug Discovery Group, embedded in UCL-SoP, has supported 14 early drug discovery projects securing £3.9M in funding.

Linking to our Global Healthcare objective (§1.5.1) **Todd** supports Open Source Pharma, a drug discovery initiative in removing intellectual property restrictions to facilitate access to new and existing medicines in low and middle income countries and indeed worldwide.

### 1.5.6 Development of novel biomaterials and devices

Our successes in this arena now underpin our objective to transform and improve treatments (§1.4.3). **Knowles**, with funding from EPSRC, RAFT and UCL TRO (total £0.23M), led the development of a new light curable degradable polymer that is now patented by UCL. **Cunningham** and **Hunt**, with colleagues at Bristol, developed an Index of Orthognathic



Functional Treatment Need (IOFTN) that is now promoted by international care organisations and employed nationally for NHS commissioning of care. In response to the challenge of childhood tooth decay and the recent COVID-19 pandemic, **Young** and **Ashley** are driving a Phase II trial of their novel antibacterial, remineralising, no-drilling/no-aerosol generating dental restorative material (>£1M NIHR and NIHR BRC and ~£200k in kind support from industry). In addition, **Fedele** has received funding from NIHR i4i, NIHR BRC, and UCL Innovation & Enterprise (total £0.3M) to develop and validate novel devices for non-invasive early diagnosis of oral cancer and pre-cancer. To support this initiative, we have made three appointments (**Nguyen, Poma, Chau**).

#### **1.5.7 Advanced therapy medicinal products (ATMPs) in neuroscience**

We made four academic appointments to take the lead on cell and gene therapies for neurological diseases (**Schorge, Rahim, Phillips**) and using bioinformatics to model complex degenerative disorders of the brain (**Manzoni**). We now have >4 gene therapy treatments progressing to first-in-human trials, as well as hosting a UCL spinout developing engineered tissue for nerve repair (Gliaalign, §3.2) We have invested £0.2M in a facility (GeneTxNeuro, §1.4.4) designed to support gene therapy researchers across UCL. This places our unit at the centre of this vibrant research area, preparing to deliver on our objectives for both new treatments (§1.4.4), and attracting new venture investment bringing gene therapy products to clinical trials (e.g. UCL Technology Fund, §3.2) plus commercial collaborations (§1.4.2).

#### **1.5.8 Harnessing pharmacoepidemiology, data mining and artificial intelligence**

Pharmacoepidemiology research has thrived in our unit, as evidenced by 38 high quality research outputs since REF2014, and is underpinning one of our key current objectives (§1.4.1). Our global remit is supported by formal collaborations with Hong Kong University (HKU), Peking University and PharmAlliance partners; these collaborations have led to the shared availability of large international patient databases (e.g. 4M individuals from the UK; 23M from Taiwan; 150M USA). We applied data mining and artificial intelligence technologies to build on our strengths in pharmacoepidemiology (**Wong, Wei**). We recruited (**Bauer, Lau**) to support the next generation of epidemiological expertise within our community. Work in this area has resulted in publications highlighted in Objective 1, and our collaboration with HKU on AI and Pharmaceuticals in Non-Communicable Diseases (£3M total, £0.5M to UCL) is central to our aim to harness global data for global health (§1.4.1).

#### **1.6 Support for interdisciplinary research**

A majority of the researchers in the unit carry out interdisciplinary research (64%) with extensive collaborations in biomedical and other fields (§4.1). Our research is strategically aligned with our partner NHS Trusts, with co-location of UCL academics within the University College London Hospitals NHS Foundation Trust and the Royal National and Eastman Dental Hospital, and active collaborations throughout the network of NHS trusts of UCLPartners (§4.1.3).

Examples of UCL funding supporting interdisciplinary work include awards from the UCL Global Engagement Office to establish collaborations with colleagues across the world (12 awards, total of £38k) and funding for UCL's Grand Challenges (10 awards, total £32k). Support from the UCL European Research & Innovation Office (ERIO) has contributed to winning €6.5M of European grant income for the unit. We also receive support for our commercial and translational research (§3.2).

#### **1.7 Progress towards an open research environment**

UCL's high-level commitment to research transparency and integrity are underpinned by the institutional statements/policies described in REF5a. All research in this unit complies with UCL's Statement on Research Integrity (which incorporates the principles of the UK Concordat to Support Research Integrity), Code of Conduct for Research, and Statement on Transparency in Research. These include policies regarding the use of metrics for Open Research in the context of UCL's commitment to the principles of the San Francisco Declaration on Research Assessment (DORA). UCL is a founding member of the UK Reproducibility Network. Extensive

training and enabling mechanisms (including recognition in promotions criteria) have been developed as described in §2.1.2.

To support our objective to deliver new treatments (§1.4.4), we recruited a world-leading expert in Open Science (**Todd**) who is a founder of the global Open Source Pharma movement, and aims to take new medicines to market using a patent-free business model. We also invested in open research methods, including the rollout of online laboratory notebooks for all PhD students in UCL-SoP. Additional flagship investments in promoting reproducibility include the Consensus Statement on Ethnopharmacological Field Studies (ConSEFS) establishing best-practice in research on traditional uses of medicinal and food plants (**Heinrich**), and research that confirms global targets for healthcare workforce are reproducible in a number of WHO regions (**Bates**).

In the REF period, 38% of staff published research that reproduces key findings in their field, including publishing a textbook for research methods applied to pharmacy settings (**F Smith**). Systematic reviews provide widespread involvement in increasing reproducibility (including 7x Cochrane reviews).

We uphold the highest levels of research integrity, and three main initiatives promote a culture of integrity from 'pitch' to patient. Firstly, major research proposals are subjected to **internal peer review** where they are vetted by 'Peer Pitching' sessions prior to applications for funding. These sessions aim to oversee not just the quality of the proposed science but the integrity and robustness of the team. Secondly, we support the **3Rs in Animal research**, including sitting on the funding panel of the NC3Rs (**Chau**), co-chairing the UCL 3Rs committee (**Schorge**) and sitting on the UCL Animal Welfare Strategic Committee (**Shah**). Finally, as work progresses to the clinic, all academic staff involved in clinical and translational research maintain up to date **good clinical practice (GCP)** training overseen by the ECIC. Clinical Research Governance of all studies with human participants complies with the current national regulations (e.g. NHS Ethics, MHRA) and local (UCLH) SOPs.

In addition to upholding the UCL standards for Open publishing, 33% of staff have deposited research data into open source public sharing platforms, including: whole-genome sequences, 3D printing files, neuronal reconstructions, and novel chemical structures. Platforms include: Biological Magnetic Resonance Data Bank (BMRB), ModelDB, NeuroMorpho.org, Zenodo, CALIBER (a platform consisting of 'research ready' variables from electronic health records (EHR)).

Both UCL-SoP and UCL-Eastman have been involved in improving research reporting, with 19% of staff delivering examples of best reporting practice. These include: meeting best practice for clinical trial designs, PROSPERO, PRISMA Extension for Network Meta-analysis, clinical and diagnostic studies fitting STROBE, CONSORT, and STARD guidelines and use of online public laboratory notebooks.

## 2. People

### 2.1 Staffing strategy and staffing development

All parts of the unit are committed to securing the vitality and future sustainability of our research environment via staff development and recruitment. We attract, develop and retain academic leaders through a comprehensive programme of support and development opportunities to ensure a vibrant and inspiring research environment characterized by research excellence and contributions to research impact.

Our HR team, Faculty and Institute-level leaders help staff thrive by offering comprehensive training courses and leadership development programmes, facilitated by industry-leading trainers, as well as online learning and bespoke activities. To ensure we are aware of any staff concerns, and to assist in the design of support mechanisms, UCL surveyed our staff in 2015 and 2017.

### 2.1.1 Staffing strategy

All parts of the unit actively implement the 2019 “Concordat to Support the Career Development of Researchers” (<https://bit.ly/3qtbD3o>) at all career stages through appraisal probation and promotion schemes, mentoring, networking, training, succession planning, and by developing leadership that reinforces our commitment to the Concordat. We map skills with our research priorities to target recruitment of academic staff who will contribute to, and benefit from, a thriving research environment. Recruitment is based on excellence, and is targeted to sustain the critical mass needed to deliver real impact in our priority areas. All the academic appointments since 2014 match the themes outlined in REF2014 (§1.5). Professional support staff, including professional technical staff, support research and training activities across the unit (e.g. trained technical staff support our NMR and confocal imaging facilities). We also have a trial manager, a trial coordinator and 3 research nurses supporting our clinical trials unit ECIC.

Supporting fair recruitment is central to our mission of increasing diversity, and a centrally supported programme provides Fair Recruitment Specialists to assist with this, while UCL Human Resources policies aim to ensure that all stages of the appointment process acknowledge core principles of Equality, Diversity and Inclusion. Evidence of our success is that since REF2014, the unit has made 22 academic research appointments, of whom 55% are female. Transparent processes are applied to all recruitment along with well-defined recruitment procedures to ensure equitable practices. Along with gender equality, we ensure recruitment panels reflect the ethnic diversity of our community and applicants.

### 2.1.2 Staff development and promotion

UCL’s Academic Careers Office (ACO), which brought in £9.2M in grant funding in 2018/19, promotes, supports and develops all aspects of academic and clinical academic careers in SLMS through a range of programmes and support schemes. Their career schemes aim to give researchers the funding, skills and personal qualities necessary to succeed in research. In 2019-20, the ACO trained >1000 UCL research staff. UCL also offers a cross-institutional BAME mentoring programme and an Inclusive Advocacy sponsorship programme, which aims to increase the proportion of BAME staff in UCL leadership.

We provide all new staff with structured induction and mentoring, opportunities for coaching via a recognized set of UCL-registered professional advisors, and provide funding and senior leadership support and mentorship for major leadership training courses (e.g. 22 staff attended the Women in Leadership course, 11 attended Senior Women in Leadership, and 11 staff attended the UCL Future Leaders course). UCL also invests in a large number of training courses within the Staff Development programme; this includes opportunities for our professional support staff to spend time working in other divisions to enhance their skills. For example, our Biological Services Unit technical staff now work across UCL rather than just in UCL-SoP, thereby enhancing their skills and experience.

The UCL annual appraisal scheme provides a structured template for staff to develop ambitious but realistic objectives, help realise career goals, and mentor towards promotion (which is discussed at every appraisal), in particular identifying areas within the broad categories of research, teaching, knowledge transfer, and enabling where support may be required for progression. These appraisals and mentoring approaches have resulted in a successful promotions profile with 20 academic staff promoted since 2014.

Many staff are allied to non-academic institutes, with 12 pharmacists and 28 dentists delivering research within the primary (e.g. Greenlight Community Pharmacy) or acute NHS sector (e.g. Imperial Hospital Pharmacy, and Eastman Dental Hospital). Five staff have taken secondments or periods of leave in order to establish or maintain links with non-university groups, including the Royal College of Surgeons (**Hunt**), secondments in the NHS (**Franklin, Bates**), a sabbatical at KAIST in South Korea (**Murdan**), and a Marie Curie RISE grant (**Williams**), which funds academia-university collaborations. We have also won three secondments from the UCL Innovation and Enterprise managed EPSRC Impact Acceleration Account aimed at embedding research in industry (total of £52k).

Promotions follow UCL's Academic Career Framework (ACF) which was comprehensively revised in 2017/18 to support every type of academic career path via a robust set of processes with clear criteria. Whether academic staff deliver research and education in equal measure, specialise in enterprise or focus on teaching or research, the framework ensures that contributions are assessed consistently and fairly. The ACF has explicitly recognised contributions to open science, incorporating UCL's commitments as a signatory of the San Francisco Declaration on Research Assessment.

Evidence supports that our efforts are having impact. Since REF2014, we have increased the representation of female professors from 12 (27%) to 16 (31%). We have also positively supported non-white staff with an increase from 6 (13%), to 10 (20%) at professorial level. While these data are encouraging, and suggest our activities are helping increase under-represented staff, we work to improve procedures to ensure the trends continue.

### 2.1.3 Support for early career researchers

Within the unit, our support for Early Career Researchers (ECRs) and researchers on fixed term contracts is evidenced by 7 staff on fixed term contracts or Fellowships being appointed to full academic posts within the unit (71% female).

We also have access to specialised funding for ECRs. In collaboration with Kings College School of Pharmacy, UCL-SoP runs the Maplethorpe Fellowship scheme, whereby typically one Fellow is appointed annually for a two-year period, often leading to further positions including permanent academic posts (e.g. **F Smith** is a former fellow). UCL offers funding for ECRs to present at meetings, and the unit typically adds a further 50% to successful applications. PharmAlliance (UCL, Monash and UNC) also supports a scheme targeting ECRs for pilot and travel funding and we are developing a shared, international mentorship scheme for ECRs. To support effective grant writing, our ECRs work with UCL SLMS Research Facilitators, a team trained to advise on fellowship applications, including preparation for interviews. During COVID-19 UCL supplemented the furlough scheme, adding 20% to top up the salary to full rates, and ECRs were given priority as active researchers to return to our campus facilities where social distancing limited numbers.

Our support for ECRs results in international prizes and awards, including: R. Earl Robinson Periodontal Regeneration Award at the 2018 Annual Meeting of the American Academy of Periodontology in Vancouver (Buti), and the EAPD Young Scientist Award (Lygidakis).

## 2.2 Postgraduate research students

Postgraduate Research (PGR) students form a key part of our research community. We currently host 219 Postgraduate Research (PGR) students (165 in UCL-SoP and 54 in UCL-Eastman). Since 2014, 304 full and part time PGRs completed their degrees. We work to maintain diversity of our PGR population, and are proud to have maintained a ~50% female intake since 2014, while increasing our population of students that do not identify as white to ~80% in 2019/20 (from 60% in 2013/14). Our programmes are highly international with >66% of students from outside the UK/EU (increased from <50% in 2013/14).

Our PGR students have dedicated study spaces in the new 1000 seat Student Centre (§REF5a), new facilities for UCL-Eastman including a 1338.1 m<sup>2</sup> Hub on the Bloomsbury site and 1005.8 m<sup>2</sup> in the Royal Free site, as well as dedicated library, study and social space in the 'Junior Common Room' at UCL-SoP.

### 2.2.1 PGR Programmes

We have had extensive success obtaining funding from prestigious funding bodies including fellowships from the Royal Society, Leverhulme Trust, EPSRC, NIHR, ESRC, European Commission. We co-host two EPSRC Centres for Doctoral Training; the Advanced Therapeutics and Nanomedicines CDT (£4.6M from the EPSRC, joint with Nottingham, led by **Williams**, with Co-I **Knowles**), and the EPSRC & SFI CDT in Transformative Pharmaceutical Technologies (£6.4M overall; UCL £3.1M, led by **Brocchini**). Both CDTs link academic and industry research (60 PhD students over 10 cohorts/16 years). In collaboration with European academic and

industrial partners, the unit is building a new doctoral training programme funded by the European Commission (£225k to UCL, **Orlu, Basit**). UCL-Eastman has a successful research-driven Doctorate in Dental Surgery in Paediatric Dentistry (the D.Dent, led by **Ashley** and **Parekh**). Finally, following a recent gift, the Thomas Marns Fund (£1M) has been established to fund students from disadvantaged and diverse backgrounds to study for a PhD.

### **2.2.2 Monitoring progress and supervision**

All research students are supported throughout their degree by the UCL Doctoral School which has regular milestones (literature review, progress reports), and upgrade from MPhil to PhD is expected after 9-12 months. A Departmental Graduate Tutor (DGT) is responsible for ensuring fair and equitable student recruitment, appropriate supervision, progress from MPhil to PhD registration, and thesis submission. Tutors also advise students about additional resources that may be necessary and provide support if they encounter difficulties. All students are allocated to an experienced principal supervisor, while subsidiary supervisors have specific expertise in parts of the research undertaken. Staff must attend a course on PhD supervision before being permitted to supervise (44 staff have completed this training since 2014) and must act as a subsidiary supervisor before being primary supervisor.

Progress is monitored in real time using the online Research Student Log. This documents academic progression and skills development training and reflects a dialogue between students and principal and subsidiary supervisors. It allows students to record and reflect on their review meetings (including important milestones such as the MPhil to PhD upgrade) plus discussions on academic (subject discipline), generic and transferable skills training.

### **2.2.3 Training and career support**

Particular emphasis is placed on careers guidance and skills development both via the Doctoral School and the student's research group. The success of these mechanisms is confirmed by first destination data from the Graduate Outcomes Survey: of PhD students graduating in 2017-18, 89% went on to graduate-level full- or part-time employment, and 4% to further study, and the median starting salary was £39K.

All students are expected to take advantage of the Doctoral Skills Development Programme and/or appropriate departmental courses for a period equivalent to 2 weeks per year. There are over 220 different courses across the full range of skill domains defined by the Researcher Development Framework (RDF). Training activities are assigned points and students are expected to accumulate an average of 20 points per year. Examples include the following: we have had 33 students complete SPERO, the new entrepreneurship training programme for PhD students provided by UCL Innovation & Enterprise; >300 PGRs have undertaken the UCL ARENA introduction to teaching, and 69 have completed the first programme of training to become educators, while 17 PGRs have completed training in Public Engagement. The training record is documented in the Research Student Log for the supervisory team and DGTs. Research students regularly assess and plan their skills training needs in discussion with their supervisory team using the skills self-assessment tool in the Research Student Log.

Students are encouraged to hone their presentation skills at the Annual PhD student days (with prizes for best poster and best talk) and engagement with the National 3MT (Three-minute Thesis competition). They also compete for sponsored prizes in dentistry, and philanthropic Medal prizes. All students are encouraged, and offered financial support, to present at major international conferences. PharmAlliance offers funds for travel and research for UCL-SoP students. UCL also offers support for financial hardship and wellbeing issues.

Recent awards to our PGRs include: 'Best Abstract' from AAPS (2x 2019), Most Innovative Publication from Pfizer (2018), as well as being recognised as in the top 200 Women in Technology by We Are Women Tech (2019).

### **2.2.4 Support during COVID-19 pandemic**

The COVID-19 pandemic and the temporary closure of non-essential research facilities and laboratories in March 2020 created major challenges for our doctoral researchers. To support all PhD students, UCL implemented several measures to ensure continuity of supervision, support,

training, and funding throughout the period of lab closure and beyond. These measures include: (i) the UCL Stipend Extension Scheme to support final-year funded students in submitting their thesis, by underwriting funding at the agreed minimum London UKRI rate for up to 3 months and allowing Departments/Supervisors to top-up extensions for longer periods from their own funding sources; (ii) provision of 200 free places for online bespoke training for biomedical PhD students in computing and statistical methods, including artificial intelligence (SysMic).

### 2.3 Equality and diversity

Achieving representation of staff from diverse backgrounds is central to our aim of creating a vibrant, sustainable environment that facilitates world-class research. Since REF2014, we have 4% more women, as well as a 14% increase in staff who do not identify as white. Moving forward, our focus is to increase the recruitment of BAME staff, and to better support the career development of existing BAME staff and students.

Our active EDI committee provides representation on all senior committees. Institutional EDI practices include training on unconscious bias, gender equality, best interview practices and gender fluidity awareness as well as clear guidelines on inclusivity within committees, family-friendly working practices and data scrutiny on degree classification, promotions and staffing recruitment and seniority. All UCL-SoP staff undertake EDI training as part of the MPharm accreditation by the General Pharmaceutical Council. Local best practices include:

- UCL-Eastman extended Athena SWAN Action group to consider all aspects of EDI across all staff and students
- UCL-SoP established a BAME subgroup to the EDI committee immediately attracting over 40 volunteers
- UCL-Eastman runs unconscious bias training programmes and has extended externally-sourced unconscious bias and EDI training (by national groups – Goss consultancy) to all students
- **Uchegbu** and **Ali** are active members of the UCL Race Equalities Group
- **Uchegbu** is also the Provost's Envoy for Race, a formal UCL leadership position.
- The Pharmacy Schools Council published a national BAME support policy drafted by **Craig** and Brown (UCL-SoP Principal Teaching Fellow)
- The unit supports one of the very few black female professors in the UK (**Uchegbu**, highlighted in Nature Career Feature 'What does it take to make an institution more diverse?' 2018).
- UCL-Eastman (**Porter**) contributes to the UK Diversity in Dentistry Action Group.

#### 2.3.2 Sustaining and tracking success

The impact of our EDI work is monitored by annual staff surveys. Changes within UCL-SoP are overseen by the new coordinator of Wellbeing activities (**Lever**). The UCL-Eastman Athena SWAN (now EDI) group is overseen by **Parekh** and the Institute Manager. UCL-Eastman won Athena SWAN Silver status in 2015 (extended to 2021) and UCL-SoP achieved Bronze status in 2014 (extended to 2022).

#### 2.3.3 Supporting flexible working

The unit supports staff working flexibly, both to allow them to work in different environments such as collaborating universities or companies, and to support staff with family and other commitments. Examples include **Wong** (0.2 FTE with Hong Kong University), **Della Pasqua** (0.5 FTE with GSK), **F Smith** (0.6 FTE), **Mills** (0.6 FTE). The success of this support is underscored by **Franklin** who on a 0.2 FTE contract (with Imperial College Hospital Trust) is leading one of our Impact Case Studies. The unit is supportive and flexible for welcoming staff back from individual and shared parental leave (which has no qualifying length of service requirements), including phased returns, realistic workload expectations and supporting progress towards promotions.

We support integration of practice and clinical contracts with research. We have 12 GPhC registered pharmacists, 9 teaching practitioners, 12 NHS secondees, and 28 GDC registered dentists providing activities to the NHS, 24 (86%) of whom are specialists and/or NHS Honorary consultants. Two staff are also GMC-registered and provide research training to NHS medical trainees and undergraduates.

#### 2.4 EDI considerations in preparation of this REF submission

One of our principal objectives in preparing our submission was to ensure that all staff, regardless of background, were equitably represented. Staff were invited to submit their best outputs and, to minimise the influence of bias, these outputs were reviewed by at least two members of a panel selected to be representative of the diversity of our staff population (33% female, 20% non-white). Equalities analysis carried out by the UCL REF team provides evidence that our approach has been successful, with BAME staff being more likely than white staff to have an output attributed to them (1.03 vs 0.89 probability), and increases were seen for both BAME men and women. The results for women were slightly less encouraging, however, with the likelihood of output attribution being 0.83 for women and 1.13 for men. We will feed this information into the ongoing implementation of our Athena SWAN action plans and, in particular, investigate whether success is correlated with any of our interventions e.g. leadership training (§2.1.2).

### 3. Income, infrastructure and facilities

#### 3.1 Income summary

The unit has been awarded £39M in competitive research income since 2014 plus an additional £8.2M in consultancy funds. Research income is from diverse sources including Research Councils (£13M), charities (£3M), industry (£6M), government bodies (£13M) and other sources (£4M).

Examples of major funding successes include:

- Two Centres for Doctoral Training (EPSRC contribution £11M) outlined in §2.2
- European Commission: The Discoveries Centre (£3.8M) **Knowles**
- MRC DPFS award for Gene therapy in epilepsy (£1.8M) **Schorge**
- EPSRC grant to support the Centre for Nerve Engineering in collaboration with UCL Mechanical Engineering (£1.1M) **Phillips**
- EPSRC grant for Raman nanotheranostics (£1M) **Uchegbu**
- NIHR for new dental restorations (£0.97M) **Young**

The overview is in §REF4b; here we focus on how the environment has promoted the generation of income and funded research.

#### 3.2 Support from UCL for research funding, impact and best practice

The UCL community provides a broad network of support, close links to major funding sources and opportunities for commercial and clinical funding. The SLMS Research Facilitators provide directed support to staff in the effective preparation of grants and fellowships, including support letters, internal peer review and mock interviews. UCL Research Services facilitates all external grant applications, including providing alerts for opportunities, specific support for Fellowships and large programme grants, costing and financial management of grants. The unit's finance officers assist with costing and monitor our internal peer review system (a requirement for submission) to ensure best practice.

We support and accelerate commercialisation, including patent protection and/or licensing, through UCL Business; one of the UK's largest and most successful technology transfer companies), which provides dedicated professional support to researchers to develop, protect

and exploit IP. Many of our collaborations involve funding beyond basic research and within UCL this work is supported by strategic funding schemes:

**Translational funding.** The Translational Research Office funds research transitioning towards clinical or commercial realisation, including internal proof-of-concept funds (Therapeutic Acceleration Awards, TAS), and the EPSRC Impact Acceleration Account (for previously funded EPSRC research). TAS funding supports translational concepts, with >£200k awarded to the unit, including funding to: optimise nerve engineering work, translate gene therapy for rare diseases, and 3D printing of implantable devices. Internal funding is focussed on generating pilot data for applications to external funders such as the MRC Developmental Pathway Funding Scheme. We currently hold three DPFS awards (representing a total of £3.3M funding), and have had an additional award (£2M) since starting the new REF period.

**Venture Funding**, including the Apollo Fund (£40M available) and the UCL Technology Fund (£53M), supports research projects close to commercialisation. These funds provide support to bridge the gap between basic research and industrial funding. Examples of such funding within the unit include £1M from the UCL Technology fund interrogating lead nucleotide targets in pancreatic cancer (**Neidle**), and £500k from Apollo to develop gene therapy for Gaucher disease (**Rahim**). The UCL Technology fund also supports spinouts: an initial £120k investment in Glialign (**Phillips**) has allowed the spinout to progress to a further funding round (in progress). The momentum in this area is evidenced by >£3.5M invested since the start of 2020 by the UCL Technology Fund in three projects with partners in the unit (**Phillips, Rahim, Schorge**).

**Consultancy** UCL Business and UCL Consultancy are instrumental in assisting with the establishment of spinouts and major consultancy activities (£8.17M to the unit since 2014), including the joint (pharmacy, dentistry and medicine) project with New Giza University (§4.1.1).

### 3.3 Research governance

UCL has a set of research governance policies, detailed in REF5a, that underpin expectations about the conduct of research. The Code of Conduct for Research articulates UCL's expectations and defines action to be taken if an individual is suspected or accused of research misconduct. All issues relating to confidentiality and security in the use of patient and participant data fall under UCL's Data Protection policies and the Data Protection office provides extensive training, guidance, and support.

### 3.4 Facilities and infrastructure

The two main facilities for UCL-Eastman and UCL-SoP (described in §1.1 & §1.2) are complemented by additional hubs supporting specialised research needs. We have access to a number of central sources of funding for the infrastructure required for research, including direct support of facilities (£49M since 2014), and awards through a central Capital Equipment Fund (£1M since 2014) to purchase specialised equipment.

#### 3.4.1 New infrastructure at the UCL-Eastman

Since 2014 UCL has invested £32M in relocation and new infrastructure for UCL-Eastman to support and extend research capabilities. Clinical trials and translational research have been enhanced by the establishment in 2020 of a research facility within the Rockefeller building (and by close apposition to UCLH Eastman Dental Hospital) that includes 8 fully equipped clinical rooms, all with disabled access, a biobank within a dedicated laboratory for the processing and storage of clinical samples (including new medicinal products relevant to tissue engineering, cell and gene therapies) and new on-site imaging facilities including Cone Beam Computed Tomography (CBCT) and Ultrasonography. UCL-Eastman also negotiated ring-fenced facilities within the new £100M UCLH Eastman Dental/ENT Hospital for clinical research.

The construction of an innovative joint imaging facility at the Royal Free Hospital, led by UCL-Eastman Department of Biomaterials and Tissue Engineering, will consolidate existing facilities within the Department with those of the UCL Division of Surgery. An additional investment of ~£300k to install a new state of the art FE-SEM confocal and AFM-Raman microscope systems capable of TERS imaging enhances opportunities for several SoP groups (e.g. **Phillips, Harvey**) as well as those of UCL Surgery and Interventional Sciences and Medicine (returned in UoA1).



Research is supported at the Royal Free site by significant upgrades including: investment in three Category 2 laboratories, a new chemistry and characterisation laboratory, a new tissue culture facility and significant new imaging capabilities in a dedicated suite.

The Dental Public Health Group offices have recently been extensively refurbished to upgrade the teaching and research facilities.

### **3.4.2 New infrastructure at UCL-SoP**

Since REF2014, ~£17M has been invested in upgrading UCL-SoP facilities, including improvements to infrastructure, refurbishing research laboratories, and upgrading the dedicated animal facility (BSU) based within UCL-SoP to provide one-way flow and individually ventilated cages (IVCs) for animals. Central capital equipment funding supports specialised research, including: enhanced imaging for live cells using a Zeiss LSM 980 with Airyscan 2 capable of super-resolution imaging (down to 120nm). UCL-SoP also purchased two EVOS® FL Imaging Systems which are integrated digital systems for four-color fluorescence and transmitted-light applications. This live cell imaging complements an enhanced electron microscopy facility including AFM, TEM, and SEM microscopes with technical support.

Growing success in research into applications of 3D printing for drug formulation and delivery is supported by 3D printing equipment; in addition to the bespoke printers in individual labs, a core facility featuring an Aether 1 Bioprinter that processes 24 materials simultaneously. Altogether there are ~40 3D printers available in UCL-SoP and two Form 3 printers.

Drug discovery and pharmaceuticals are supported by suites of analytical equipment that are managed by dedicated senior technical staff. This includes two LCMS analytical and preparative systems for mass directed purification from mixtures of compounds in solutions (£127k each), a Microscale thermophoresis instrument (£120k), and a Horiba XploRA Plus Raman Microscope coupled with Omegascope optical platform for SPM (£150k). These investments complement our existing suite of HPLC systems, mass spectrometry facility, shared x-ray diffractometer suitable for small molecule and protein work, as well as essential fume hoods, centrifuges and imaging equipment.

### **3.4.3 Access to extensive institutional specialist research facilities**

Equipment purchased within UCL is available to all staff through the UCL Research Equipment Catalogue providing access to >1800 pieces of shared equipment (mostly above £25,000 in value). In the assessment period we have also sought to transform our shared research facilities (space, equipment and technical expertise) and to improve the career structure and support for our technical workforce. We have done this by launching an initial eight Science Technology Platforms (STPs): Genomics and Sequencing; NMR Spectroscopy; Mass Spectroscopy; Biological Services; Imaging; Radiochemistry; Cell Sorting. STPs have academic and technical leadership who provide strategic oversight of the services offered, its equipment and its technical support needs. STPs are subject to rigorous annual review and accountability, after which strategic goals are prioritised for funding.

Two examples of how UCL resources support our objectives are:

- Our gene therapy in epilepsy studies use the world-leading wireless telemetry facilities based at Queen Square Institute of Neurology (total cost: >£100k). This facility allows 24/7 EEG-video recordings of rodents (mice and rats) in their home cages for up to six months in randomised, blinded pre-clinical studies of treatment efficacy. All EEG and video data are uploaded and stored on UCL's Research Data Storage Service (§REF5a).
- Our research studying biophysical processes, including studies of DNA and peptides which are informing our design of new medicines, uses the ONI nanoimager co-owned with the London Centre for Nanotechnology (cost >£250k). This equipment enables single molecule fluorescence studies of labelled biomolecules with excellent spatial (~10nm) and temporal (milliseconds) resolution in a range of physiologically relevant environments (in solution, membranes and living cells).

#### 4. Collaboration and contribution to the research base, economy and society

##### 4.1 Contribution through collaboration

Collaborative research is at the core of our unit's approach. Data contributing to this section were gathered in a survey of UOA3 staff in August 2020. 76% of staff collaborated internationally with academic colleagues and institutions; 79% of staff were involved in collaborative research projects with academic colleagues in other institutions in the UK, many involving shared funding or co-supervised PhD students and 63% of staff have collaborators from different disciplines. 62% of staff collaborate with industry, commercial entities and third sector partners. External collaborations are supported through honorary positions. On the census date, 110 honorary research positions were held in the unit.

##### 4.1.1 International collaborations

Larger strategic collaborations include participation in the PharmAlliance Partnership that brings together researchers based at schools of pharmacy at UCL, Monash and the University of North Carolina. Major long term funded collaborations are established with Dankook University (**Knowles**) and supported by joint appointments e.g. **Wong** (Hong Kong University). We have created new Pharmacy and Dentistry Schools at New Giza University, Egypt.

We have a broad and successful portfolio of EU-funded collaborations through the FP7 funding stream (Transit, EpiTarget, CloSed, EpiMiRNA, GRIP, PERS), H2020 programmes (Infradev, conect4children, BATCure, EPTRI, BISON) and the EU Marie Skłodowska-Curie training networks. The Newton fund provides collaborative links with Thailand (**Wong, Taylor**) and Vietnam (**Chau**). Funded collaborations in emerging countries include: partners in Guatemala (**Heinrich**), Sri Lanka (**Williams**), Brazil (**A Smith**) and a strategic partnership fund with IITD-Delhi India (**Parhizkar**). These are in addition to our extensive links with USA, China, European and Middle Eastern partners, which are led by individual PIs. Twenty-two staff hosted international researchers in the REF period, ranging from established investigators to PhD students from countries such as Thailand, Brazil, India, Japan, Korea and Italy.

##### 4.1.2 Interdisciplinary collaborations

Interdisciplinary collaborations across UCL's partner hospitals are central to our strategy of translating our research into improved pharmaceutical and oral healthcare. These include collaborations with the UCLH Eastman Dental Hospital (six staff), Great Ormond Street Hospital (four staff), the Royal Free Hospital and The National Hospital for Neurology and Neurosurgery, Queen Square (five staff).

We collaborate with engineers within UCL and externally. These activities are often supported through funding streams where interdisciplinarity is encouraged e.g. EPSRC. Collaborations span the engineering disciplines including; Chemical, Electrical, Fluid, Mechanical, Medical and Tissue Engineering. Staff also reach across boundaries to develop and deliver new treatments through *in silico* research where there are growing collaborations with computational, mathematical and modelling experts.

Less traditional collaborations include the European Space Agency (**P Taylor**) and Kew Science – Kew Gardens (**Heinrich**).

##### 4.1.3 Collaborations with industry

Building close links to industry partners is a core objective for the unit (§1.4.2), and we support collaborations ranging from large pharmaceutical, biotechnology or engineering companies to smaller local community pharmacies. Examples with larger multi-national corporations include: Astra Zeneca (**Chau, Haider**), GlaxoSmithKline (**Lane, Todd, Della Pasqua, Spratt**), Merck (**Woon**), Pfizer (**Tuleu, Browne, Craig**), Procter and Gamble (**Lane, D'Aiuto**), Unilever (**Hunt, Lane**).

We collaborate extensively with small-medium sized enterprises (SMEs) such as Cerner (**Franklin**), GW Pharmaceuticals (**Ruiz, Ali**), Hygiene International Ltd (**Ng**), Minerva Research Labs (**Orlandi**), Santen Pharmaceutical (**Brocchini**), Southern Implants Company (**Petridis**).

Further collaborations reaching outside the biomedical space include Blockchain Systems (**Heinrich**) (sustainable sourcing of natural products), Cambridge Reactor Design (**Browne**), Dyson (**Knowles**), Rakuten (**Hopper**), Team Consulting Ltd (**Chau**).

## 4.2 Evidence of interactions with key research users, beneficiaries and audiences

### 4.2.1 Contributions to the economy

Research from UCL-SoP and UCL-Eastman has made significant contributions to the UK economy. 23% of staff (19) had patents awarded (or approved) with some staff holding multiple patents (up to ten). 6 have licenced patents (often more than one). Through UCLC, 27 staff are engaged in consultancy.

### 4.2.2 Spinout companies

Our researchers have commercialised research through the formation of 13 spinout companies during the assessment period, including:

- **Intract** awarded £1.4M from Innovate UK to develop a scalable manufacturing process for novel oral antibody products using its proprietary Soteria® technology (see **Basit** Impact Case Study)
- **Nanomerics** spinout: 2016 APS Innovative Science Award and Royal Society of Chemistry's 2017 Emerging Technologies Award
- **Keregen Therapeutics Ltd** was started through the European OneStart competition in 2014 (a bio-entrepreneur competition)
- **senCeutics Ltd** is a services-based spin-out company to provide specialist pre-clinical and clinical human taste evaluation models
- **Optceutics** uses a dynamic ophthalmic pharmacokinetic model to develop intravitreal injection and implant based biologic and pharmaceutical products

### 4.2.3 Translation of research towards patient benefits

Translational research represents a significant strength for both pharmacy and dentistry. Clinical academics at UCL-Eastman have developed a large portfolio of NIHR-adopted studies with a focus on complex experimental medicine clinical trials, directly supporting the UCLH BRC Oral Health & Disease Theme. Over the last 5 years these unit staff have recruited 4 times more patients (1257 vs 304) than our nearest UK comparator, the NIHR BRC Oral Health Theme at Guy's Hospital - a difference of 122%, and presently have a portfolio of 19 trials funded by NIHR, MRC, Versus Arthritis and other charities. Trials cover a broad range of healthcare needs including devices (e.g. SALRISE), delivery systems (DERMTREAT), repurposing of drugs (e.g. SAVER and PIT-STOP), and probiotics (e.g. CABRIO). 20% of staff were awarded translational research funding in the REF period (Total >£6M).

## 4.3 Contribution to society via engagement with wider audiences

Staff in the unit (74% in total) developed relationships with many beneficiaries or audiences outside the university sector, including cultural organisations (e.g. museums, art galleries), schools, the media, patient groups, local communities. These activities include: media coverage, exhibitions, open days, public lectures, community-based teaching, student mentoring/work placements, and the involvement of the public in developing research.

### 4.3.1 Working with schools and education professionals

Examples of events in schools include British Science Week 2020 where 439 children and their parents consented to taking part in two academic research studies on the comparison of children and adult's sensitivity to bitterness (**Tuleu**). **Tuleu** also designed and ran a study aimed at supporting the use of a swallowing aid (PillGlide), following guidance from a young patient with HIV at Great Ormond Street Hospital for Children (GOSH). **Todd** led open source work on new medicines for mycetoma (a fungal infection) with 6<sup>th</sup> form students from Sevenoaks school (Royal Society partnership funding). **A Smith** and **Spratt** have established a 3-year oral

microbiome and health study with Haileybury School (Hertford, UK) years 7-11 (ages 11-16). The importance of antimicrobial resistance was promoted by **Allan** via “Biology4all” programme in schools, whilst **Heilmann** and **Watt** were commissioned by NSPCC Scotland, Children 1st, Barnardo's Scotland and the Children and Young People's Commissioner Scotland to produce a report that was pivotal for banning smacking in Scotland. Overall 33% (26 staff) participated in career talks in schools, with many presenting repeatedly over the assessment period.

#### 4.3.2 Public engagement and the media

In response to the significant interest in our research among both patients and the public, we developed an approach ensuring the effective communication of new findings to these audiences. We work with the UCL Media Relations office and the press offices of funding organisations (e.g., MRC, Wellcome) so publication of important findings is linked to press releases and media contacts.

We track and record the media coverage of our research. Our staff appear regularly in print and broadcast media, and during the period ~30% of staff have been on major national and international channels, among them BBC1, BBC2, ITV, C4, C5, CNN, and German and Indian channels/radio, and all major print media (e.g., Guardian, Times, NY Times, Reuters, Evening Standard, Daily Mail).

Unit staff have organised national and international events open to the public to disseminate research, including: “The Age of Anxiety” (**Jovanovic, Mercer**), a UCL-wide public engagement event held at the Wellcome Collection in London, engaging the public in discussions of anxiety disorders; “Death for life” exhibition (Royal Institution, London, UK, **Teshima**); “Future pharma” panel (Royal Institution, London, UK, **Uchegbu**).

Unit staff have delivered talks to public bodies including Parliament (**Buanz, Hunt**), Royal Institution (**Uchegbu, Tuleu**), Royal Society Summer Festival of Science/Science Exhibition (**Allan, Schorge, Teshima**), Cheltenham Science Festival (**Teshima**).

These activities have received awards in multiple occasions including the UCL Provost's Award for Leadership in Public Engagement for 2017 (**Needleman**), and helped us secure new funding to engage external audiences (e.g., Royal Society partnership funding, EPSRC/UCL-Trellis 2020-21 award).

Finally, we encourage staff to use social media to engage with the public, and staff are active on Twitter, Facebook, Instagram and LinkedIn, as well as exploiting dedicated websites/blogs.

#### 4.3.3 Engagement with patients and end-users

We work with patient populations to solicit their input on our research questions. **Leeson** co-leads focus groups for temporomandibular disorders patients to develop PROMS (patient related outcome measures) and PREMS (patient related experience measures); **Whittlesea** leads three NIHR-funded research studies (CHAMP-1, CHEMIST, ADAM) which include patients and patient groups; **K Taylor** chairs the stakeholder consultation groups (including patient groups) of the Commission on Human Medicines (CHM)/MHRA that inform decisions on medicines legal classifications; **Needleman** developed a co-production team on diabetes-gum health research with community members.

Staff also present their research to patients and carers. Examples include ARUK Oxford Research Dementia Day (**Ali, Manzoni**); Diabetes UK support group Science talks (**D'Aiuto**). Staff have authored guidelines for patients (e.g., Ehlers-Danlos syndrome, Lupus UK and Epidermolysis Bullosa. **Porter**).

#### 4.3.4 Researchers engaging with art

Staff in the unit use art as a medium to convey scientific and medical concepts to the public. Examples include the EPSRC/UCL-Trellis 2020-21 award to work with artists Jane Watt and Sara Heywood, part of the UCL Public Art and Community Engagement strategy (**Chau**); the “Arts in Dentistry” exhibition project: *A dry and silent world: living with hidden disabilities* involved artists and researchers exploring dry mouth and hearing loss (Bush House, 2019, **Teshima**), a

neuroscience & art exhibition based on research “Action Potential” (Swiss Cottage Library Gallery, **Ruiz**).

#### 4.3.5 Working with policy makers

We encourage staff to contribute their expertise to a range of national and international policymaking bodies, including:

- The Commission on Human Medicines: **K Taylor, Lane**
- The MHRA: **Tuleu, Knowles, Heinrich**
- NICE: **Wong, Needleman, Ashley, Horne, Watt**
- Public Health England: **Watt, Needleman, Hunt, D’Aiuto**
- Royal Pharmaceutical Society: **Craig, Horne, K Taylor, Bates**
- WHO: **Franklin, Tuleu, Tsakos, Bates, Franklin**
- International Pharmaceutical Federation: **Bates, Franklin, Horne**
- World Dental Federation: **Tsakos**
- British Pharmacopoeia Commission (Chair), and Leader of the UK Delegation to the European Pharmacopoeia Commission: **K Taylor**.

#### 4.4 Indicators of influence and recognition, and overseeing research

67% of staff have been elected or appointed to influential bodies, including learned societies and academies (33 members of staff), professional bodies (32 members of staff), and national or international research committees or boards (18 members of staff).

Examples of these appointments include:

- Dean of the Faculty of Dentistry of the Royal College of Surgeons of Ireland (**Leung**)
- Dean of the Faculty of Dental Surgery of the Royal College of Surgeons of England (**Hunt**)
- Chair of the Pharmacy Schools Council (**Craig**)
- Fellow of the Royal College of Surgeons of England (**Hunt**)
- Eminent Fellowship of the Academy of Pharmaceutical Sciences (**Heinrich**)
- Chair of the Oral Microbiology and Immunology Group of the British Society for Oral and Dental Research (**Spratt**)
- British Orthodontic Society Chair for research funding in Orthodontics (**Ryan**)
- National Deputy Lead NIHR specialty role (**D’Aiuto**)
- Chair of the Platform for Better Oral Health in Europe (**Tsakos**)
- Chair of working group for European Society of Paediatric Dentistry to develop international guidance on sedation in dentistry (**Ashley**)
- Honorary Secretary of the European Orthodontic Society (**Cunningham**)

Our unit also includes many Fellows of: Royal Pharmaceutical Society (six in total), Royal Society of Chemistry (five in total), and Royal Society of Medicine (**Leeson**).

48% of staff have been awarded scholarly fellowships or related awards. Major honours/prizes awarded include: OBE in Queens Honours for services to Dentistry and Orthodontics, Honorary Life Membership of World Federation of Orthodontists (one of only 15 ever), and Honorary Membership of British Orthodontic Society (**Hunt**); **Uchegbu** was awarded a Doctor of Science honoris causa degree by Lincoln University for services to pharmaceutical sciences; Society for Ethnopharmacology India Life time achievement Award & International scholar in ethnopharmacology (**Heinrich**); Lifetime Achievement Award in clinical PDT (**Hopper**); IADR

Global Oral Health Distinguished Scientist Award, and Honorary Fellowship in Dental Surgery with Royal College of Surgeons (**Watt**); UKCPA Lifetime Achievement Award, and the Royal Pharmaceutical Society Charter Medal (**Bates**).

#### 4.5 Contribution to sustainability of the research base

Staff contribute their time and expertise widely, serving on >35 national (Research Council or similar) or international grants panels (21 staff), whilst 75% of staff participate in grant peer review, including: US NIH Rare Disease Panel (**Rahim**); Daphne Jackson Fellowship Panel (**Chau**); EPSRC Physical Sciences Grant Prioritisation And Fellowship Panels (Chair of both, **Uchegbu**); Pharmacy Research UK Award Panel (**Mills**); Human Brain Science Project Grant evaluation panel (**Shah**); NIHR Applied Health Research Programme Grants (**Watt**); European Orthodontic Society Grants Committee (Chair, **Cunningham**); British Orthodontic Society (Director of Research, **Cunningham**).

51% of staff gave invited keynote or plenary lectures (>60 during the census period), and 72 members delivered invited lectures. Examples include: Northcroft Lecture for the British Society (**Cunningham**); Menzies Campbell Lecture at the Royal College of Surgeons (England) (**Porter**); Bradshaw Lecture at the Royal College of Surgeons (England) (**Hunt**); plenary lecture at the World meeting of Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology (**Basit**).

53% of staff chaired conferences or scholarly meetings, and 52 are standing members of organising committees for over 20 conferences (e.g., Gordon Research Conferences; World Biomaterials Congress; European Orthodontic Congress; Pharmaceutics; Academy of Pharmaceutical Sciences); and 78% examined doctorates (>600 in UK, >150 abroad); 94% are involved in some aspect of refereeing/peer-reviewing, and 23 helped peer review of candidates for national or international senior appointments (e.g. Chairs, Institute Directors).

54% of staff serve on journal editorial boards of >40 different journals (49 members of staff), 37% in editorship positions [including Executive Editor of the *British Journal of Clinical Pharmacology* (**Della Pasqua, Wei**), Editor in Chief for: *Materials Highlights* (**Williams**), *BMJ Quality & Safety* (**Franklin**), *Pharmaceutical Nanotechnology* (**Uchegbu** and Editor for *Cochrane Oral Health* (**Needleman**)].

#### 4.6 Responding to national and international priorities and developing best practice

Our overall approach to research transparency and reproducibility is detailed in §1.7.

We are also providing international leadership in pharmacy schools worldwide via a research-driven, teaching-led 'Fight the Fakes' campaign (Pyzik) to improve reliability and reproducibility in medicines. Since 2019, this global campaign has involved or facilitated 34 presentations in 120 countries (of which 83 are LMICs) with 146 inter-governmental organizations and civil society groups, including the World Health Organization's 72nd World Health Assembly event in Geneva in a campaign against counterfeit medicines, hence delivering on our REF2014 Global Healthcare aim (§1.5.1).

#### 5.0 Concluding comments

The environment of our unit has advanced significantly since REF2014, supported by major investment in infrastructure. We continue to prioritise a vibrant, sustainable approach that supports our staff to solve problems affecting citizens and patients across the globe. We engage with industries and policy makers to maximise productivity, minimise public costs and deliver transformative benefit to individuals and communities.