

<b>Institution: Imperial College London</b>
<b>Unit of Assessment: UoA1</b>

## 1. Unit Context and structure:

### 1.1 Overview and context:

The strategy of Clinical Medicine at Imperial College London is to recruit and retain the strongest academic staff, train the next generation of research leaders, invest in discovery research and achieve the most efficient translation of our discoveries into clinical benefit. We are returning **488 researchers** (439.51 FTE) in UoA1, (from 406 (334.18) in REF2014, an increase of 24%FTE including **106 early career researchers** (ECRs) and 10 former staff who have made significant contributions to our research environment.

Since 2014, our researchers have spent **£953m of competitive research funding**, equating to **£310k per FTE/year**. Our **sustainability** is demonstrated by our staff age profiles, where 50% are <50 in our return, with 78% of all researchers in the Faculty of Medicine (FoM) being <50 years and where 30-39-year-olds form our largest age group (comprising 46.2%). Our **vitality** is reflected by our career development; 41 have been promoted to Professor since 2014, 48 to Reader and 22 to Senior Lecturer; of these promotions, 40% were female. We have also awarded over 1400 PhDs.

We strive to create a **supportive research culture**. Across FoM, we have a **53%/47% male/female** split with 26.1% of staff identifying as black minority ethnic (BME). To ensure **equality, diversity and inclusion (EDI)** is central to our mission, we have formed the **FoM Culture Initiatives Management Group (CIMG)**, [Chair – Lloyd, 2019]), reporting directly to the Dean, CIMG will create an inclusive culture and environment, shape strategies, policies and processes, and generate resources and improved signposting for students and staff at all levels and career stages. Since REF2014 we have re-organised the Faculty of Medicine (FoM) to focus more strongly on our thematic research (**Fig. 1**). We have created eight smaller departments (from five in 2014), specifically fostering mentorship and career development, and for the first time achieving a gender balance among our 8 Heads of Department. This reorganisation has enabled us to be more agile, to better support our staff and students, and to respond dynamically to the changing research landscape, demonstrated most notably in our coordinated response to the COVID-19 pandemic.

We have been investing in modern **purpose-built research facilities** and strategic **physical co-location** to promote interdisciplinary collaboration. Imperial College has invested approximately £2bn in the reorganisation of its estate since 2014, in order to focus its undergraduate campus at South Kensington and develop a new post-graduate campus at White City. Clinical medicine laboratories, which were still housed in 34 buildings over 5 clinical sites in 2014 will now be concentrated in our new research buildings on our Hammersmith Hospital and adjacent White City campus, bringing bio-engineering, data science and physical sciences immediately alongside clinical medicine and public health.

We recognise the importance of **working across academic boundaries** to facilitate interdisciplinarity across the FoM and whole College as key to our sustainability. This **interdisciplinary drive** has been recognised by a range of funders including: National Institute for Health Research (NIHR) **Biomedical Research Centre (BRC)** (£202m, 2012-2022) in partnership with Imperial College Healthcare Trust (ICHT); **Cancer Research UK (CRUK)** Major Centre in Convergent Science (£14m; Behrens, joint with Inst Cancer Research), Imperial Centre (£2.3m; Hanna) and Accelerator Award (£4.5m French [UoA9] and McNeish); The **British Heart Foundation (BHF)** (Imperial College Centre of Research Excellence, £4m Wilkins); **The Wellcome Trust** (£7.5m, multiuser equipment, biomedical resources and technology awards) and the **EPSRC** (£7.8m Artificial Intelligence in Healthcare doctoral training partnership). We were successful in our bid to lead **five NIHR Health Protection Research**

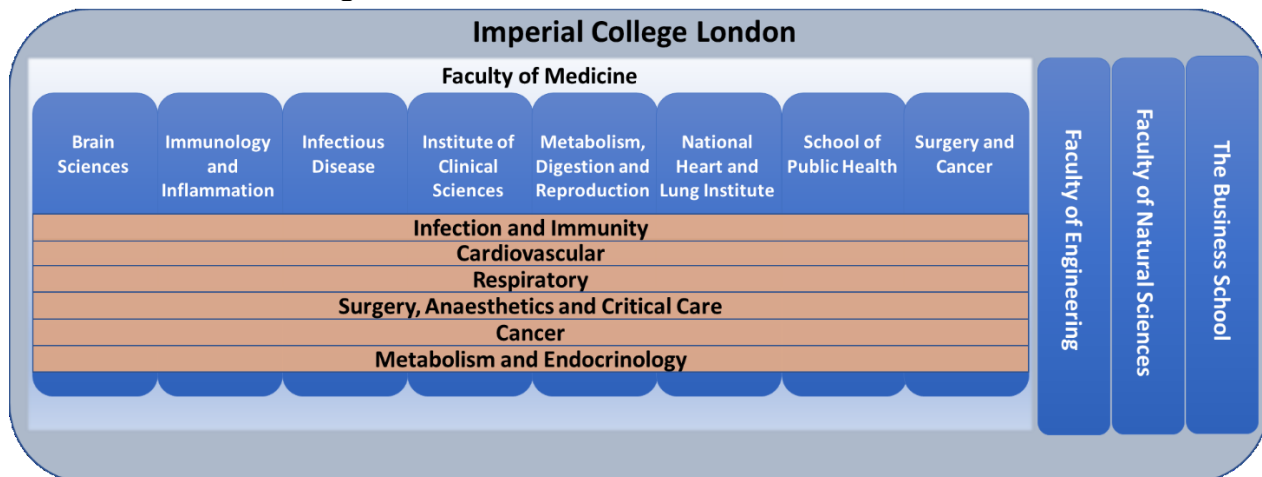
**Units (HPRUs)** at Imperial (£20m; Chemical and Radiation Threats and Hazards, Environmental Exposures and Health, Healthcare Associated Infections and Antimicrobial Resistance, Modelling and Health Economics, Respiratory Infections). In addition, we secured EPSRC Centre for Mathematics of Precision Healthcare (Barahona [UoA10]). To take maximum advantage of these interdisciplinary opportunities across FoM and the College, our clinical medicine research themes all share a core strategy of convergent science.

We partner with UKRI in the **MRC London Institute of Medical Sciences (LMS)**, embedded in our Hammersmith Hospital campus; we have co-invested with BEIS in building a new £105m LMS building, co-locating MRC and FoM scientists; 26 LMS scientists (24 of whom are returned in UoA1, two in UoA4) hold appointments in the FoM. Five investigators from Clinical Medicine have satellite laboratories in our partner **Francis Crick Institute** (Lloyd, Zhang, Barclay, Shenoy and Wilkinson) and seven Crick investigators hold part-time appointments in the FoM (O'Garra, Tybulewicz, Stoye, Reis y Sousa, Way, Cherepanov, Kassiotis). We have partnered internationally to build strong bilateral research and educational relationships to enhance our sustainability in a post-Brexit world; with Nanyang Technological University (NTU) in Singapore (establishing the **joint Lee Kong Chian (LKC) Medical School**, whose first 50 doctors graduated in July 2018), with Technological University Munich and with Massachusetts Institute of Technology.

Since 2014 we have also addressed global challenges through establishing College Institutes, Centres and Networks with intramural core funding. Two Imperial Institutes, **the Institute of Infection** (Co-Directors, Bangham and Baum [UoA5]) and the **Institute of Global Health and Innovation** (IGHI [Darzi]) are led from Clinical Medicine. We lead a further nine Centres and ten Networks, including the Centre for Antimicrobial Optimisation, the Centre for Paediatrics and Child Health, the Centre for Cardiac Engineering and the Centre for Translational Nutrition and Food Research and we are active participants in a further 14 Centres and 14 Networks.

**Partnerships** are key to sustaining our strategy for the longer term; our clinical translation is driven through our highly structured relationship with our NHS partners in West London via the Department of Health and Social Care (DHSC)-designated Imperial College **Academic Health Science Centre (AHSC)**. Since 2014 we have expanded the AHSC to include the specialist postgraduate Royal Marsden and Royal Brompton (until Feb 2021) hospitals, Chelsea and Westminster Hospital and the Institute of Cancer Research (ICR). This enables us to align strategies and maximise our impact. Our closer strategic relationship with ICR has underpinned and enabled our successful joint CRUK Major Centre in convergent science in 2018 (Director, Behrens).

Our research structure has allowed us to respond with agility and pace to new challenges, best reflected in our research response to the COVID-19 pandemic (see below). We developed a SARS-CoV-2 self-amplifying RNA vaccine programme into phase II studies (Shattock); led the UK human SARS-CoV-2 challenge programme (Chui, Openshaw); led a major international clinical trial in critical care which has altered therapy globally (hydrocortisone, anti-IL-6, REMAP-CAP trial, Gordon, see impact case studies), translated a novel point-of-care test into widespread uptake by the NHS (CovidNudge, Cooke, see impact case studies) and undertaken national population level anti-SARS-CoV-2 testing (REACT, Barclay, Cooke, Darzi with Elliott Riley and Ward [UoA2]).

**Figure 1. Imperial College London Faculties, structure of the Faculty of Medicine and associated cross-cutting research themes**

Research in clinical medicine reflects Imperial College's academic strategy to deliver transformative impact for societal benefit on a global scale. It draws on our ground-breaking discovery science to generate new knowledge on disease mechanisms and translate this knowledge into new treatments and preventive strategies to enable change for a healthy society. Sitting within the FoM at Imperial College, to fully deliver the College's and the Unit's strategy, Clinical Medicine is returned in six themes, each with a critical mass of researchers spread across all eight departments (**Fig 1**).

- Infection and immunity (98.4 FTE)
- Cardiovascular (73.5 FTE)
- Respiratory (63.8 FTE)
- Surgery, anaesthetics and critical care (66.0 FTE)
- Cancer (46.7 FTE)
- Metabolism and endocrinology (91.2 FTE)

ECRs denoted by *italicised text* throughout.

### 1.1.1 Infection and Immunity theme:

**Number of highly cited outputs:** 17 outputs over 200 citations, 7 outputs over 300 citations, 5 outputs over 500 citations, 4 outputs over 600 citations including 2 over 800 citations. Our reach is demonstrated by publishing in specialist journals (e.g. Lancet Infect Dis [11], Nature Immunology [7]) as well as general medical and scientific journals (e.g. NEJM [13], Nature [18], Science [14]).

**Key centres:** Institute of Infection (Bangham), MRC Centre for Molecular Bacteriology and Infection (CMBI, [Holden to 2019; Penades]); NIHR HPRU in AMR and Healthcare Acquired Infection (Holmes); Centre for Infection Prevention and Management (Holmes); Centre of Excellence for Antimicrobial Optimisation (Holmes); IAVI Human Immunology Lab (Gilmour, Professor of Practice); DHSC/EPSC Future Vaccine Manufacturing Research Hub (Shattock); the London BioFoundry (Freemont); the UKAS-accredited Molecular Diagnostic Unit (Taylor);

**Research income (pro-rata): £213m**

**FTE:** 98.4

**Number of ECRs:** 27 (*Aylett, Bellos, Bidmos, Cucunuba Perez, Davies, Edgar, Gibani, Hill, Hogan, Lai, Li, McCarthy, Medjeral-Thomas, Nijman, Page, Pollock, Pons Salort, Predecki, Riglar, Rodriguez Manzano, Sarkisyan, Short, Unwin, Vaubourgeix, Verity, Warnecke, Willicombe*)

Infection and Immunity research at Imperial aims to integrate fundamental pathogen biology with human immunity and clinical medicine to treat or prevent diseases of global importance. We aim to integrate understanding of infectious disease from microbe to human to populations as

well as immune processes such as autoimmunity and inflammation. Together with our infectious disease epidemiology theme (**UoA2**), we represent one of the largest groupings of infectious disease researchers globally. In parallel, our immunology and inflammation researchers focus on the discovery of the fundamental immunological mechanisms underpinning responses to organ damage, especially in the kidney and skin, and how to translate them to advance molecular medicine.

In 2020 we launched a multidisciplinary, interfaculty **Institute of Infection (IoI)** at Imperial College. The IoI brings together the expertise and experience of clinician scientists and basic biologists with scientists in chemistry, physics, engineering and mathematics. In addition to integrating our clinical and basic research, a key purpose of the Institute is postgraduate training, with a focus on mentoring and multidisciplinary postgraduate courses to equip students from widely diverse backgrounds to be leading researchers on infection.

*Research achievements since REF2014:*

- **Bacterial pathogenesis:** Internalization of *Salmonella* by macrophages induces formation of non-replicating persisters (Science, 2014); EROS protein is essential for host defence (J Exp Med, 2017); role for the lymphatic system in the metastasis of invasive *S pyogenes* (Nat Commun, 2020); and structural insight into how a sigma factor blocks entry of DNA template into the RNA polymerase active site in transcription (Science, 2015).
- **Viral pathogenesis:** Identification of ANP32A as an essential host partner to support influenza virus replication (Nature, 2016, 2020); viral targeting of the molecular circadian clockwork (PNAS, 2016); HIV drug resistance and the structural basis of second-generation HIV integrase inhibitor action and viral resistance (Science, 2016, 2020).
- **Paediatric infections:** the DIAMONDS project (Diagnosis and Management of Febrile Illness using RNA Personalised Molecular Signature Diagnosis), has identified a novel two-gene transcription signature in children that can distinguish bacterial from viral infection (JAMA, 2016); host transcriptional patterns to diagnose paediatric tuberculosis (NEJM, 2014, and review NEJM, 2020).
- **Global Health:** PopART trial demonstrates impact of HIV Universal Test and Treat to reduce HIV incidence (NEJM, 2019); RIVER trial of HIV eradication (Lancet, 2020). The Transfusion and Treatment of Severe Anaemia in African Children Trial established best practice (NEJM, 2019); machine learning to refine efficacy estimates of dengue vaccine (Nature, 2018).
- **Viral oncogenesis:** First method to detect pre-malignant clones of T-cell leukaemia in patients with chronic HTLV-1 infection years before disease onset, being developed as a target for early diagnosis and supporting interventional clinical trials (Blood, 2020).
- Novel roles of the **innate immune system** in neoangiogenesis and mitochondrial metabolism (PNAS, 2014; Science, 2018); how the immune system regulates induction of tolerance to self-antigen by modulating intracellular processing of dying cells (Nat Commun, 2014); type 2 immunity in skin inflammation (Nat Immunol, 2018; Cell, 2018; J Exp Med, 2018) suggesting that anti-inflammatory targeting of the NF- $\kappa$ B signalling pathway in keratinocytes might be effective early treatment for skin inflammation.

*Progress against 2014 REF targets:*

- **Vaccines:** £10m EPSRC/DHSC Future Vaccine Manufacturing Hub launched in 2018 (Shattock and Shah [UoA12]); partner in the £66m Innovate UK Vaccine Manufacturing and Innovation Centre (Chair, Shattock); first ever early clinical trial of a vaccine for genital chlamydia, phase IIb PrePVacc HIV Vaccine efficacy trial (Weber, European and Developing Countries Clinical Trials Partnership, Euro 15m), and a £22m investment by UK Government to accelerate saRNA vaccine for COVID19 development (Nat Commun, 2020).
- Enhance **infection trials** capacity from phase I-III: we have built capacity for human infection challenge, conducting studies of RSV and influenza virus, and we lead the first ever challenge study world-wide of SARS-CoV-2.
- Extended our bacteriology centres with over £13m combined funding, including the NIHR HPRU in Health Care Associated Infections and Antimicrobial Resistance (established 2015, renewed 2020); the Centre for Antibiotic Optimisation; the second phase of the CMBI with >£2.3m funding from the MRC and the appointment of a new director (Penades).



*Research aims of the Infection & Immunity theme for the next 5 years:*

- **Pandemic preparedness**, building on our expertise in basic biology and host range determinants of emerging pathogens; with experience and facilities to work at containment level 3 *in vitro* and *in vivo*, and strengths in respiratory viruses with pandemic potential (influenza, coronaviruses), we are at the forefront diagnosing and responding to emerging pathogens; we shall expand our expertise to vector-borne viral infections.
- **Bacteriology and antimicrobial resistance**: development and optimization of precision antimicrobial therapies – grow our expertise in the molecular basis of bacterial physiology, pathogenesis and innate immune responses to bacterial infections, including the molecular and structural science that underpins the understanding of bacteria and their interactions with host; apply this knowledge to understand bacterial antibiotic resistance and develop innovative therapeutic and diagnostic strategies.
- **Vaccinology and Human Challenge**: capitalize upon our expertise in the application of RNA based technologies for the next generation vaccines through a Centre for RNA vaccinology – including expertise in related areas of RNA biology, cellular responses to RNA challenge, animal and human challenge models – to develop vaccines against a range of high profile infectious diseases and other vaccination targets.
- Towards curative therapy of **chronic viral infection** (in particular HIV, HTLV-1 and HBV), based on our expertise in the clinical application of novel strategies for cure of chronic viruses.
- Research to improve disease outcomes by understanding the mechanisms of **immune-mediated organ injury** – building multidisciplinary teams via our Centre for Inflammatory Disease, combining expertise in basic science in renal inflammation, skin immunology, complement and autoimmunity with translational research to achieve improved health impacts.

**1.1.2 Cardiovascular theme:**

**Number of highly cited outputs:** 20 outputs with over 200 citations, 12 outputs over 300 citations, 8 outputs over 400 citations, and 3 outputs over 500 citations. This includes one output with more than 1800 citations and one with more than 5000 citations. We reach as broad an audience as possible through publishing in specialist journals (e.g. *Circulation* (23 papers), *Journal of the American College of Cardiology* (9) and the *European Heart Journal* (6)) as well as general medical and scientific journals (e.g. *NEJM* [11], *The Lancet* [9] and *Nature* [11]).

**Key Centres:** BHF Centre for Research Excellence, BHF Centre for Regenerative Medicine.

**Research income** (pro-rata): **£159.2m**

**FTE:** 73.5

**Number of ECRs:** 19 (*Chowdhury, Foldes, Halliday, Keene, Khalique, Khamis, Lodge, Nilles-Vallespin, Nosedá, Paschalaki, Petraco Da Cunha, Ramasamy, Sattler, Shun-Shin, Srivastava, Taghavi Azar Sharabiani, Tayal, Vikhorev, Whiffin*).

Imperial College conducts world-leading cardiovascular research, from discovery science to highly impactful clinical trials in a multidisciplinary environment, recognised through continued designation as a **BHF Centre of Research Excellence** and renewal of the **BHF Regenerative Medicine Centre**. This theme comprises one of the UK's largest grouping of cardiovascular scientists and clinicians, an NIHR BRC theme, **8 BHF programme grants** (£9.2m), and a newly awarded BHF doctoral training programme. Our cardiovascular research strategy embraces convergent science, drawing on scientific expertise in disciplines across the College through formal cross-College Networks and Centres (a Vascular Science Network [Director, Haskard], a Centre for Cardiac Engineering [Director, Peters], a Centre for Vasculitis [Director, Mason] and a Microbiome Network [Lead, Dumas]) and an EPSRC-funded Centre for doctoral training in artificial intelligence (AI4Health). Research is predominantly conducted in our National Heart and Lung Institute (NHLI) and our associated NHS Trusts but extends across College to maximise its impact on cardiovascular health. This combination of expertise is highly sought after by pharmaceutical and devices companies, including Amgen, Bayer, Gilead, Medtronic, Pfizer, Volcano and Philips for our PI's unique skills and success in technology development.

*Key achievements of the Cardiovascular theme since REF2014:*

- **Pivotal clinical trials** to inform clinical management of cardiovascular disease: the SAMSON trial, TRED-HF treatment withdrawal in patients recovered from dilated cardiomyopathy, and long-term follow up of patients in the ASCOT trial (Lancet, 2018, 2019; NEJM, 2020).
- **New devices** for diagnosis and management of cardiovascular disease: high precision non-invasive, algorithm-based and patented technology for identifying optimal pacemaker settings (CRT TrueMax pacemaker optimisation method), Instantaneous Wave-free Ratio (iFR) and Ripple Mapping, forming impact case studies.
- **Deep-phenotyping patient cohorts** to reveal mechanisms of cardiovascular disease. e.g. identification of *titin* variants in health and disease (Nat Genetics, 2016); novel, rare and common variants in *SOX17* and *HLA-DPA1/DPB1* associated with pulmonary arterial hypertension (Nat Comms, 2018). As a result, genetic testing is now routine practice for all patients presenting with dilated cardiomyopathy and new genes have been added to the Pulmonary Artery Hypertension (PAH) panel.
- **Integrating cardiovascular imaging with genetic data** to develop innovative analytical tools for identifying causal relationships (Nature, 2020); *titin* variants as genetic risk factors for heart failure (Nat Genetics, 2017) and prediction of survival in patients with pulmonary hypertension (patent number GB1816281.8, Wilkins; Nat Mach Intell, 2019)
- Leading the **Cardiovascular NIHR Health Informatics Collaborative** and using routinely collected NHS data from five tertiary centres to identify novel risk factors that inform the management of patients with non-ST elevation myocardial infarction (Lancet, 2020).
- Established the only currently active UK programme to characterise intact human donor hearts deemed unsuitable for transplantation. This, coupled with large-scale single-cell and single-nucleus transcriptomes, has enabled a major contribution to the human cardiac cell atlas (Nature, 2020).

*Progress against REF2014 aims:*

- Developed a College-wide Vascular Science Network of Excellence and Centre of Excellence for Cardiac Engineering, within new laboratory space in the recently opened Biomedical Engineering Research Hub at White City. These broad partnerships contributed to the renewal of our British Heart Foundation Centre of Research Excellence.
- Delivered high profile clinical trials including establishing the FOURIER trial, long-term follow-up of the ASCOT trial and ORBITA trial.
- The Cardio-Oncology Research Initiative multi-centre programme was established to investigate the interaction between heart disease and cancer therapies and is now funded by the BHF, Leducq Foundation and CRUK.
- BHF Regenerative Medicine Centre was established leading to the ground-breaking publication of the human cardiac cell atlas.

*Cardiovascular theme plans for the next 5 years:*

- Remain at the forefront of digital, personalised cardiovascular health care integrating strengths across the College in Remote Monitoring, Bioengineering, Environmental Health, AI4 Health and Big Data Science.
- Work with our global networks and local communities to understand inequalities in the burden of cardiovascular disease. Global reach will be extended through partnership with The George Institute for Global Health UK, recently transferred from the University of Oxford and located to our White City campus, and locally, expand the LOLIPOP cohort of ~30,000 South Asians in North West London as part of the Wellcome Trust-funded S Asia Biobank (Kooner, [honorary], £5m) to identify novel molecular biomarkers underlying high risk of cardiovascular disease and diabetes in this population.
- Build on our multidisciplinary cardiovascular translational research hub in the new Sir Michael Uren Building on the White City campus, which brings together PIs from Bioengineering, Molecular Sciences, Data and Computational science and the School of Public Health (**UoA2**). It will incorporate our state-of-the art electrophysiology, remote monitoring and novel technologies programmes.

- Train the next generation of cardiovascular basic and clinical scientists through our BHF-doctoral training programmes (DTP), expanding intercalated BSc and Masters (MSc and MRes) courses, while establishing a new PG Certificate in Heart Failure.
- Consolidate cardiovascular investigators currently located across 5 West London sites onto the Hammersmith and White City campus by 2025.

### 1.1.3 Respiratory theme:

**Number of highly cited outputs:** 13 outputs with over 200 citations, 4 outputs over 400 citations, including 1 with over 1000 citations. We reach as broad an audience as possible through publishing in specialist journals (e.g. American Journal of Respiratory and Critical Care Medicine (AJRCCM) (37), Lancet Respiratory Medicine (14) and Journal of Allergy and Clinical Immunology (JACI) (30) as well as general medical and scientific journals (e.g. NEJM [9], Lancet [4], Nature [2]).

**Key Centres include:** MRC HIC-Vac Network in Vaccine Research & Development (Openshaw & Chiu); NIHR Health Protection Research Unit in Respiratory Infections (Lalvani); Asthma-UK Centre in Allergic Mechanisms of Asthma (Johnston); National Centre for Mesothelioma Research and the Asmarley Centre for Genomic Medicine (Cookson); Margaret Turner Warwick Centre for Fibrosing Lung Disease; NHLI Foundation Centre for Early Airways Disease; Three cystic fibrosis (CF) Trust Strategic Research Centres: EpiNet (Bilton & Carr [both honorary, RBH]), Personalised approach to Pseudomonas aeruginosa and Pseudomonas infection in CF (Davies)

**Research Income (pro-rata): £138.3m**

**FTE: 63.8**

**Early Career Researchers:** 14 out of 71 staff returned are ECRs (*Allsopp, Bernardino de la Serna, Bloom, Byrne, Farne, Fontanella, Fuertes, Lam, Molyneaux, Mumby, Nolan, Patel, Santos Amaral, Thwaites*).

Our aim is to develop improved understanding and better treatments for both common conditions such as asthma, chronic obstructive pulmonary disease (COPD) and respiratory infections; and rarer diseases such as interstitial lung diseases, CF, paediatric lung diseases and occupational lung diseases. This is enabled by working across multiple clinical sites (Hammersmith, St Mary's, Charing Cross, the Royal Brompton and Harefield Hospitals), and our strong ties with the pharmaceutical industry including a Strategic Alliance with Boehringer Ingelheim (Alton, Barnes, Donnelly, Griesenbach), GSK (Johnston, Asthma-UK Centre; Openshaw, Chilvers-EMINENT MRC consortium partnership), AstraZeneca (Belvisi) and the Early COPD Cohort with AstraZeneca, Boehringer Ingelheim (BI), Chiesi, GSK and Novartis (Donaldson, Wedzicha).

#### *Key achievements of the Respiratory theme since REF2014:*

- **Lung-microbe Interactions:** Mechanisms of viral exacerbations in COPD (AJRCCM, 2019) and asthma (JACI, 2019); viral respiratory immunology (Science, 2020); human viral challenge studies (Nature Med, 2017); understanding the respiratory microbiome and pulmonary disease (AJRCCM, 2015).
- **Early influences and disease trajectories across the life course:** Lung function trajectories and early life exposures (Lancet Resp Med, 2018); trajectories of allergen sensitisation (JACI, 2018); European collaboration on airways disease trajectories (AJRCCM, 2016, 2017) and leadership of international cohorts e.g. European Community Respiratory Health Study, Ageing Lungs in European Cohorts and Burden of Obstructive Lung Disease (BOLD) study.
- **Mechanisms underlying lung diseases:** Immunological mechanisms underlying lung diseases (J Exp Med, 2020; Science Immunol, 2018); biomarkers in idiopathic pulmonary fibrosis (IPF) (Lancet Resp Med, 2020) and the U-BIOPRED allergen sensitisation pattern and relation to severe asthma (JACI, 2020).
- **Adult & Paediatric therapy trials:** Design of trials specific for outcomes in children – CF trials (NEJM, 2018); biologics in paediatric severe asthma (Lancet Resp Med, 2019); respiratory syncytial virus (RSV) in infancy (AJRCCM, 2018); and in adults: COPD (NEJM, 2016; JAMA, 2016); novel therapeutics and biomarkers in IPF (Lancet Resp Med, 2018).

- **AI/Machine Learning/ Electronic Healthcare Records:** UNICORN (Unified Cohorts Research Network, Custovic MRC £2.3m) - integrating birth and patient cohorts with clinical trials in paediatric asthma; AI-driven analysis of CT findings in IPF (Lancet Resp Med, 2016); Electronic Health Record (EHR) data analysis in BREATHE - the Health Data Research UK Hub for Respiratory Health (PI Quint, £1.5m).
- **Environmental exposures & Occupational health:** Role of outdoor and occupational environmental exposures on respiratory health (Lancet, 2018); pollutant exposures and exacerbation of COPD (AJRCCM, 2019).

*Progress against 2014 REF targets:*

- **Infection:** Established and renewed the NIHR Health Protection Research Unit in Respiratory Infections (Lalvani, Zambon) and three national Centres investigating cystic fibrosis (Davies).
- **Mechanisms of disease:** Establishment of the National Centre for Mesothelioma Research, the Asmarley Centre for Genomic Medicine (Cookson); and the NHLI Foundation Centre for Early Airways Disease.
- **Therapeutics:** Established new multi-million-pound strategic partnerships with AstraZeneca and BI. Set up and lead three new cross-Faculty Networks and Centres: The Imperial Network of Excellence in Aerosols and Health, the Imperial College Centre of Excellence in Advanced Therapy Medicinal Products (ATMPs) and the Imperial College Network of Excellence in Microbiome research.

*Respiratory theme plans for the next 5 years:*

- **Drivers, determinants, and early detection:** Increase understanding of life course events to define susceptibility to, and onset of, respiratory disease through our strengths in digital health research, paediatric respiratory medicine, early viral and environmental exposures, lung immunology and cell biology. We aim to define the factors determining lung capacity and disease susceptibility, and those influencing respiratory disease onset and severity.
- **Exacerbation science:** Predict, prevent and treat respiratory disease exacerbations through harnessing novel technologies. We will focus on exacerbations with precipitating factors (viruses, bacteria and environmental factors) to develop novel therapies. We aim to define, recognize and treat (at a very early point) periodic and often frequent and severe exacerbations of asthma, COPD, bronchiectasis, cystic fibrosis and IPF.
- **Advanced Therapies:** Application of novel technologies and outcome measures for patients with severe respiratory disease, accelerating proof of principle trials. We will apply the engineering, immunology and physical science strengths at Imperial to improving the quality and length of life for patients living with advanced respiratory disease.
- **Lung remodelling and fibrosis:** Establish the Margaret Turner Warwick Centre for Interstitial Lung Disease, funded by the Rayne and NHLI Foundations focussed on lung remodelling and fibrosis across the life course. Funds already secured for immunology, cell biology, imaging, and trials via Wellcome Trust Senior Fellowship (Snelgrove), NIHR and MRC Programme (Jenkins), Wellcome Trust Investigator (Lloyd).
- **Development of interdisciplinary work:** We have advanced plans and funding in place to build a new Respiratory Science research facility on the Hammersmith Hospital Campus linked to our Cardiovascular sciences base and the MRC LMS, and adjacent to Imperial at White City.

**1.1.4 Surgery, Anaesthetics and Critical Care theme:**

**Number of highly cited outputs:** 11 outputs with over 200 citations, 5 outputs over 300 citations, including 1 over 1000 citations. We reach as broad an audience as possible through publishing in specialist journals (e.g. Ann Surg [15]) as well as general medical journals (e.g. NEJM [5], Lancet [6], Nat Med [2], JAMA [2]).

**Key Centres:** Surgical Innovation Centre, the Hamlyn Centre for Surgical Robotics, the Helix Centre (jointly with Royal College of Art), the Institute of Global Health Innovation and Centre for Health Policy, the NIHR London In Vitro Diagnostics (IVD) Co-operative.

**Total research income (pro-rata): £143.1m**

**FTE: 66**



**Number of ECRs:** 15 (Antcliffe, Boshier, Fiorentino, Jones, Judah, Kemp, Markar, Martin, Ni, Onida, Patel, Scott A, Scott G, Soni, Thompson)

The Surgery, Anaesthetics and Critical Care theme has expanded significantly since 2014 with the appointment of two new Chairs, five new Clinical Senior Lecturers and three Non-Clinical Senior Lecturers in addition to 15 ECRs, of whom five are women. The theme has played an internationally leading role in the COVID-19 pandemic, in particular, the assessment of steroids, immune sera and anti-IL-6 in critically ill patients (REMAP-CAP trial) and through the REACT programme. The theme hosts the largest academic Department of Surgery in the UK, generating practice-changing research on the management of peripheral vascular disease and venous ulceration. Theme researchers have played leading roles on the prevention and early diagnosis of both colorectal and gastrointestinal cancers, in partnership with the School of Public Health (**UoA2**), as well as the stratification of localised prostate cancer.

*Key achievements of the Surgery, Anaesthetics and Critical care theme since REF2014:*

- Led research that led to change in national **post-polypectomy surveillance colonoscopy guidelines** for those at risk of colorectal cancer, showing that a large proportion of post-polypectomy patients require less frequent colonoscopy surveillance than previously recommended. These findings will reduce colonoscopic surveillance workload by up to 80%. (Lancet, 2017; Lancet Oncol, 2017, see impact case study).
- Implementation of **surgical technology** to improve patient outcomes: use of rapid evaporative ionisation mass spectrometry in breast and cervical cancer surgery (JAMA Surg, 2017; PNAS, 2020); development of photonics with endoscopy for intra-operative imaging jointly with our Faculty of Engineering (Nat Comms, 2019); development of AI algorithms for improved detection of breast cancer (Nature, 2020) and sale of "HARK" clinical management tool to Google DeepMind.
- Development of **volatile organic compound (VOC) detection** in exhaled breath as a method to detect oesophago-gastric cancer (OGC); phase II trials showed that VOC detection has high diagnostic accuracy in OGC, with AUC of 0.85, sensitivity 80% and specificity 81% (JAMA Oncol, 2018).
- Led pivotal studies in **vascular surgery**, including demonstrating that early endovenous ablation of superficial venous reflux resulted in faster healing of venous leg ulcers than deferred ablation (NEJM, 2018) and that endovascular repair of abdominal aortic aneurysm has early survival benefit but inferior late survival, necessitating lifelong surveillance (Lancet, 2016)
- **Improving sepsis treatments:** assessed the effects of levosimendan and vasopressin in septic patients and identified gene expression signatures in peripheral blood leucocytes associated with good and poor outcome in sepsis (NEJM, 2016, JAMA, 2016); AI approaches to optimise treatment for sepsis (Nat Med, 2018).
- **Critical care research:** UK lead for the international [REMAP-CAP](#) study, an adaptive platform trial in Covid-19 pneumonia, including assessment of intravenous hydrocortisone (JAMA, 2020) and, separately, of two IL-6 receptor antagonists, tocilizumab and sarilumab, in severely ill COVID-19 patients.

*Progress against REF2014 targets:*

- Developed **translation research platforms** in surgery and led surgical clinical trials to translate these technology platforms into clinical practice, to reduce the trauma of access and transform endoscopic surgery from intra-cavity to endo- or trans-luminal surgery
- Made critical contributions to assessing **quality of surgery** in GI cancer trials (Lancet Oncol, 2015; Gut, 2015) as well as to quality of surgical training in laparoscopy (Ann Surg, 2015) and to monitoring surgeon stress in the operating theatre (Ann Surg, 2018), providing greater surgical consistency and higher surgical standards in prospective clinical trials and in both training and routine care.
- Adoption of **innovation into surgical practice:** Established **spin-out companies**, Embody (Cobb), surgical planning software to visualise and interact with 3D bone models and developing the H1 implant, the first ceramic on ceramic resurfacing arthroplasty in the world; and Mina Therapeutics has taken small activating RNA (saRNA) from laboratory to clinical

trial as a new class of anti-cancer therapeutics (Clin Cancer Res, 2020); established the **Centre for Performance Science** taking an interdisciplinary approach to investigating performance in surgery, in partnership with the Royal College of Music.

*Research plans of the theme for the next 5 years:*

- A **Centre for Critical Care Research** that will combine basic and translational science in organ injury with clinical trials in sepsis, building on the success of REMAP-CAP before and during the COVID-19 pandemic.
- Develop large scale studies of **volatile organic compound (VOC) detection** for at risk population to detect oesophago-gastric, colorectal and pancreatic cancers, aiming for regulatory approval and the introduction into routine clinical practice
- Expand **portfolio of clinical trials in surgery**, with particular focus on RCTs of surgical devices and novel surgical technologies, working with the Imperial Clinical Trials Unit (ICTU).
- Establish a new **Centre for Interventional Science** that will combine interventional radiology, surgery and bioengineering around a technology-focussed Clinical Research Facility in partnership with Imperial College Healthcare NHS Trust as well as industry.
- Establish a **Pan-London diagnostics ‘test-bed’** with MedCity, in collaboration with the Greater London Authority and the other two Academic Health Sciences Centres in London, enabling rapid evaluation and implementation of novel diagnostic methodologies and technologies.

### 1.1.5 Cancer theme:

**Number of highly cited outputs:** 14 outputs with over 200 citations, 9 outputs over 300 citations, 5 outputs over 400 citations including 1 output over 600 citations. Our reach is demonstrated through broad publication in specialist journals (e.g. Mol Cell [5], Lancet Oncol [6], Cancer Cell [4] as well as general medical and scientific journals (e.g. Lancet [5], Nature [11], Cell [5],).

**Key centres:** CRUK Convergence Science Centre (Behrens, held jointly with ICR), CRUK Imperial Centre (Hanna), Imperial Experimental Cancer Medicine Centre (Seckl, ECMC), the Ovarian Cancer Action Research Centre (McNeish), the Hugh and Josseline Langmuir Centre for Myeloma Research (Karadimitris), the MRC Comprehensive Cancer Imaging Centre (Aboagye).

**Research income** (pro-rata): **£101.2m**

**FTE:** 46.7

**No. of Early Career Researchers:** 8 from 56 (*Barozzi, Fletcher, Grech-Sollars, Iskander, Nijhuis, Salehi-Reyhani, Sarkies, Shenker*)

The Cancer theme incorporates laboratory and clinical research programmes with particular strengths in breast, ovarian, prostate, gastrointestinal and haematological cancers as well as clinical and pre-clinical cancer imaging. Cancer epitomises our convergent science approach at Imperial College, with research spanning all four Faculties. The theme also houses the world's largest centre for gestational trophoblastic disease research. There are major streams in the following areas: cancer evolution and adaptation, including genetic, epigenetic and immunological evolution; improved cancer detection and diagnosis using molecular imaging and pathology; and nuclear receptor signalling. There is a large clinical trials programme, with over 40 Imperial-led clinical trials in cancer open at any one time in addition to >100 multi-centre academic and commercial trials. The MRC LMS has cancer research embedded throughout its themes of epigenetics, integrative biology and genes and metabolism. The Centre for Haematology co-ordinates the largest clinical practice in Chronic Myeloid Leukaemia (CML) in Europe, focussing on molecularly targeted therapies, and houses the new Hugh and Josseline Langmuir Centre for Myeloma Research.

*Key achievements of the Cancer theme since REF2014:*

- **Discovery research**, provided deep understanding of the epigenomic and genomic landscapes of breast (Nat Med, 2018 [2]) and ovarian cancers (Nature, 2015, Nat Genetics, 2018), especially as they evolve in response to treatment.
- Greater understanding of **cancer-immune interactions** including key requirement for NKT

cells in the initiation of anti-viral B cell immunity (Cell, 2018), the role of aberrant tumour metabolism in immune evasion (Cell, 2015) and the importance of NK cells in recruiting dendritic cells into tumours (Cell, 2018).

- Developed potent **CAR19-iNKT cells** with dual targeting of CD19 and CD1d that have greater pre-clinical activity in diffuse large B cell lymphoma than conventional CAR-T cells (Cancer Cell, 2018)
- Progressed **two new anti-cancer agents**, developed at Imperial College, into phase I and II trials: the first-in-class GADD45 $\beta$ /MKK7 inhibitor DTP3 targets aberrant NF- $\kappa$ B signalling in myeloma and diffuse large B cell lymphoma (Cancer Cell, 2014) – the phase II trial, funded by MRC/DPFS will recruit in 2021; the first-in-class CDK7 inhibitor ICEC0942/CT007 (Mol Cancer Ther, 2018) entered phase I clinical trials in 2018 in collaboration with Carrick Therapeutics.
- Led **pivotal clinical studies** that have led to the licencing and regulatory approval of pembrolizumab for relapsed, chemotherapy-resistant gestational trophoblastic disease (Lancet, 2017), and rucaparib as treatment for patients with relapsed, *BRCA1/2*-mutated ovarian cancer who have had two or more prior lines of chemotherapy (Lancet Oncol, 2017)
- Demonstrated the accuracy of **multi-parametric MRI** (MP-MRI) in diagnosing clinically significant prostate cancer: when used as a triage test before first prostate biopsy in men with serum PSA  $\leq$ 15 ng/ml, MP-MRI reduced unnecessary biopsies by 25% and reduced over-diagnosis of clinically insignificant prostate cancer with improved detection of clinically significant cancer (Lancet, 2017).

*Progress against 2014 REF targets:*

- Embedded convergence and multi-disciplinarity into all aspects of research, facilitating development of machine learning algorithms to improve radiological diagnosis of ovarian (Nat Commun, 2019) and breast (Nature, 2020) cancers, and aid early diagnosis of solid cancers using analysis of exhaled breath volatile organic compounds (Nat Biotech, 2020); work with bioengineers revealed the critical role of mechanical tension in cancer morphogenesis (Nature, 2019).
- Deepened basic understanding of breast cancer including the earliest events in mammary morphogenesis (Nature, 2018), the differential role of oestrogen receptor variants in lobular and ductal breast cancers (PNAS, 2014), the genomic events driving resistance to aromatase inhibitors (Nat Genetics, 2017) and the development of new HER2-targeting monoclonal antibodies (Lancet Oncol, 2017)
- Demonstrated the utility of circulating biomarkers in cancer monitoring, showing that ctDNA can identify relapse and drug resistance in high-risk breast cancer up to two years before conventional clinical investigations (Clin Cancer Res, 2017)

*Research plans aims of the Cancer theme for the next 5 years:*

- Expand **early phase trials** activity in both solid tumours and haematological malignancies, including establishment of a new phase I unit on the Hammersmith campus; aim to take at least two Imperial-developed compounds from the lab into phase I trial, one of which will target epigenetic alterations in cancer.
- Develop specific clinical trials in **multiple myeloma** via funding from the new Langmuir Centre for Myeloma Research with a specific aim to open clinical trials of CAR19-iNKT therapy in relapsed myeloma.
- Develop other **advanced therapy** medicinal products from laboratory towards clinical trial, including RNA-based cancer vaccines and self-replicating RNA vectors.
- Expand multidisciplinary **convergence science** research, especially in collaboration with ICR, to ensure that the best engineering, physical and data science is applied to cancer; move novel technologies developed at Imperial towards clinical evaluation and consolidate as a major centre for clinical trials of novel cancer technologies.
- Embed early detection, early diagnosis and **prevention research** (with ICR and School of Public Health [UoA2]) into the cancer theme with particular focus on upper gastrointestinal and ovarian malignancies; develop a national phase III evaluation of volatile organic compounds in early detection and take an ovarian cancer early diagnosis method into clinical evaluation.

**1.1.6 Metabolism and Endocrinology theme:**

**Number of highly cited outputs:** 13 outputs over 200 citations, 7 outputs over 300 citations, 5 outputs over 400 citations, 3 outputs over 500 citations, including 1 with over 975 citations. We reach a broad audience through publishing widely in specialist journals (e.g. Cell Metabolism [9], Gut [9]) as well as general medical and science journals (e.g. NEJM [3], Nature [14], Cell [5]).

**Key Centres:** Centre for Translational Nutrition and Food Research (Frost), The National Phenome Centre (NPC, [Takats]), UK Consortium for Metabolic Phenotyping (Takats), Tommy's National Miscarriage Research Centre (Bennett), March of Dimes European Prematurity Research Centre (Bennett).

**Research Income (pro-rata): £197.8m**

**FTE:** 91.2

**Early Career Researchers** 23 of 97 staff returned in this theme are ECRs (*Abbara, Alexander, Alexiadou, Atkinson, Childs, Clarke, dos Santos Cebola, Garcia Perez, Hall, Izzi-Engbeaya, Jones, Leitch, Li, Liu, Martinez Sanchez, Mullins, Mullish, Pasma, Sandhu, Schiering, Scott W, Triantafyllou, Vergis*).

Metabolism and Endocrinology's mission is to build a robust and supportive academic community across basic, clinical, translational and big data research to provide diagnostic tools, therapeutics and novel insight into mechanisms of disease. Metabolism and Endocrinology collaborates extensively within Imperial exploiting the world leading expertise in the faculties of Chemistry, Engineering, Mathematics, and Life Sciences. Furthermore, the theme has extensive international and national collaborations, and are active participants in multiple international consortium-based research projects. One quarter of our staff are ECRs and we are committed to support their career development at all stages through mentoring and mid-career support structures.

**Key achievements of the Metabolism and Endocrinology theme since REF2014:**

- Novel molecular strategies for targeting **GLP-1 receptor** in type II diabetes and reducing side effects of GLP-1 analogs (Nat Commun, 2018).
- Novel roles and potential therapeutic applications for **kisspeptin** in emotion, sexual behaviour and infertility (J Clin Invest, 2017, 2020) and neurokinin 3 receptor antagonism in the treatment of menopausal flushing (Lancet, 2017).
- Integration of systems genetics and large-scale **mouse phenotyping** identified novel therapeutic targets in osteoporosis and osteoarthritis (Nat Genet, 2017, 2019; eLife, 2020).
- Developed, validated and modelled the impact of strategies for the **elimination of viral hepatitis** in low and middle-income countries (Lancet Glob Health, 2016; Lancet Infect Dis, 2016; Gut, 2016, 2017; Lancet, 2019; Lancet Gastro Hep, 2019).
- Therapeutic options and biomarkers for **alcohol related liver disease** (NEJM, 2015; Gastroenterology, 2015, 2017, 2018; Gut, 2017; Nat Commun, 2019).
- Reproductive tract microbiome signatures that are risk factors for miscarriage, **pre-term birth** and neonate health (Sci Transl Med, 2016) and role of maternal and foetal cardiovascular factors in pre-eclampsia and foetal growth restriction (Lancet, 2015); established European March of Dimes Prematurity Research Centre (\$10M over 5 years) and Tommy's National Miscarriage Research Centre (£2.5M over 5 years).

**Progress against 2014 REF targets:**

- Partnership with the European Bioinformatics Institute to create an analytical engine for the NPC (Takats) with in-house bioinformatics capability for metabolomics phenotyping widely available through the MRC-funded MAP/UK Partnership.
- Phase I-II clinical trials of oxyntomodulin and PYY analogues and identification of new genetic causes of obesity and factors influencing response to bariatric surgery; developed a wearable pump delivery programme showing that it is both practical and efficacious and highly potent long-acting analogues for weekly or fortnightly subcutaneous injection (Nat Commun, 2018); phase I clinical trials of these novel analogues showed full efficacy and no safety issues (Diabetes Care, 2019; ClinicalTrials.gov NCT01945840).



- Discovery of new genetic associations controlling bone strength and structure (Nat Metab, 2019; Nat Genet, 2017, 2019).

*Research aims of the theme for the next 5 years:*

- Expand interrogation of the **microbiome** to explore mechanisms of colonisation resistance for therapeutic use and to identify microbiome-derived metabolites which manipulate metabolism and inflammation.
- Develop our cross-faculty, inter-disciplinary **Centre of Translational and Food Research**, to tackle major global challenges in non-communicable disease by evaluating diet, under-nutrition and food shortages in low- and middle-income countries (LMICs) and among those with socio-environmental constraints.
- Establish **kisspeptin as a novel therapy** for reproductive disorders with translational partners Myovant Sciences and Crinetics Pharmaceuticals; employ aptamer technology to transform the diagnosis of endocrine disease and bring novel hormonal therapies to the clinic to treat obesity, diabetes and infertility.
- Improve **survival from alcohol-related liver disease** through development of more effective biomarkers and treatments and inform government and WHO policy to help eliminate viral hepatitis in LMICs.
- Build on our expertise in obstetrics and foetal medicine that leverages our Tommy's Centre of Miscarriage and March of Dimes Prematurity Research Centre with solutions for the prediction and prevention of pregnancy loss and **pre-term birth**.

### 1.2 The Imperial UoA1 Response to COVID-19:

The clearest evidence we can present to demonstrate the impact of our research strategy and environment is our broad and agile response to the COVID-19 pandemic. Working across academic boundaries and building on core strengths through our thematic research groups, our researchers across **UoAs 1, 2 and 4** have been central to national and international efforts to understand, control and treat COVID-19. In partnership with ICHT, we have contributed to 21 clinical trials, including RECOVERY, REMAP-CAP trial and vaccine trials, and have recruited 3728 patients at a rate of 428 patients per 1000 admissions.

This collaboration goes beyond pure research. To deliver this level of impact took alignment of researchers, administration, finance, human resources, and health and safety within Imperial and also across our NHS partnerships. We immediately established our **Imperial AHSC COVID-19 Research Committee** in March 2020 to review all COVID-19 related research projects. This ensured they were deliverable within our partner NHS Trusts and not duplicative nor likely to overburden hard-pressed services; we also provided scientific peer-review and advice to investigators. With representation from researchers in virology (Barclay), immunology (Openshaw), respiratory (Chilvers), infectious disease (Cooke), intensive care (Gordon), data science (Aylin [UoA2]), nursing (Wells, ICHT) plus senior leadership in College (Vice Provost and Dean) and NHS Trusts (Research Directors), the committee to December 2020 reviewed 176 projects from across the AHSC. In addition, through philanthropic donations, we created the Imperial COVID-19 Research Fund. £2.8m was invested in 45 short- and medium-term projects across College from 159 projects submitted and reviewed by this committee. We utilised the flexibility of our devolved funding schemes to provide no-cost and, where needed, costed extensions to ensure projects funded under these schemes can complete. Using our UKRI COVID-19 allocation (£7.8m) plus internal funding, we have also provided support for all funded PhD students to ensure they can complete their courses and we are currently allocating emergency funding to projects and programmes.

Imperial researchers are central to guiding UK COVID-19 policy: three Imperial scientists served on the **Scientific Advisory Group for Emergencies** (SAGE; Barclay, Bangham, Ferguson [UoA2]). Nine are members of the **Scientific Pandemic Influenza Group on Modelling** (SPI-M) that has performed modelling pertinent to UK COVID-19 management. Their advice is based on infectious disease modelling and epidemiology (Barclay, Baguelin; Bhatt, Brett, Ferguson, Grassly, Lucas and Riley [all UoA 2]; Gandy [UoA8]). SAGE takes advice from the **New and Emerging Respiratory Virus Threats Advisory Group** (NERVTAG) on the threat

posed by new and emerging respiratory viruses which has three Imperial members (Openshaw – Deputy Chair, Barclay and Ferguson [UoA2]). Barclay chairs the **SAGE subgroup on Vaccine Science Coordination**. Kellam as part of the vaccine Task Force chairs its **Vaccine Update Expert Advisory Group** which Barclay is also a member of. We also have members on other Government advisory bodies: the **PHE Serology Working Group** (Barclay, Kellam); **COVID-19 Clinical Information Network** (CO-CIN, Openshaw); **Children’s Task and Finish Working Group** to provide advice on the transmission of COVID-19 in children and within schools (Riley, [UoA2]); and the **Hospital Onset COVID-19 Working Group** (Holmes, Price).

*COVID-19 research contributions by UoA1 themes:*

**Infection and Immunity theme:** Our teams have been at the forefront of the national and international response. The Barclay group rapidly diverted its influenza programme to understand more about the biology and transmission potential of SARS-CoV-2. We are one of a handful of institutions in the UK to have BSL3 level facilities able to propagate SARS-CoV-2 *in-vitro* and in diverse animal models. We have provided validated virus samples of variants of concern to groups across the UK including to PHE, members of the Genotype to Phenotype Virology consortium (Barclay leads), Centre for Virus Research Glasgow, Kings College London, UCL, Cambridge and Bristol. We also validated seed stocks for generating the GMP viral isolates for the COVID-19 Human Challenge led by Imperial (BEIS, £1.7m). Shattock has developed and tested a self-amplifying RNA vaccine, taking a new technology from cell-based assays, through animal models, first in-human, onto larger phase II clinical trials in less than 12 months; working through a social enterprise start up, this secured £22m from UK Government. We have also received MRC COVID-19 and Wellcome Trust rapid response funding to develop therapeutic antibodies (Xu) and serological assays (Cherapanov, McClure and Tedder).

We have accelerated the development of rapid SARS-CoV-2 diagnostics developed by Imperial engineers (DNA Nudge technology, Cooke, Toumazou [UoA12], see impact case study). Early in the pandemic, we established a facility for rapid PCR testing (Taylor, Freemont), which developed into a formal partnership with the DHSC Lighthouse Programme and £7.5m investment. We are leading the REal-time Assessment of Community Transmission (REACT) Study, a major DHSC programme of home testing for SARS-CoV-2 to track the progress of the infection across England. It is one of the largest, most significant pieces of research looking at how the virus is spreading across the country and the lasting effect on immunity within communities. The REACT team has produced a series of reports to highlight the prevalence of virus and of antibodies, used to inform government strategies and policies (Barclay, Cooke, Darzi; Elliott, Riley and Ward [UoA2]).

We have published reports identifying a Paediatric Inflammatory Multisystem Syndrome temporally associated with SARS-CoV-2 - a rare syndrome in which COVID-19 leads to severe inflammation in young children. Similar to Kawasaki disease, our researchers identified the main symptoms and clinical markers to diagnose and evaluate treatments (JAMA, 2020).

We have provided guidance for managing patients with thrombocytopenia associated with COVID-19 (Brit J Haematol, 2020) and the effect of COVID-19 on end-stage kidney disease (eLife, 2020). Finally, we are running the C19-RISP study to describe the clinical course and outcome of COVID-19 in renal and immuno-suppressed patients.

**Cardiovascular:** The Preventing Cardiac Complications of COVID-19 Disease with Early Acute Coronary Syndrome Therapy (C19-ACS) trial was initiated at Imperial and is now recruiting internationally. Using single cell technologies and post-mortem tissues from affected patients we identified SARS-CoV-2 entry factors and their cellular distribution (Nat Med, 2020) and demonstrated the lack of ACE2 expression and replicative infection by SARS-CoV-2 in human endothelial cells (Circulation, 2020).

**Respiratory theme:** The ISARIC consortium, originally set up in response to ‘flu pandemic in 2009 to standardise consent and sampling protocols, has collected data and biosamples from as many acutely ill patients as possible nationally (from >150,000 consented patients). This has

proven invaluable and ISARIC-4C (MRC £5.9m Openshaw co-lead), is the largest prospective study of COVID-19 cases (BMJ, 2020, Lancet Infect Dis, 2020). Imperial College/ICHT is the second biggest recruitment site nationally for Post-Hospitalisation COVID-19 Study (PHOSP-COVID) (UKRI £8.4m Chilvers Co-I), which is investigating outcomes following hospitalisation for COVID-19.

**Surgery, Anaesthetics and Critical Care theme:** Imperial is the UK-lead for REMAP-CAP an international (15 countries) adaptive platform trial originally designed for community acquired pneumonia but was specifically designed to be employed in a pandemic to evaluate multiple interventions simultaneously in critically ill patients. This has proved to be a highly successful trial platform, rapidly identifying anti-IL-6 as a new treatment for use in broad clinical practice, confirming the role of hydrocortisone in critical care patients and demonstrating no advantage for use of immune-sera (JAMA, 2020). We also created PanSurg - a global hub for surgeons and related professionals to share experiences, policy, data and research for the delivery of safe, effective surgery during the pandemic (Kinross).

**Cancer theme:** ON-COVID, an Imperial-led study has revealed valuable insights into the impact and risk factors for cancer patients with COVID-19. The findings, from almost 900 cancer patients diagnosed with SARS-CoV-2 infection in the UK, Spain, Italy and Germany suggests that we should adapt our clinical services to minimise in-hospital transmission. Their research also suggests the use of anti-cancer treatments such as chemotherapy and immunotherapy does not seem to increase mortality from COVID-19 (Cancers, 2020).

**Metabolism and Endocrinology theme:** To better understand how COVID-19 affects early pregnancy, foetal growth, prematurity and virus transmission to the baby, Imperial researchers have been funded by the MRC to construct a registry of women with suspected and confirmed COVID-19 from early pregnancy to after delivery of the baby (Mullins). Healthcare professionals from the UK and across many international centres will contribute data via a web portal (Lees, Mullins). We also identified association between high serum total cortisol concentrations and mortality from COVID-19 (Lancet Diabetes and Endocrinology, 2020).

### 1.3 Our Research Strategy:

Our research strategy, whose agility, depth and breadth is reflected above, is to make fundamental discoveries and translate these most efficiently into the clinic, to benefit local, national and international populations. As noted in Section 1, since the last REF, we have reorganised our Faculty into eight thematic departments (from five in 2014) and our research is delivered through six cross-cutting themes that are submitted here in UoA1 (**Fig.1**). The Faculty reorganisation has given greater visibility of our core disciplines to the other College Faculties, facilitating “first contacts” to promote interdisciplinary research. These smaller departments have allowed us to better address mentorship, research culture and career development, achieving gender balance among the departmental leadership. The departments deliver the College’s Academic Strategy by applying their core strengths to transdisciplinary partnerships with other Faculties and with external partners to promote a healthy society. We aim to achieve our research strategy through local, national and international partnerships, externally funded centres of excellence and PI-led funding. Our joint AHSC research infrastructure facilitates the translation of our research into the clinic, driven by BRC funding.

#### 1.3.1 Working in partnership:

Our major investments have been targeted to increase the interaction between our fundamental scientists, clinical researchers, data scientists, engineers and natural scientists. We have invested over £2bn on physical infrastructure focussed mostly on our White City and adjacent Hammersmith Hospital Campus. This includes a £105m partnership with BEIS to build a new dedicated home for the MRC/Imperial College **London Institute of Medical Sciences** (LMS, formerly the MRC Clinical Sciences Centre). The Faculty is proud to continue our close working partnership with the MRC and the LMS (£82.6M, 2011-16; £89m 2016-2021). This new home will provide 12 000m<sup>2</sup> for LMS and Imperial researchers, physically designed to facilitate collaboration. The key foci for LMS are epigenetics (Hajkova), quantitative biology

(Merkenschlager) and genes and metabolism (Miguel-Aliaga), providing high quality basic science expertise in cellular and molecular biology. LMS researchers cut across our research themes (Cardiovascular – Cook, O'Regan, Ramasamy, Simoes Monteiro de Marvao; Metabolism and Endocrinology – Brown, *Schiering*, Carling, *Leitch*, Withers, Lenhard, Martinez Perez, Miguel-Aliaga, *Scott*; Infection & Immunity - *Warnecke*, *Sarkisyan*; Cancer – Merckenschlager, Fisher, Barr, Aragon, Gomes Cabreiro, Hajkova, *Sarkies*, Speck); 26 LMS researchers have contracts with Imperial College who have secured a further £36m in peer-reviewed external funding since 2014, co-supervise graduate students and MSc projects. We celebrated the 10<sup>th</sup> anniversary of the **Chain-Florey** clinical training programme in 2019; run jointly by the LMS and the Imperial BRC, we place clinical PhDs into basic science labs under joint supervision, using a cohort approach with specific mentoring; since 2018 we have expanded the scheme to include Chain-Florey Foundation Year 2 fellows, Chain Florey Clinical Research Fellowships (usually ST 2-5), Chain-Florey Clinical Lectureships (ST 4-5) and in 2018 a Chain-Florey Clinical Senior Lectureship. This scheme has now nurtured a growing cohort of clinical scientists: 25 Fellowships have been awarded and 17 clinical academics have graduated with the skills to tackle experimental medicine research questions.

Imperial College London is a founding partner of the **Francis Crick Institute** opened in August 2016 and has helped to shape the Crick's scientific vision. Since opening, we have established five satellite groups within the Crick (Barclay, Zhang, Lloyd, Shenoy, Wilkinson). Each satellite comprises a small group of university researchers embedded in a Crick research group or Scientific Technology Platform (STP), while the PI remains at Imperial. We are returning 7 Crick researchers in UoA 1 with 0.2 FTE contracts (O'Garra, Tybulewicz, Stoye, Reis y Sousa, Way, Cherepanov, Kassiotis). These working relationships date back to the National Institute for Medical Research and have been extremely scientifically productive. We have co-supervised 52 PhD students (6 clinical), published over 50 papers and won >£10m joint research income; 61 Imperial MSc students have undertaken research projects at the Crick. We have also hosted joint symposia, for example, the pan-London Infections and Immunity Symposium (Ley) and Malaria Symposium (Cunnington). Our clinical and translational partnerships are described in detail in **sections 1.5 and 3.1.4**.

### 1.3.2 Externally Funded Centres of Excellence:

We house 27 externally-funded centres of excellence all of which bring interdisciplinary research methodologies to a range of health challenges. This external investment of over £100m is matched through our own investments in staff and indirect costs. As stated in Section 1, since REF2014, we have renewed our **three MRC Centres** – the Centre for Molecular Bacteriology and Infection (CMBI, Director Holden FRS until 2019 then Penades; £2.3m; the CMBI continues to be the largest centre for molecular bacteriology nationally); the MRC Centre for Global Infectious Disease Analysis (GIDA, UoA2) and the MRC Centre for Environment and Health (UoA2, UoA14) were both successfully renewed for a third 5-year term in 2018, two of only three MRC Centres nationally to achieve this. New in this REF cycle was the creation of four HPRUs in 2014, two of which sit in UoA1 – Respiratory Infections (Director, Lalvani) and Healthcare Associated Infections and Antimicrobial Resistance (Director, Holmes). These Centres were renewed in 2019 when we secured funding for all four renewals including Health Effects of Environmental Exposures which previously was held jointly with King's College London, together with transfer to Imperial of one new Centre. **We are the only UK Institution to house five HPRUs with a total £20m investment.**

We have extended our success in cancer research; in 2017, we renewed our CRUK Imperial Centre (Director, McNeish), a partnership between Imperial College London, Imperial College Healthcare NHS Trust, Cancer Research UK and Imperial Experimental Cancer Medicine Centre (ECMC) with a new mission to emphasise convergence science and facilitate collaborations between clinicians and biologists with the physical sciences, engineering and mathematics. The success of this Centre and development of a strategic partnership with the ICR then led to the award of the CRUK Convergence Science Centre, a £14m Major Centre (Director, Behrens) with a remit to work across the entirety of both the ICR and Imperial to support the clinical translation of novel cancer technologies and therapeutics.



In cardiovascular disease, the British Heart Foundation (BHF) Centre for Research Excellence at Imperial was established in 2008 (Director, Schneider) and renewed in 2019 (£4m; Director, Wilkins) with greater emphasis on interdisciplinarity, adopting and adapting machine learning and artificial intelligence techniques to interrogate large patient and population datasets to identify molecular drivers of disease, develop biomarkers for patient stratification and improve diagnostic and patient management pathways. Imperial College is also the only UK HEI to house two Dementia Research Institute (DRI) Centres (UoA4); the UK DRI at Imperial (£20m; Director, Matthews) and the UK DRI Care Research and Technology Centre (£20m; Director, Sharp).

#### **1.4 Developing and delivering interdisciplinary research:**

Interdisciplinary research is a long-term commitment across this UoA, the Faculty and the College. We have addressed this through large-scale **physical co-location**, such as the £105m Sir Michael Uren Building for medicine and bio-engineering at White City (2020); through College-wide **virtual co-location** in Institutes, Centres and Networks; through Faculty re-organisation; through pump-priming interdisciplinary translation and through a Faculty-wide strategy of convergent science.

At the researcher level, each Centre of Excellence, where we bring together our convergent science approaches, includes provision for PhD training programmes, discipline hopping and sandpit events to bring researchers together and foster new ideas. This person-centred approach ensures vitality and sustainability as well as developing researchers and research leaders for the future. For example, since 2015 the MRC LMS and FoM have instigated 12 innovation mixer events with contributions from 109 researchers, including 55 researchers from the LMS (50%), 24 from FoM (22%), 19 from the Faculty of Natural Sciences (17%), 5 from the Faculty of Engineering (5%) and 6 external collaborators (6%). Two thirds of the innovation mixer events led to collaborations, publications, grant applications, joint studentships and/or translational funding.

Interdisciplinary research has also been enhanced and facilitated by the Imperial College Networks, Centres and Institutes. Our Global Challenge Institutes harness the talents of a wide variety of researchers to address some of the world's most important issues. The Imperial Centres of Excellence aim to galvanise a critical mass of researchers, transcending Faculty boundaries to support a multidisciplinary theme. The Imperial Networks of Excellence aim to establish and grow connections around an important multidisciplinary area that is being explored at an earlier stage than the centres. UoA1 researchers are members of the Data Science Institute (Director, Kennedy [UoA17]); The Institute for Global Health Innovation (IGHI) and the Institute of Infection (launched 2020).

##### **1.4.1 Our Global Challenge Institute – the IGHl:**

The IGHl (Dir Darzi) works to transform health and care through evidence-based innovation. Focusing on health and care challenges with the greatest potential impact, they take innovation to patients through design, policy and safety. It is a collaborative grouping of Centres of Excellence – the Hamlyn Centre for robotic surgery, the Helix Centre bringing design and innovation together to develop clinically-evaluated digital solutions (Thompson); the Centre for Health Policy works on the development, uptake and distribution of innovative, evidence-based health policies around the world (Darzi); the Centre for African Research and Engagement, a virtual resource showcasing the work of Imperial College across the African continent, and a platform for cross-disciplinary exchange (Maitland) and the NIHR Patient Safety Translational Research Centre to address safety at patient level and systems level to make advances across the care continuum (£7m, Darzi). The IGHl has been central to the design and delivery of COVID-19REACT programme.

##### **1.4.2 Researchers from UoA1 are involved in the following interdisciplinary Centres and Networks:**

**Centres of Excellence:** Abdul Latif Jameel Institute for Disease and Emergency Analytics (J-IDEA, UoA2), Advanced Therapy and Medicinal Products (ATMPs; Dir, Alton), Blast Injury Studies (Director, Bull [UoA12]; UoA 1 researchers: Dickinson, McGregor, Rankin, Rice, Sharp, Wilson); Cardiac Engineering (Co-Directors, Harding, Peters); Drug Discovery Science (Co-Director, McNeish); Integrative Systems Biology and Bioinformatics (Director, Sternberg [UoA5]); Mathematics of Precision Healthcare (Director, Barahona [UoA10]); Musculoskeletal Medical Engineering (Director, Bull [UoA12], Cobb); Neurotechnology (Co-Director, Matthews [UoA4]), Shultz [UoA12], Wisden [UoA5]); Performance Science (Director, Kneebone); Structural Biology (Director, Meier [UoA5]); Synthetic Biology (Freemont); Translational Nutrition and Food Research (Director, Frost); UK Dementia Research Institute (Directors, Matthews and Sharp [UoA4]); Vasculitis (Director, Mason).

**Networks:** Air Quality (*Fecht* [UoA14]); Antimicrobial Research Collaborative (Director, Holmes); Artificial Intelligence (Director Faisal [UoA12]); Diabetes (Director, Rutter); Glycobiology (Director, Feizi); Human Behaviour and Experience in STEM (Director, Harding); Innovative Imaging Across Scales (Director, Fisher); Malaria (Co-Directors, Baum [UoA5], Cunnington); Microbiome (Director, Dumas); Organ-on-a-chip (Director, Overby, Lloyd); Robotics Forum Space Lab (Bello, Elson); Stem Cell and Regenerative Medicine (Le Celso [UoA5], *Foldes*); Trauma Bioengineering (Director, Bull [UoA12], Sharp [UoA4], Wilson); Vaccine Research (Director, Chiu); Vascular Science (Director, Haskard); Wound Healing and Regeneration (Director, Stevens [UoA12]).

### 1.5 Maximising our impacts:

To ensure maximum impact from our research, translation remains critical to our strategy and we have developed mechanisms to support academics right across the translational pipeline. The framework for our translation activity is provided by our **Imperial AHSC**, created in partnership with ICHT in 2007 and formally renewed by DHSC 2020. Imperial College AHSC now includes the Royal Marsden Hospital, Royal Brompton Hospital (to Feb 2021), Chelsea and Westminster Hospital and the ICR. This represents the first time all the research-intensive organisations in West London have committed to a shared research, education and clinical care vision in their 170-year histories. With over 22,500 staff, our largest, co-located clinical academic sites are at South Kensington (Marsden, Brompton, ICR, Chelsea and Westminster); White City/Hammersmith Hospital (Imperial, ICHT); and Sutton (ICR, Marsden).

Our human experimental medicine research engine continues to be our NIHR **Imperial BRC** (£202m, 2012-2022, Director, Thursz) with disease specific themes and technology platforms in genomics, stratified medicine, molecular phenotyping, informatics and biobanking, and imaging. These themes are congruent with the research groupings returned across UoA1, 2 and 4. The BRC not only provides thematic funding streams but also supports the **Institute of Translational Medicine and Therapeutics (ITMAT)**, a virtual centre built on a number of core technology platforms across Imperial College, the BRC and ICHT - genomics, imaging technologies and health informatics. Research projects are supported through an annual funding call with direct support for each of the technologies.

Earlier phase, interdisciplinary translational research across our Faculties and AHSC is facilitated by the Imperial Translational Fund comprised of BRC funding and devolved funding streams - MRC Confidence in Concept (CiC) Scheme, EPSRC and Biotechnology and Biological Sciences Research Council (BBSRC) Impact Accelerators, the Wellcome Institutional Strategic Support Fund (ISSF) and the Higher Education Innovation Fund. It is also supported by the Royal Marsden NHS Foundation Trust and the Rosetrees Trust plus industrial support through a strategic partnership with AstraZeneca, Wuhan Pharmaceuticals, Heptares and Boehringer Ingelheim. Our annual funding competition, **Imperial Confidence in Concept (ICiC)** has become an event in the Imperial calendar, kicked off at the annual "All You Can Innovate" event in our White City Campus. The last event attracted >150 researchers, 10 companies and 11 funders. We provide an opportunity for researchers to pitch their projects at an industry focused panel, "speed dating" events and surgeries. From an average ICiC total pot of approx. £1.5m per year, we have seed-funded 162 projects since its inception in 2013, from experimental proof

of concept to technology validated in the lab; these have gone on to leverage an additional £94m in follow-on-funding, including over £8.4m from Imperial College; more than 62 patent applications have been awarded/filed, and there have been in excess of 214 publications. We have also funded three **translators in residence**, Dr Mike Ramanos (2014-2016), Dr Richard Knowles (2016-2018) and Dr Richard Rutter (2018-present). All have a pharma/industry background and work with successful and unsuccessful applicants to help overcome challenges specific to each project. To date, they have advised >150 people on a range of activities such as developing spin outs, facilitating new connections, preparing applications for translational research and obtaining funding.

Human trials are supported from first-in-man clinical trials, through large scale phase II/III studies through to implementation and evaluation in the community. In 2016, the **Imperial Clinical Research Facility** was renewed (£11m 2017-2022; Director, Wilkins) supporting experimental medicine studies in humans to identify the causes and mechanisms of disease and/or to test the validity and importance of new discoveries and treatments. ICHT was recently re-awarded the Local Clinical Research Network (LCRN), a £75m award to build clinical research and trials activity throughout NW London. The **Imperial Clinical Trials Unit (ICTU)**; Co-Directors Poulter and Ray [UoA2]), established in 2009 with full UKCRC registration status in 2012, is now a nationally recognised CTU. With investment from NIHR CTU support funding, the Imperial BRC and School of Public Health, the Unit provides trial expertise to investigators across the Imperial College AHSC. In July 2019, Imperial, in partnership with Chelsea and Westminster Hospital, was awarded an NIHR **Applied Research Collaboration** (£9m, Director, Majeed [UoA2]) to support applied health and care research that responds to, and meets, the needs of local populations and local health and care systems.

#### 1.5.1 Supporting commercialisation and translation:

Our Industry Partnerships and Commercialisation (IPC) team link business with researchers (and vice-versa) and help academics develop impactful research partnerships. During this REF period, we have supported 309 new opportunities, 78 discussions with companies about a research collaboration or leverage funding opportunity; supported 58 successful industry partnership deals with 24 different industry partners, from the pharmaceutical, diagnostics, MedTech, BioTech and Food and Beverage Sectors. In total, we have secured £97.4 funding from industry partners.

Examples of our commercial success include: The **Nestle Nutrition Research Centre** (Frost); **AstraZeneca Innovation Fund** and AZ Fellowships - £5m commitment over 5 years to support translational research projects and fellowships (15 projects/fellows funded in UoA1 to date). The **AZ Respiratory Pharmacology Lab** (Belvisi, Birrell, Tetley); **Heptares**, target discovery and validation focused on G protein-coupled receptors to develop new treatments for gastrointestinal disease (Frost, £700k); **Shionogi – Antimicrobial Resistance** partnership (Edwards); the **MRC/GSK- EMINENT** collaboration (£1m, Chilvers, Openshaw); Bayer – Using AI to identify key drug targets in heart disease (in partnership with LMS, O'Regan, £500k).

#### Technology commercialisation in this REF period:

- >100 new invention disclosures annually
- 94 new priority filings
- 225 new patents granted
- 83 licensing deals
- 12 start-ups formed

**Licensing:** for example, our Volcano-Philips licensing deal for instantaneous wave-free ratio (iFR, see impact case study); UK Cystic Fibrosis Gene Therapy Consortium (GTC; Imperial College, Universities of Oxford and Edinburgh); Boehringer Ingelheim and Oxford BioMedica to develop new viral vector-based gene therapies to take to clinical trials.

**Start-ups:** Vac Equity - social enterprise start-up in response to the COVID-19 crisis established to accelerate access to COVID-19 vaccine developed at Imperial. Myricx Pharma, originally funded through the CiC scheme, secured £4.5m seed financing.

### 1.5.2 From experiments to policy:

As well as translating our research into new treatments, diagnostics and devices, we also guide policy through our research. Our five HPRUs are partnerships with Public Health England (PHE) to fund research that enhances the ability of PHE to use innovative techniques to protect the public's health and minimise the health impact of emergencies.

To maximise our impact at policy level, Imperial College has established The Imperial Global Science Policy Forum to connect Imperial academics with senior international science and technology advisers and diplomats, UK government policymakers, industry experts and other relevant stakeholders. We have established the Centre for Health Policy (Co-Directors Darzi and Mossialos) and the NIHR Patient Safety Translational Research Centre (Co-Directors Darzi and Redhead [ICHT]).

### 1.6 Achieving impact:

Our approaches to achieving impact are exemplified in our impact case studies. **Working across our faculties**, we have developed novel CDK7 inhibitors with Department of Chemistry (Coombes) and repurposed technology from Department of Electrical and Electronic Engineering to develop COVIDNudge (Cooke) – an accurate, quick and easy-to-use diagnostic test for COVID-19. **In partnership with industry**, researchers from the NHLI have successfully demonstrated the transformative effects of novel treatments for CF (Davies); we have globally implemented new ways to diagnose coronary stenosis (Mayet, ICHT) and improve cardiac ablation (Kanganatham, Royal Brompton). All of these studies were also **in partnership with our AHSC**, along with first in man studies through to clinical commissioning of lung volume reduction for emphysema (Hopkinson) and the demonstration that glucocorticoids improve COVID-19 survival (Gordon). **Taking our research into policy**, we have changed guidelines for the use of influenza vaccines in children with egg allergies (Turner), post-polypectomy surveillance (Cross), improved diagnosis for ovarian cancer (Bourne) and revised WHO burden estimates of TB (Seddon). Our work also has **global reach**, for example, setting the international standard for diagnosis of miscarriage (Bourne), preventing the progression of latent TB in patients with HIV (Wilkinson), controlling outbreaks of Ebola (Cori) and reducing the burden of hepatitis globally (Cooke).

### 1.7 Open Research:

Imperial College is committed to disseminating its research and scholarship as widely as possible. The College has implemented an open access mandate for all research publications, subject to publishers' copyright policy, to be deposited in Spiral – our institutional repository. Outputs across the Faculty of Medicine (UoAs 1, 2 and 4) are 98.4% OA compliant with 95.8% compliance in this UoA. Researchers have access to the Imperial Open Access Fund to support publishing in open access journals. Our researchers also deposit their data on a range of open access platforms such as National Centre for Biotechnology Information Gene Expression Omnibus (GEO) Database - a public functional genomics data repository.

Across this submission and indeed, FoM, data has been deposited on GitHub (some examples include Glen, Lenhard, *Posma*, Seddon, *Whiffin*, Ware as well as studies from the NPC [Takats] and Imperial BRC Genomics Facility [Ferrer]). Much of our epidemiological research, which underpins returns across UoA1, 2 and 4, draws on data from national and multinational cohort studies. The Airwave Health Monitoring Study Cohort Data (Tzoulaki) are available to researchers via the Dementias Platform UK data portal with the data shared with >30 research groups worldwide. The development and sharing of code through GitHub has also enabled independent validation of research methods and code to be undertaken. For example, two COVID-19 reports (Reports 9 and 13) have been certified as reproducible by CODECHECK ([www.codecheck.org.uk](http://www.codecheck.org.uk)), a collaborative project between the Universities of Cambridge and Munster, Germany, to increase the availability and reproducibility of code used for scientific



research. The research findings of these two high-profile reports have also been independently verified and re-published in the BMJ (led by University of Edinburgh researchers) and at [www.turing.ml](http://www.turing.ml) (by University of Cambridge researchers).

Research reproducibility is also key to our impact and success. In a recent example, two pharmaceutical companies have reproduced our work showing neurokinin 3 receptor (NK3R) antagonists reduce menopausal symptoms (Lancet, 2017) demonstrating the high efficacy for this class of compound in relieving menopausal flushing. NK3R antagonists are now being taken forward in phase III trials.

### 1.8 Maintaining research integrity:

The College is a signatory of the UK Concordat to Support Research Integrity and is committed to “maintaining the highest standards of rigour and integrity in all aspects of research”. The College provides guidance and training to staff and students across a wide range of areas linked to research integrity, including mandatory plagiarism awareness training for doctoral students. Within Medicine we use plagiarism software for all PhD theses and Masters’ Dissertations.

Researchers across the Faculty (UoA1, 2 and 4) and the broader AHSC are supported by teams in the Joint Research Office (JRO) and the Research Governance and Integrity Team (RGIT). The JRO staff facilitate the management of research grants, contracts and EU projects while the RGIT ensures our researchers meet their responsibilities in relation to research governance to fulfil the legal, ethical and scientific obligations of the healthcare research process. This includes general data protection regulations (GDPR) via the data protection team and human research ethics via Imperial College Research Ethics Committee (ICREC) which reviews health-related research involving human participants and/or their data that is undertaken by College staff or students, where this is not covered by the Health Research Authority Research Ethics Committees. We have also established the Science, Engineering and Technology Research Ethics Committee (SETREC) to review non-health related research involving human participants and/or their data and high-risk educational research that is undertaken by College staff or students.

## 2. People

Our very highest priority is our staff. To ensure vitality and sustainability across all UoAs, we strive to attract and retain world-leading and rising-star academics, develop our own researchers to become leaders in their fields and develop our professional support staff to fulfil their potential. We aim to foster an intellectually challenging and invigorating environment to stimulate collaborative science. Mentoring young investigators, continual training and professional development for staff and developing leaders in all spheres increases staff motivation and serves to enhance our research output.

Since REF2014, in UoA1, we have **recruited 25 professors, 8 readers, 36 senior lecturers and 47 lecturers**. We have prioritised recruitment to our themes and, where strategically advantageous, we have **made joint appointments with the Crick (8), MRC-LMS (26) and with PHE (4)**. To ensure recruitment aligns with our research strategy, all new posts (both new and replacement) from lecturer to professorial are reviewed by the Dean’s Management Group. A full scientific and business case needs to be prepared outlining how the new post will add to research, teaching and pastoral environment. To equip these more senior academic staff with the practical skills and awareness required for organisational leadership, the College runs a Senior Academic Leadership Programme based on the National Occupational Standards for management and leadership and accredited with the Chartered Management Institute. We measure through qualitative and quantitative evaluation data the enhanced effectiveness and progression and impact of succession plans put in place. The College also has in place clear guidance for sabbatical leave to pursue their research interests. During this time, there is no commitment to College activities required and continuous service is protected.

We recognised in 2017 that the age profile of our Faculty was becoming imbalanced and so we focussed our strategy on developing and recruiting junior researchers. To boost our pool of future research leaders, the FoM ran a campaign for “new blood” lecturers successfully appointing 11 (*Ahnstrom, Clarke, Denton, Judah, Low, Noseda, Santos Amaral, Salehi-Reyhani, Sancho-Shimizu*; Robinson [UoA14], *Turner*). Imperial College and the Faculty have developed and refined the Imperial College Research Fellowships (formerly the Imperial Junior Research Fellowship) to support the brightest and best junior researchers from across the world. We have appointed 42 ICRFs (Aug 2013- Dec 2020), with 19 submitted in this UoA. These have gone on to secure awards and appointments both internally and externally; for example, Behmoaras now a Reader in Immunology & Inflammation, Brown is a senior lecturer in ICS, Dorigatti is Lecturer at Imperial College London, *Helaine* is now Assistant Professor of Microbiology at Harvard, *Thurston* has secured a BBSRC David Phillips Fellowship and *Siciliano* is Tenure Track and lead at Istituto Italiano di Tecnologia. In total, over this REF period, we have supported over 160 junior researchers (clinical PhDs, clinical and non-clinical junior and intermediate fellows) from a broad range of funders including 12 Wellcome Trust Sir Henry Dale and 4 Sir Henry Wellcome fellows, 16 MRC intermediate fellowships (clinician scientist and career development awards), 14 BHF training and 8 BHF intermediate fellowships, 11 NIHR junior and intermediate fellowships, 5 Future Leader Fellowships. We use our Wellcome Trust Institutional Strategic Support Fund (ISSF) to support researchers on the pathway to becoming an independent researcher, for example, to collect data in preparation for larger grant or fellowship applications through our springboard fellowships (45 awarded since 2014).

### 2.1 Integration into the research culture:

On appointment, staff have a formal induction, are provided with a Department and College “Welcome Pack” and directed to online material. This sets out key information such as events and minutes of committee meetings as well as how to access key resources (e.g. Postdoc and Fellows Development Centre [PFDC], mental health awareness). We provide regular email updates detailing funding, career development and training opportunities. We operate a “buddy” system for new recruits – all new staff are offered mentors and required to participate in a supportive, annual appraisal programme. All new staff are guided through “Imperial Expectations”- an online tool that sets out our seven expectations to shape the working lives of all, including an online game.

### 2.2 Support for Junior Researchers:

Support for our 160 junior researchers (141 REF-defined ECRs plus 19 junior researchers not included in REF definition) is provided by the PFDC. This award-winning Centre provides bespoke courses; pop-ups; funder showcases; one-to-one support; mock interviews and online resources. The College and FoM have invested and committed to the core funding of the PFDC since 2012. All ECRs at Imperial benefit from ten days training and development in their contracts. For this REF period, our junior researchers have had 603 one-to-ones (384 female, 188 male, 31 unknown), received 186 mock interviews (96 female, 60 male, 10 unknown) and attended 1023 courses. The PFDC also has a bespoke programme of support for our independent research fellows and clinicians actively pursuing academic careers at Imperial delivered in partnership with our Clinical Academic Training Office (CATO).

Within Departments, all junior researchers have a clear line of supervision and management, access to a mentorship programme and are given an identified “buddy” to ensure they are orientated within the research theme, and also to provide a safe space to be challenged and supported. Each year, every member of College staff is required to undertake a Personal Review and Development Plan, a two-way discussion between staff member and manager aimed at recognising achievement, providing constructive feedback, and assisting with career development. The College’s flexible working policy is applicable to all staff.

The College has been committed to the HR Excellence in Research since 2012, originally mapping the HR Excellence in Research Award against the ‘UK Concordat to support the Career Development of Researchers’. Imperial’s focus on The European Charter for Researchers & the Code of Conduct via the HRS4R implementation and continued commitment as a UK institution

to the UK Concordat offers a dual focus strengthening the actions and aims of the College to continue being sector-leading in the researcher development landscape, enabling our researchers to excel. The revised Concordat was released in September 2019 and aims to set the gold standard in researcher development. Imperial has signed up to the new Concordat and has created an action plan to engage in initiatives aimed at successfully implementing the new concordat.

### 2.3 Contribution of our postdocs:

We have a thriving postdoc community including a Post Doc Network of over 70 reps from every Department and across all campuses. Currently 31 of these are from FoM. They have been instrumental in shaping policies around PhD supervision, HR excellence awards and inductions. Each department has a Postdoc Champion - an academic who ensures that postdocs and fellows' needs are being met by their department. Within Departments, we have postdoc reps on management committees such as People and Culture Committee and dedicated postdoc mailing lists. Our post-doc community also benefits from the support of the PFDC.

### 2.4 Recognition and reward:

As well as recruiting and developing junior researchers, we take retention of staff equally seriously and have implemented a suite of activities to recognise and reward our staff. We run annual promotions rounds at departmental level, using open expression of interests for those wanting to be considered, and reviewing all staff for promotion whether or not requested by the staff member. Clear promotion guidelines are made available to all eligible staff with reminders sent out on a regular basis. Promotions documentation explicitly considers administration, pastoral, outreach, mentoring and diversity activities, as well as caring responsibilities or parental leave. Quality of research is emphasised over quantity and teaching contribution is emphasised especially at lower grades, while research, mentoring and international reputation are emphasised at higher grades. Interview panel members have all undertaken unconscious bias training and include academic representation, an Athena Swan representative and a College Consul who serves to ensure fair process across all Faculties. Over the REF period, we have **promoted 41 people** to Professor, 48 to Reader and 22 to Senior Lecturer (60% male/40% female) in UoA1.

We use the Total Remuneration Package as a more complete way of remunerating staff. We run annual pay relativity exercises to objectively review each member of staff's salary in line with benchmark information or the relevant Pay Progression Framework in order to ensure parity between colleagues undertaking similar roles, as well as comparisons across other institutions in UK, EU and US. Annually we run the President's Awards for Excellence in Research to recognise staff members who have made outstanding contributions in a number of categories. Previous recipients from FoM include MacIntyre, Snelgrove, Giannarou (UoA12) plus the teams of Alton, Barrett, Coombes, Dhillon, Harding and Levin. The Julia Higgins Awards are made to those who have made a significant contribution to the support of academic women at the College; recipients include Salem, Lloyd, Mitchell, Randi, Rankin and Harding.

### 2.5 Research Students:

We have doctoral training accounts (DTAs) from the MRC (DTP and iCASE, 11.5 per year for 5 years, 2015-2021), BBSRC (approx. 5 per year, 2015-2021) and EPSRC (approx. 8 per 2019-2020). In addition, the LMS receives 8 DTA studentships per year from the MRC as part of its quinquennial award. Imperial College also offers President's PhD Scholarships for up to 50 research students across the College; 48 scholarships have been awarded across the UoA1 themes. We have been awarded a number of theme-specific PhD programmes: in infectious diseases the CMBI received a DTA allocation of 5 students (four plus one clinical) per year at its renewal in 2017 from the MRC; 4-Year PhD Programme in Epidemiology, Evolution and Control of Infectious Diseases (3 per annum). In cardiovascular, our BHF centre has 4 associated students; NHLI BHF 4-year MRes/PhD studentship programme, 3 students per annum. In cancer, our CRUK Imperial Centre has two to four studentships per year and CRUK Convergence Science Centre four studentships per year joint with ICR; the STRATiGrad multi-commercial partner supported PhD training programme appoints four PhD students per year.

We also hold the UKRI Centre for Doctoral Training in AI for Healthcare to train 100 PhD students (85 non-clinical, 15 clinical) over 5 years, and started in October 2019. During this REF period, **we have awarded 1406 PhDs**.

Within the clinical arena, we have been awarded the prestigious Wellcome Trust Clinical PhD Programme, the WT/GSK Translational Medicine and Therapeutics Programme, the MRC/BRC Chain Florey Fellowships and the CRUK Clinical Academic Training Programme (four Clinical Research Fellows [CRFs] per year, joint with ICR, and four intercalated PhD students per year). In addition to the Chain Florey programme, NIHR Imperial BRC has fully or part-funded clinical PhDs and CRFs in the following themes: infection and immunity (32), cardiovascular medicine (12), respiratory medicine (4), surgery, anaesthetics and critical care (35), cancer (29), endocrinology and metabolism (14), and a cross-cutting genetics programmes (26).

Internationally, building on our highly successful LKC School of Medicine, we award a joint MBBS degree with NTU in Singapore; we have also developed a PhD exchange programme and post-doctoral exchanges with NTU to attract the brightest graduates. Funded by Imperial College, Research England and NTU in 2019, we will further develop flagship international studentships, expand academic exchange, accelerate frontier research with seed funding, and launch bespoke doctoral programmes in the field of healthcare and technology. Sadly, COVID-19 has delayed implementation of this programme until 2021.

### **2.5.1 Ensuring diverse PGR student recruitment:**

The FoM strives to recruit PhD students in an open and diverse manner, ensuring our opportunities have widespread visibility through conventional and on-line advertising, and targeted advertising through agencies such as “Black British in STEM”. We are also engaged with the British Medical Association racial harassment charter for medical schools. The FoM is also leading the way with the 2eMPower Project – Making STEM (Science, Technology, Engineering & Mathematics) accessible for students with specific learning difficulties. This is a joint project between Imperial (Rankin) and University of New South Wales, Australia aiming to inspire and enable more students who have neurodiverse learning needs, such as dyslexia, developmental conditions like autism, attention/behaviour difficulties like ADHD, or various other conditions to undertake STEM degrees. We have successfully raised £80k to support a range of workshops and outreach activities to support such students (Rankin).

Our interviewing processes are overseen by Departments and require that panel members are trained in unconscious bias, and use processes modelled on HR procedures. Over this REF period, we have recruited 992 full and part-time PGR students, 42%male/58%female with slightly more female students undergoing part-time courses (49.4%male/50.6% female). We have seen small movements in our ethnicity profiles over this period (60% white, 40% BME) compared to (66% white, 34% BME). We recognise we have a way to go to increase our diversity and are trying new approaches. This year, we staged a PG recruitment webinar called “Think Imperial!”, to further improve widening participation rates and diversity. The event targeted UK institutions, and had ~440 students registered, representing 172 institutions, with 65% from the UK being non-Russell group. Based on these figures, and student feedback, this has been judged to be a successful event, which, moving forward, will become an ongoing feature of the FoM PGR recruitment strategy.

### **2.5.2 Supporting our PGR students:**

PGR students are registered in one of our eight Departments, where they are supported by departmental Directors of Postgraduate Studies (DPS) and their Postgraduate Administrators. Here they receive specific research training, and engage in local research, training and support networks, including journal clubs, colloquia, social events and wellbeing activities.

Departmental PGR students are represented by Departmental Student Representatives, who meet on a monthly basis with the FoM Lead for Doctoral Degrees in a forum that ultimately informs Faculty PGR practice and policy. This input has been particularly valuable during the COVID-19 crisis in helping to develop Faculty and College-level student support structures,



exemplified by the Imperial College costed extensions scheme, and the action plans in the HEI Postgraduate Research Experience Survey.

Further professional development training complementing academic studies is integrated into the Imperial College PhD timeline. In the first nine months following registration, PhD students are required to complete an Early Stage Assessment (ESA), which needs to be supported by completing two Graduate School development courses and a Late Stage Review (LSR), carried out between 18-24 months and the completion of a further two Graduate School credits. In addition to the criteria for the ESA, the LSR review is used to assess whether the student will complete within the registration period and provides verbal and written feedback. For the ESA and LSR assessments, all reviewer reports, student feedback and supervisor feedback are discussed and ratified by the FoM Post Graduate Education Committee (PGEC), headed by DPSs, before being returned to the College Academic Registry as completed. At 36 months, students are able to register for “Completing Research Status”, which allows the student a further 12 months continued access to the College, solely for the purposes of writing. While a mandatory minimum of courses is required to pass through the PGR milestones, attendance of additional Graduate School Courses, workshops and retreats is encouraged, and can be accessed at any time during PGR studies. For this REF period our average submission rate (within 4 years of initial enrolment) is 86%. The FoM also provides a series of regular PGR themed meetings and workshops under the heading of “PG Connections”. An example is the “How to be a strong applicant” workshop run with our PFDC.

Most recently, the FoM, in collaboration with the Imperial College Careers Service and our PhD students, has been developing “Attributes and Aspirations” - a new on-line blended learning course that supports students in the process of deciding post-PhD destinations, by aiming to develop a core set of skills and qualities to match their aspirations. Core skills include training in the effective use of professional networking, including LinkedIn, and creating and maintaining personal web pages, together with approaches to career planning via the novel use of career avatars. Core skills augmented with training in Resilience, EDI, Active Bystander, Unconscious Bias, Mental Health First Aiding. Attributes and Aspirations are being trialled by PhD students, and we anticipate roll-out towards the end of 2021.

### **2.5.3 PGT Training and supervision:**

The College’s award-winning Graduate School develops and delivers an innovative and engaging provision ensuring all postgraduate students are provided with excellent professional development training. This complements their academic studies and provides opportunity to develop skills for a range of careers. The Graduate School works with academics and students across College to help build an integrated, interdisciplinary environment and help postgraduates to move on to the next stage in their careers. It has four strategic areas: Supporting World Class Research; Community Belonging and Support; Engagement and Impact; and Developing Students Who Teach. Within this, the Professional Skills Development programme for students provides staged learning to ensure that all postgraduate students acquire basic research skills at the start of their doctoral studies. This includes courses on research integrity, research impact, communications and business skills.

### **2.6 Clinical Academic Training:**

Imperial AHSC set up a Clinical Academic Training Office (CATO) in 2015, with a dedicated team under the leadership of Prof Jeremy Levy, reporting directly to the Dean and AHSC NHS Chief Executives. CATO takes responsibility for the entire academic training path for Health Education England and NIHR funded fellows (foundation doctors, ACFs, clinical lecturers) as well as managing clinical PhD programmes and supporting all clinicians undertaking PhDs. CATO runs a novel 2-year Post-Doctoral Fellowship to support doctors after PhDs before applying for intermediate fellowships. CATO also supports our growing non-medical clinical academic programme, leveraging NHS and BRC funding for Nursing and Allied Health Professional clinical academic leads embedded in CATO. Funded fellowship opportunities have been established for pre-doctoral and postdoctoral clinicians (one-year secondments) to develop their research interests and capabilities, and to apply for further funding. CATO provides a range

of support activities specifically for non-medics across career paths and shared across the Imperial AHSC to allow for shared learning and multidisciplinary collaboration. Some outputs and successes in this UoA include:

- AHSC support for Nurses, Midwives, Allied Health Professions, Healthcare Scientists, Pharmacists, Psychologists – since 2015, five attendees from CATO-delivered AHSC research skills course have secured National Institute of Nursing Research (NINR)-funded Pre-Doctoral Clinical Academic Fellowships.
- ACF/CL next post destinations – 91% of our ACFs have been registered for a higher degree within 2 years of completion of the ACF, of whom ~70% have been awarded a prestigious MRC, Wellcome Trust or NIHR Clinical Research Training Fellowship. In many specialties 100% of ACFs have achieved PhDs e.g. cardiology, renal medicine, endocrinology, respiratory medicine (.
- CL academic retention: Since 2015, 70% of our CLs have gone on to achieve an academic position such as Clinician Scientists, NIHR/Wellcome/BHF or other fellowships or University Senior Lecturers. For example, in cardiology of the last nine CLs, seven are university-appointed Senior Lecturers, one is a Professor, and one a senior academic clinical trialist (in an NHS post). In neurology our five previous CLs have gone on to obtain two MRC Clinician Scientist awards, one followed by an NIHR Professorship, one Wellcome Trust Intermediate Fellowship, and one NIHR Senior Lectureship. Four of our CLs in surgery have become academic Senior Lecturers. Three of four CLs in Endocrinology have won intermediate fellowships, and the remaining one is an NHS consultant with strong research outputs. In paediatrics, academic retention of NIHR CLs has been 100%, producing to date one Professor, one Reader, five Senior Lecturers and 3 Clinician Scientist fellowships. In gastroenterology 11 of 12 CLs have progressed to career clinical academic positions across the UK; three are now professors and 8 have won Clinicians Scientist or other intermediate fellowships.
- Imperial Post-Doctoral Post-CCT Research Fellowships are managed by CATO as part of the Imperial Strategic Support Fund (ISSF) from Wellcome. We invest in medical trainees at the point they might take up Consultant posts and potentially be lost to research. Since inception, awardees have gone on to win NIHR Clinician Researcher award (*Abbara*), secured a Wellcome Clinical Research Career Development Fellowship (*Scott*) and University Clinical Senior Lecturer position (*Pinato*). Other recipients are planning applications in 2021.
- Imperial / Wellcome Trust 4i programme – clinical PhD programme, 2017-2022, managed by CATO. This has proven to be very popular, with very high numbers of strong applicants each year. The first 2017 cohort are just finishing and already two of them have gone on to be awarded clinical lectureships – which is the key intended outcome for developing clinical academic leaders of the future.

In addition, in 2018 Imperial established a new Healthcare Professionals Academic Group (HPAG) and supported a Nursing Professor, bringing together a critical mass of leaders and creating a “home” for Imperial non-medical clinical academics and patient-centred research. HPAG supports growth in research led by healthcare professionals across the AHSC by supporting and expanding inter-professional and multidisciplinary working, providing peer-to-peer and research services support, mentoring and networking opportunities.

### 2.7 Supporting entrepreneurship:

We have a number of mechanisms to develop, support and promote our most enterprising researchers to develop their ideas into business opportunities. This ranges from mentoring and project management support through to funding opportunities. Our Techcelerate programme, now on its fourth cohort, supports researchers to create impact through commercialising research and linking with venture funding (Kelwick, Rodriguez Manzano). To support at an earlier stage, we run “The Wings for Ideas” fund aimed to provide postdocs and fellows with up to £10,000 to work on research that might lead to a new venture, a product, or a prototype. Supported by the Advance Hackspace, the IPC teams and Techcelerate a total of eight projects have been funded.

## 2.8 Equality and Diversity:

Recognising, as a sector, there are issues to overcome in equality and diversity, over the past REF period, we have made substantial changes to support all our staff. We have formally implemented structures at College, Faculty and Departmental levels to ensure that individuals are empowered. At College level, we have established an executive **Equality, Diversity and Inclusion (EDI) Strategy Group, headed by the Provost**, appointed Imperial's first Assistant Provost (EDI) and established an EDI Forum with a broad and representative membership. These new bodies will work closely together to promote the integration of the values of EDI within the whole organisation as envisaged in the strategy document.

The **FoM Culture Initiatives Management Group (CIMG)** reports directly to the Dean and is Chaired by the Vice Dean Institutional Affairs. This Group aims to create an inclusive culture and environment and is involved in shaping strategies, policies and processes, as well as generating resources and improved signposting for students and staff at all levels and career stages. It was formed in 2019 to bring together the numerous activities underway and to develop new approaches. We have also convened a **Black Lives Matter working group**, reporting in to the CIMG, to specifically focus on issues of racial inequalities for students and staff. Recognising the importance of this work, in late 2019, we appointed our **inaugural Project Director to the CIMG** – Dr Sarah Essilfie-Quaye. We have gathered significant baseline data to enable us to measure impact and progress of initiatives to improve culture and/or diversity in our different cohorts – from undergraduate students to senior leadership. Within FoM as a whole, we have a **53%/47% male/female** split with 26.1% of staff identifying as BME. Within this **UoA we have a 67%/33% male/female** split with 75% white, 16% BME and 14% not disclosed. Currently, 80% of UoA1 staff are on open-ended contracts. Of those on fixed-term contracts, 39% are female and 16% BME. We have 17.5% on part-time contracts, of these, 35% are female and 5% BME.

We are developing an action plan to tackle EDI and cultural issues. This incorporates our current baseline data and short, medium and long-term goals and deliverables. All departments are participating in the development of the action plan, which has strong support from the Dean and Heads of Departments. The FoM has also begun to explore new opportunities to better understand why our diversity declines as roles become more senior, and to develop and implement initiatives to improve our culture and access to medicinal sciences for under-represented groups at all levels. We are looking at various options for resourcing a wide-reaching and dedicated position to address these questions directly, through academic research and the development and implementation of new interventions.

At Departmental level, all new departments have a People and Culture lead that sits on the departmental management board. Many also have established People and Culture Committees to implement and manage on the ground delivery of EDI policies. For example, they would take the lead on development of departmental Athena Swan proposals. All our Departments hold an Athena Swan award. Departments of Surgery and Cancer and the Institute of Clinical Sciences hold Athena Swan Silver. Brain Sciences, Immunology and Inflammation, Infectious Disease, Metabolism, Digestion and Reproduction as new departments, hold interim Silver awards while National Heart and Lung Institute and the School of Public Health hold Bronze awards.

Our commitment to EDI across a range of protected characteristics is demonstrated through the College's accreditations (Athena Swan, Race Equality Charter, Time to Change, Disability Confident, AccessAble, Stonewall), and networks (Able@Imperial, Imperial 600, Imperial as One). We are also engaged with the British Medical Association racial harassment charter for medical schools. All three co-Chairs for "Imperial As One", Imperial College London's BME staff network sit within the FoM (Essilfie-Quaye, Samuel, Mitchell).

### 2.8.1 Diversity in recruitment:

As part of the Faculty restructuring, our new Dean (Weber, appointed 2018) adopted the use of the open expression of interest (EOI) recruitment model for the appointment of new Heads of Departments (HoDs) coupled with an open advert. This proved successful and we achieved full gender balance across the HoDs. Our recruitment process is highlighted in our recent campaign

to recruit new lecturers: in 2019 we embarked on a major recruitment campaign across all departments in FoM. The advert was run through software similar to Textio to help attract people from broad communities using language and relevant phrasing suggestions based on current best practice in EDI. The advert was run in science journals and we shared with communities and networks that had recognised strengths in EDI and early career researcher groups (e.g. the British Society of Immunology).

We received 215 applications which were allocated to departments according to preference of applicant for shortlisting. All departments used the same shortlisting criteria and instructions and we gave clear direction on gender balance and EDI for the shortlisting panels. In total, 56 candidates were shortlisted, with 55 accepting interview slots across all of our eight departments. A core interview panel (Vice Dean Research, Vice Dean Institutional Affairs and the Head of the PFDC) was present for all interviews to ensure consistency, the relevant departments were able to select up to three additional representatives with appropriate expertise. We actively managed diversity within and across panels by guiding and prompting changes with the departmental representatives. A consul was included according to Imperial guidelines. We ensured that panel members had undertaken unconscious bias training (56% male/44% female). Our core panel guided the questioning using an open questioning style to promote a discussion rather than a combative Q and A session. Our EDI data were:

	<i>Female</i>	<i>Male</i>	<i>ND</i>	<i>%Female</i>	<i>%Male</i>	<i>total</i>
<i>Applications</i>	105	108	2	49	50	215
<i>Shortlisting</i>	30	26		55	45	56
<i>Interviews</i>	30	25		55	45	55
<i>Offers</i>	8	9		47	53	17
<i>Acceptances</i>	5	7		42	58	12

### 2.8.2 Enabling flexible working:

Flexible working options such as part time working, and adaptable hours help recruit a more diverse staff. Within this return, **17.4% of staff are on part-time contracts** (65% male/35% female) of which 50% are <50. This helps to support those with caring responsibilities as well as cross-institutional working and supporting transition to retirement.

Lockdown has changed the way we all work, and we have had to adjust rapidly. The delivery and impact of our COVID-19 work has shone a light on how we embraced this change. We ensured employees had the necessary equipment needed to work, including attention to relevant health and safety needs. However, the Faculty and the College has always championed flexible and remote working with a commitment to providing a supportive work environment for all. Since 2016, we have run a **shared parental leave** scheme with 35 members of faculty using this so far. We are proud to have been listed in this year's **Top Ten Employers for Working Families** ([workingfamilies.org.uk](http://workingfamilies.org.uk)) and to have won **The Cityparents Best for all stages of Fatherhood Award** (2017).

### 2.8.3 Supporting staff:

The College provides a suite of measures to support staff with for example illness, disability and return from long term absence. This includes developing “**Staying Healthy at Work**” plans, access to 24hour confidential care line and **mental health first aiders** (51 within FoM across all campuses). Each department has a **disability officer** as the first point of contact for staff and students and there is financial support for adjustments to support those with a disability. Within FoM, for example, this has included provision of staff for an individual with a degenerative condition and support for an individual with sleep disorder.

To facilitate return to work after maternity, adoption, surrogacy and/or shared parental leave, the College runs the **Elsie Widdowson Fellowship Award** to enables the Department, Division, School or Institute to relieve the academic of teaching or administrative duties in order to



concentrate fully on research. Within FoM 21 have been awarded. FoM also runs the **Daphne-Jackson Fellowship**, for individuals returning to research part time (0.5 FTE) after a career break. Launched in 2016/17, one fellowship has been awarded (2018) and, after COVID disruption, one awarded outside of the REF period and we are expecting to make further awards in 2021.

#### **2.8.4 Developing career pathways:**

We have been working with colleagues in Manchester (Professor Lennon) and Oxford (Professor McShane) to develop a clear career path for all those undertaking research roles within a Team Science context, including technologists, coordinators and managers. This will encompass all staff, including fixed-term and part-time contracts. We aim to develop a framework for career progression within the FoM with implementation in 2021/2.

#### **2.8.5 Ensuring all staff can attend conferences:**

Imperial offers two routes for financial support for carers attending work-related events taking place outside of College, and for College-based events relevant to career development held outside of core hours or during half-term holidays. The grant can be used to fund additional/alternative care arrangements for a dependent to either stay at home while the staff member travels, or to fund travel and associated care costs allowing the dependant to travel with the staff member.

As part of ongoing work to make Imperial more family-friendly and therefore more inclusive of staff with caring responsibilities, there has been a conscious effort to shift staff events (e.g. public lectures, seminars, workshops, meals with visiting seminar speakers) to more family-friendly dates and times of the day. This is not always practical, and on occasions where events are held late in the day or during school half-term holidays, we facilitate inclusion of employees with caring responsibilities by offering financial support to offset the additional cost of providing care (e.g. babysitting).

#### **2.8.6 EDI considerations in all we do:**

During the recent reorganisation of the FoM (**Fig.1**), the Dean signalled that he would 'look to our Heads of Departments (HoDs) to champion and develop early and mid-career academics, leading by example to create a supportive culture for all staff'. The process was heavily influenced by staff feedback from departmental, Faculty and College level and aimed to embed many principles from our Athena SWAN action plans into reality. This included: the development of smaller departments which will foster greater unity, cohesion, collaboration and identity; transparent job descriptions for the HoDs with a major emphasis on commitment to leadership responsibility, improved working culture and career development. Representation on our senior committees is: Dean's Management Group (responsible for day-to-day running of the Faculty) – 58% male/42% female/; Faculty Board (responsible for strategic direction of research and teaching) – 60% male/40% female/ & Faculty Culture Initiatives Management Group – 42% male/58% female/.

Imperial has established the EDI Centre, a dedicated team to support staff and promote EDI. They offer guidance, training and support as part of the College's HR services as well as striving to mainstream EDI. They run a programme of training including Active Bystander training, Disability in the Workplace, Harassment - confronting inappropriate behaviour, Harassment - the management perspective, a two-day Mental Health First Aid and Mental Health First Aid half-day. Imperial is a *Disability Confident* Leader - Disability Confident is a government scheme designed to encourage employers to recruit and retain disabled people and those with health conditions.

#### **2.8.7 Ensuring EDI in our submission:**

All academic staff are included in the REF submission. Independent research staff were identified as per the College's REF code of practice and are all included in the submission. All these staff were asked to nominate 10 outputs which were scored by a gender-balanced panel

composed of senior academic staff. A computer-based algorithm (agnostic to individual characteristics) was then used to select the outputs based on the assigned scores whilst ensuring each person returned at least one and no more than five outputs. The selected outputs were further reviewed to ensure that outputs with multiple Unit authors were assigned to the most appropriate author. **The overall distribution of outputs matches the submission gender balance and ethnicity.**

### 3. Income, infrastructure and facilities

#### 3.1 Income:

During the REF period, investigators in UoA1 have been awarded just under **£953m in competitively won research funding**, averaging £136m per year and equating to **£310k/FTE/yr**. This yearly average represents a 7.3% increase in comparison to the REF2014 period. We employ a range of coordinated strategies to ensure income generation for research and infrastructure to sustain our programmes, as well as the research field

**3.1.1 Supporting Individuals** through personal fellowships **at all career stages**. We provide mentorship through the departments and via the PFDC, internal peer review at departmental level, strong institutional support tailored to individual needs and reflected in meaningful letters of support, and mock interviews focussing both on science but also presentation skills. Our success has been demonstrated through (former staff not in submission underlined):

- Six Wellcome Trust Senior Fellowships (Lloyd, Ahmed, Wilkinson, Williams, Pickering, Snelgrove)
- Twenty-two Wellcome Trust Investigator Awards (Aragon Alcaide, Asquith, Bangham, Barclay, Bassett, Botto, Brueggemann, Dorner, Ferrer, Grundling, Holden, Lenhard, Maertens, Rutter, Speck, Strid, Thomas, Wigley [x2], Wigneshweraraj, Williams, Zhang)
- Five UKRI Future Leader Fellows (Sancho-Shimizu, *Shenker*, Robinson [UoA14], *Skene* [UoA4])
- 16 MRC fellowships (six Clinician Science Fellowships – Antoniadis, Cunnington, Gale, Seddon, Singanayagam, Turner)
- Five Career Development Awards (*Bidmos*, Denton, Helaine, *Lai*, MacIntyre)
- Four New Investigator Research Grants (*Martinez-Sanchez*, Paras, Shenoy, Tomas)
- MRC LMS Rutherford Fellowship (Guo)
- MRC/UKRI Innovation Fellowship (Peters)
- NIHR fellowships (three Research Professors – Cooke, Dhillon and Gordon; 22 senior investigators; five Clinician Scientists – *Abbara*, Battersby, Saglani, Thayyil, Walsh; two Postdoctoral fellows – Barnicot, Jayasena)
- CRUK Advanced Clinician Scientist Fellowship (Auner); CRUK Career Development Fellowship (Magnani)
- Nine BHF Fellowships (Kanagaratnam [NHS Honorary], *Khamis*, Kirkby, Randi, Rhodes, Rog-Zielinska, Santamaria, Whinnett)
- BHF Professorship (Emanueli)
- Versus Arthritis Career Development Fellowship (Pericleous)
- Sixteen Marie Skłodowska Fellowships (Argunhan, Botella, Blakney, Cerny, Delahaye, Feldhahn, Fleiss, Gahlon, Marquez Rodriguez, Soo, Stefaniak, Scaini, Toussaint, Torraca, Vazquez Ortiz)
- Three ERC Advanced Grant (Johnston, Miguel-Aliaga)
- Two ERC Consolidator (Hajkova, Takats)
- Six ERC Starter Grants (Brown, Dorner, Helaine, Li, Tolar, Vannier [LMS])
- Four Sir Henry Wellcomes: (Lynskey, *Pons Salort*, Sposini, Zhang),
- Twelve Sir Henry Dale Fellowships: (*Aylett*, Borodavka, *Clarke*, *Dorigatti*, *Edgar*, Gomes Cabreiro, Male, Owen, *Pons Salort*, *Ramasamy*, *Riglar*, *Schiering*)
- BBSRC David Phillips Fellowship (Thurston)

**3.1.2 Supporting underpinning research:** we support our investigators to pursue fundamental basic, clinical and translational research in their field through project and programme grants. In this REF period, we have secured 102 grants from MRC to the value of £76m, 86 grants from

the BHF to the value of £42m and 53 grants from CRUK totalling £25m. This includes four New Investigator Research Grants (see above). To improve our success rates, we undertake rigorous internal peer review and have established “**shadow panels**” for all project grant applications to the four standing research boards at the MRC. These comprise ex-MRC Board members who undertake an MRC-style Board review. We ran a pilot with the Infections and Immunity Board (IIB, where we have above average success rates) and the Populations and Systems Medicine Board (PSMB, where our success was much lower). These shadow panels have the remit to encourage younger academics to submit their proposals for iterative constructive criticism and improvement. Since their introduction in 2016/7, figures from the MRC show a marked increase in success rates for PSMB and maintaining our position with IIB. We have now extended this to other Boards at MRC from this year.

Board	2016/17	2017/18	2018/19
Infections and Immunity	35.7%	46.7%	33%
Populations and Systems Medicine	12.5%	31.6%	27%

**3.1.3 Developing strategic opportunities:** We have developed agile structures within the Faculties to identify and respond to new opportunities across our research themes. This is achieved through building partnerships within and across faculties, especially where our researchers can lead through close collaboration internally and externally. Our externally funded centres are highlighted in **section 1.3.2.** with thematic examples highlighted in **sections 1.1.1 – 1.1.6.**

**3.1.4 Funding translational research:** We support translational research through the **Imperial BRC** (BRC; £210m, 2012-2022, Director, Thursz). The BRC drives innovation in the prevention, diagnosis and treatment of ill-health by funding and supporting people- or patient-focused early translational research. Work is split into **eight Research Themes**, each of which represents a substantial portfolio of experimental medicine research, in areas of unmet clinical need. The current themes are: Gut Health (Frost, £8.0m), Brain Sciences (Matthews, £8.1m), Cancer (McNeish, £9.4m), Cardiovascular (Harding, £8.6m), Immunology (Botto, £11.0m), Infection (Openshaw, £12.2m), Metabolic Medicine (Bloom, £8.6m) and Surgery & Technology (Darzi, £11.7m). The BRC also invests in four cutting-edge technology platforms highlighted in **section 3.3.** It has produced a wide range of outcomes from seeding pilot projects to support major international trials. Some examples include trialling novel treatment for menopausal hot flashes (Lancet 2017), new insights into obesity biology, Nature (2015) and novel point-of-care detection of HIV-1 viremia, Nature Scientific Reports (2016). In 2017/18 the BRC leveraged a total of £70.5M external funding to actively supports active projects within the themes. It supports our **Patient Experience Research Centre (PERC, section 4.2)**, underpins our data infrastructure through support for the **Imperial’s Clinical Analytics, Research and Evaluation (iCARE)** project started in Autumn 2019 as a proof-of-concept high performance analytics environment, the Imperial College Knowledge Bank and in partnership with CRUK, set up the Circulating Biomarker Laboratory for ‘liquid biopsy’ in tailoring cancer treatments and monitoring disease progression. Finally, the BRC has been central to our COVID-19 response recruiting patients to the early clinical trials (REMAP-CAP, RECOVERY, C-19 ACS, IASRIC) aiming for every patient with COVID-19 disease admitted to one of our hospitals to be given the opportunity take part in clinical trials or studies (subject to eligibility and consent).

We have established the **Translational Research Fund** built around our MRC Confidence in Concept (CiC) award to seed fund translational projects in preparation for larger awards from external funders. Since 2014, we have supported 150 projects from experimental proof of concept to technology validated in the lab; these projects have subsequently leveraged an additional £94m in follow-on-funding, including over £8.4m from Imperial College; more than 62 patent applications have been awarded/filed, and there are in excess of 214 publications to date. Our translator-in-residence is on hand to support the development of these projects to secure larger external funding. During this REF period, we have won £15m from MRC Development

Pathway Funding (12 awardees), £8m from Seeding drug discovery, Wellcome Trust (9 awardees).

**3.1.5 Fundraising to support specific projects;** working with Imperial alumni, external foundations and donors, our Advancement team raises funds for scholarships, academic positions, research centres and capital projects. This can take the form of unsolicited gifts through to larger donations built around fundraising campaigns. Over this last REF period, FoM has benefitted from 3639 gifts, 3,387 of which were <£10k, 144 were between £10k-£100k, 80 between £100k-£1m, and 28 over £1m. In total, **our generous supporters have raised over £152m** for projects across the Faculty. This includes a £40m donation from Sir Michael Uren to develop the Biomedical Engineering Research Hub, £10m for The Hugh & Josseline Langmuir Centre for Myeloma Research, £2m to support research into the development of vaccines against COVID-19. In 2018/19 we ran a highly successful campaign to develop our School of Public Health which resulted in £25m investment to develop The Mohn Centre for Children's Health and Wellbeing and the Mohn Chair (**UoA2**).

We have established new fellowship programmes thanks to the generous support of our donors. For example, the Jean Alero Thomas Scholarship Programme awarded four new scholarships to students in FoM in 2017/18. The programme was established thanks to a legacy gift from Dr Jean Alero Thomas (Medicine 1970). £4.6m from The Edmond J. Safra Philanthropic Foundation has established scholars and fellowship programmes within neurosciences (**UoA4**) and £5m from the Lees Charitable Foundation Ltd has established the Lee Family - Faculty of Medicine Scholarships.

### **3.2 Infrastructure:**

Following on from our planned investments at our Hammersmith campus highlighted in REF2014, we continue to complete the ambitious FoM 'Space Vision'. Our focus remains to invest in realigning groups geographically to best exploit inter-Faculty and translational opportunities that now offer themselves both at South Kensington and at our Hammersmith/White City campus, and to foster the most effective clinical research and education environments possible.

Since the last REF, we have transformed our estate with an investment of approximately £2bn in our **White City Campus, situated 300m from the Hammersmith Hospital**. This investment has created a thriving hub for our convergent science, developing state-of-the-art facilities to support and sustain multidisciplinary research. The Molecular Sciences Research Hub (£167m) opened its doors in 2018 as the new home for chemistry but with an emphasis on molecular studies. The Sir Michael Uren building (£120m) became operational in 2019 bringing together over 500 engineers, clinicians and scientists to become our main hub for technology development in healthcare. It will house researchers from the UoA1 Surgery, Cardiovascular and Respiratory themes as well as groups from our Department of Brain Sciences (UoA4) and School of Public Health (UoA2).

To support innovation and entrepreneurship, we have created a network of innovation spaces for businesses of all sizes – major corporations, high-tech and high-growth companies, SMEs, start-ups and entrepreneurs – to work alongside Imperial at every stage of their development and growth. The Translation and **Innovation Hub (iHUB)** at White City provides space and facilities for companies of all sizes to work alongside our researchers to accelerate growth. We have also recently (2020) opened the **Scale Space**, 18,000m<sup>2</sup> technology and innovation centre to support new high growth technology companies emerging from this UoA but also more broadly.

In 2017 the MRC and Imperial College London announced a joint project to build a new home for the MRC LMS on the former Cyclotron site at the Hammersmith Hospital campus. This £105m new building will create approximately 12,000m<sup>2</sup> of advanced research facilities in an environment which will provide a **new home for the MRC LMS** in July 2022 and promote further collaboration between LMS and FoM as well as other stakeholders.



In addition to this macro-scale investment, we have also ensured our existing infrastructure remains at the cutting edge. Since 2014, Imperial College has committed **£138m on building and estates projects in UoA1**, with a spend to date of £57m. This includes refurbishment of lab space within the Commonwealth Building on the Hammersmith Hospital campus for cardiovascular, respiratory, metabolism and immunity research. We have invested £10m to purchase the lease for the adjacent Burlington Danes Building. We have also invested £9m refurbishing the Central Biomedical Services (CBS) on our South Kensington campus.

### 3.3 Facilities:

The Imperial BRC **Genomics Facility** provides a 'one-stop-shop' for next generation sequencing (NGS) of human genomes and microarray technology. The includes provision of key staff, access to supporting bioinformatics, data storage and sample preparation (£9.1m, lead Ferrer). In addition, we have invested £1.5m in new equipment and work in partnership with the LMS to maximise the MRC's investment in genomics.

**Imaging:** our researchers have access to state-of-the-art X-ray, ultrasound, Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) through a range of partnerships. Our Clinical Imaging Facility and the Trust's Imaging Department core-funded by the BRC (£9.8m, lead Aboagye) provide access to MRI (Siemens 3T Verio MRI scanner), PET (Siemens Biograph 6 PET/CT scanner), electroencephalography and Transcranial Electric Stimulation, all delivered in partnership with ICHT. We have also built our PET/MRI capability through our partnership with InVicro (formerly Imanova), with a £5.6m machine housed within InVicro on our Burlington Danes site. InVicro provide the staffing to run the machine as well as radiochemistry to develop new PET ligands. We provide additional MRI provision in partnership with MRC/LMS and ICHT. The scanners are chiefly used for cardiac projects, underpinning our genetic/functional insights and have recently contributed to the C-MORE COVID-19 study led by University of Oxford.

We continue to invest in **the National Phenome Centre (NPC)**, delivering an extensive range of molecular-phenotyping capabilities by providing insight into the molecular composition of samples. The NPC employs a multi-technology platform consisting of eight nuclear magnetic resonance spectroscopy instruments, twenty liquid chromatography-mass spectrometry instruments, and new hardware investments in additional mass spectrometry for proteomics and imaging, totalling more than £3m. We continue to partner with Waters plc and Bruker plc to keep us at the forefront of phenomics globally. We also lead the UK Consortium for Metabolic Phenotyping (£2.1m MRC) – a partnership of the UK's research institutions to drive cooperation, collaborative development, and education to advance the UK's biomedical research capabilities.

We have established the **London In Vitro Diagnostics Co-operative**, one of only four NIHR centres that generate evidence to support diagnostic test development. The co-operative is working with both the Medicine and Healthcare Regulatory Agency (MHRA) and the National Institute for Health and Care Excellence (NICE) to expedite development and evaluation of diagnostic devices in the NHS (Director Hanna, theme leads Buckle, Ni, Poulter and Tan).

Our biggest growth area for the FoM across all UoAs has been in data science with demonstrable success in research underpinned by the best facilities. Imperial led the **UK MEDical BIOinformatics** partnership (UK MED-BIO; Elliott [UoA2]) in partnership with the ICR, the European Molecular Biology Laboratory-European Bioinformatics Institute (EMBL-EBI), the Universities of Oxford, Swansea and Nottingham, and the MRC LMS. Our **Data Science Institute (DSI)** provides access to high-performance computing and pioneered the pharma-adopted TranSMART platform to curate and analyse genomic, molecular and other 'omics datasets alongside clinical phenotypic data. We are a substantive site in Health Data Research UK London, a pioneer site for the **NIHR Health Informatics Collaborative (NHIC)** which links routinely collected NHS patient data via electronic health record systems including clinical information, diagnostic tests and imaging data across five NIHR BRCs. We lead the NHIC programme in acute coronary syndrome, linking data on >200,000 patients; analysis of routinely

collected health data on patients presenting with chest pain demonstrated the population significance of a single troponin measurement (BMJ, 2019), and, accounting for potential biases in observational data, we found that surgical was superior to medical treatment for non-ST elevation myocardial infarction in elderly people (Lancet, 2020).

We lead **Discover-NOW** with Imperial College Health Partners as part of the Digital Innovation Hubs funded by HDR-UK and are partners in the BREATHE consortium – the Health Data Research UK Hub for Respiratory Health led by University of Edinburgh. In partnership with Imperial, ICHT won the 2019 BMJ Digital Innovation prize for its natural language processing (NPL) algorithm analysing the NHS feedback tool, the Friends and Family Test, and has developed NPL tools for smoking status and safety which have been adopted locally. Ongoing and planned evaluation of new tools developed by the AHSC include lung nodules (led by the Marsden) and sepsis – our BRC has already evaluated a digital sepsis tool on 21,000 patients. To deliver this level of activity, we have invested in large data handling and analysis facilities, underpinned by the cross-cutting **Informatics & Biobanking** theme in the Imperial BRC core platform (£16.7m, leads, Elliott [UoA2], Mayer, McNeish).

**Data sources:** The FoM works with a multitude of data sources including administrative data, bespoke data collected from deployed digital interventions, clinical trials, cohort studies and multiple qualitative datasets. Administrative data include sources such as Hospital Episode Statistics (HES), Clinical Practice Research Datalink (CPRD) and Whole Systems Integrated Care (WSIC). We have ensured that the infrastructure for collecting, storing and processing these data is secure and works within a solid information governance framework. Specifically, Imperial College has a suite of secure storage and processing facilities with appropriate information security management systems (ISO27001) to accommodate a range of sensitive datasets (de-identified and identifiable data) including the IGHI Big Data & Analytical Unit (BDAU), Data Science Institute (DSI), The Imperial Secure Enclave and Research Computing Service (RCS) environment. The College has an established information governance structure to provide assurance to data providers, the College, research participants and patients, that data are held and used appropriately. The Imperial infrastructure is able to support the entire data lifecycle.

**Data Collections:** Imperial has robust relationships with several large data controllers including NHS Digital (NHSD), MHRA, WSIC and ICHT. ISO 27001 certification and compliance with NHSD Data Security and Protection Toolkit allows Imperial to provide assurance to data suppliers that data are used with the utmost care for the benefit of health and social care systems. Imperial currently holds data covering all English patients including linked data at a person level for hospital encounters, mental health care, general practice consultations, deprivation and registry data for specific conditions e.g. cancer, diabetes. In addition, we have managed the acquisition and linkage of sensitive bespoke mental health datasets within WSIC. All mobile apps used for data collection need to be GDPR compliant with support from Imperial College's Data Protection Officer and Compliance Manager, and meet criteria based on NHS Digital Assessment Questions.

**Data storage and processing:** we have several ISO 27001:2013 certified research environments, including IGHI Big Data Analysis Unit (BDAU). This environment currently manages over **130 datasets** for researchers across Imperial College and ICHT. Other facilities, like the ISO 27001 certified Imperial Secure Enclave, allows the storage of identifiers to facilitate data linkage and secure data analysis. The Imperial High Performance Computing facility provides several world-class supercomputing clusters for performing precision medicine analysis and provide a secure, flexible and scalable platform to support the analysis of our large-scale health datasets.

Imperial's **Clinical Analytics, Research and Evaluation (iCARE)** project started as a proof of concept, high-performance analytics environment, funded by our BRC. This is a cloud-based informatics platform allowing NHS Trust staff and College researchers to access de-identified data with enhanced tooling, compute power and security. This system provides the ability to

manage access control to specific data resources with full audit of every action that staff take when using Trust data.

Imperial holds a **CPRD GOLD license**, with access to over 35 million longitudinal linked patient records. Imperial is also pioneering the analysis of the WSIC dataset which holds data on 2.2 million patients in North West London (NWL) with linked records across primary, secondary, mental health and social care records. The BDAU manages the use of HES and CPRD for Imperial College Healthcare Partners (IChP), allowing IChP to produce dashboards to provide insights across NWL NHS sites. The BDAU also holds a number of bespoke data collections, ranging from data collected as part of the Google Deepmind Streams trial in partnership with ICHT to surveys aimed at evaluating the impact of patient experience for the Care Information Exchange (CIE) across millions of NHS patient episodes in NWL.

**Data Protection:** Imperial provides data de-identification and anonymisation both internally and externally. Research environment staff are trained in GDPR and Good Clinical Practice (GCP/GxP) to meet all legal and ethical obligations. NHS Digital audited the BDAU in 2018 and found that the environment had exceptional security with robust policies and procedures for data protection throughout. The BDAU serves as an exemplar at Imperial College for data governance and currently advises on information governance committees both inside and outside Imperial.

**Data Transformation:** Imperial has robust and reproducible methods for data transformation ensuring that data integrity and availability are maintained throughout research programmes. An original immutable copy of each dataset is stored to ensure integrity of data and enable auditing of changes downstream. Utilising workflow-based tools such as KNIME, visually explorative tools like Tableau and established modules for common coding languages such as R and Python allows researchers and investigators to inspect the data transformation process and ensure that data quality is maintained. We utilise Github and SVN for version control of custom coding where applicable.

**Data Analytics:** Imperial hosts a number of analysis tools such as KNIME, HADOOP and custom natural language processing (NLP) tools. The BDAU uses NLP for the analysis of mental health data. The DSI has leading facilities for data visualisation through its [Global Data Observatory](#) and the Research Computing Services group includes a single cluster with over 25,000 cores and 20TB of memory ([UK MED-BIO facilities](#)). We built the eTRIKS platform as part of a EU Innovative Medicines Initiative (IMI) project to support the full life cycle data management for translational medicine studies. It has been successfully applied in cross-institutional collaborative medical research for big medical data integration and analytics. These include major EU/IMI projects such as U-BIOPRED (asthma), ABIRISK (multimorbidity), BioVacSafe (vaccine and biomarkers) and OncoTrack (cancer): together eTRIKS and U-BIOPRED were awarded the prestigious BioIT World Award for 2014.

Imperial facilitates **Data Sharing and Dissemination** with the wider research community. We work to ensure that data are findable, accessible, interoperable and re-usable (FAIR) for example, the Airwave Health Monitoring Study data are accessible via the MRC-funded Dementias Research platform. The Imperial Academic Health Science Network (AHSN) works with other regional AHSNs to share and utilise data for healthcare research and improvement across the entire UK. For long-term **archiving of data**, we use our Archives and College Records Unit (ACRU) internally; data are also made available through the UK Data Archive and other data portals. Working with researchers we create de-identified datasets for use by the wider scientific community, for example, the iCARE initiative between Imperial College and ICHT that provides de-identified patient-level data to researchers.

### 3.3.1 Facilities and Impact:

Ensuring impact from our translational research has been enabled by co-location of researchers within clinical sites at Charing Cross, Chelsea and Westminster, Hammersmith, St Mary's, Royal Brompton and Royal Marsden Hospitals. More broadly, how we use our facilities

and infrastructure to achieve impact is highlighted in **section 1.6**. In addition, our BRC has provided underpinning support across the FoM through these facilities (**section 3.1.4**), and we have received **£16m benefit-in-kind through the BRC award**. We also continue our fruitful partnership with Waters plc and Bruker plc to access new equipment and keep us at the forefront of phenomics globally.

For the first time since Imperial College acquired Medicine in 1997, we are moving off the original sites to concentrate and co-locate clinical science and public health alongside engineering, physical sciences and the Business School at Hammersmith Hospital/White City campus. We are creating a new, vibrant Life Sciences campus in West London which has already attracted Novartis, 25 biotech spinouts and ScaleSpace – to accelerate the growth of new innovations.

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

##### 4.1 Collaborations:

We have highlighted our strong partnerships with ICHT through our BRC award, our AHSC (**section 1.5**), our co-locations on Hospital sites and our joint appointments (**section 2.0**), highlighted below. Our working relationship was the foundation of the Imperial College AHSC, now expanded to include the Marsden, the Brompton (to Feb 2021), Chelsea and Westminster Hospital and the ICR. Managed by a Joint Executive Group (JEG), comprised of the leaders of the partner organisations and chaired by the AHSC Director (Weber), JEG identifies new initiatives and monitors delivery of joint programmes around the tripartite mission – research, education and clinical care. This close working relationship has already improved and enhanced healthcare through joint research programmes. For example, research at Imperial's **Patient Safety Translational Research Centre** (Director, Darzi) identified key factors in delivering safe and effective clinical care across teams. This led to development of a digital tool, **Hark**, that was subsequently trialled at ICHT where it improved clinical decision times and case management (J Med Internet Res, 2016). Hark was acquired by Google DeepMind in 2016, which further developed its functionality in partnership with Imperial and ICHT, evolving the application into **Streams**, a task management, decision support and alerting smartphone application now in clinical practice worldwide.

We have developed one of UK's leading real-world evidence (RWE) research platforms, **Discover-NOW**, led by our AHSN and based on WISC, which provides an integrated healthcare record linking primary, secondary, tertiary and social care data for 2.4m NW London residents. We are working through **Health Data Research UK (HDR-UK) London** – a national biomedical research initiative with all five of London's major universities in biomedicine and health (Imperial College London, King's College London, London School of Hygiene & Tropical Medicine, Queen Mary University of London, University College London), to develop the London NHSE Local Health Record and Care Exemplar. We are using the NHS partners' informatics platforms, our pipeline of digital and AI tools and the sector's networked pathology and radiology services, to develop and implement integrated clinical diagnostics.

Researchers from Imperial are central to **eight MRC Precision Medicine Consortia** – a £60m investment from MRC to support UK-wide consortia, each focused on a specific disease area, in order to develop a deeper understanding of the mechanisms underpinning disease stratification. We lead the £4.8m Minimising Mortality from Alcoholic Hepatitis consortium (Holmes, Thursz) and are partners in: the £4.1m (total award) Maximizing SLE Therapeutic Potential by Application of Novel and Stratified approaches (Botto, Lightstone, Pickering); the £5.1m Re-Imagine Consortium for prostate cancer diagnosis (Ahmed); £4.1m STOP-HCV (Cooke); £4m STRATA for schizophrenia (Howes); £4.8m UK Primary Biliary Cholangitis Consortium (Holmes, Marchesi); £4.8m Refractory Asthma Stratification Programme UK (Adcock, Chung, Johnston); £4m COPD-MAP (Adcock, Barnes, Chung, Donnelly, Kemp, Tetley). We are also members of the Bill and Melinda Gates (BMGF) Malaria Modelling Consortium (*Hogan, Verity*) and Neglected Tropical Disease Modelling Consortium (*Cucunuba*).



We have built on the success of the NIHR/MRC National Phenome Centre (established 2012) by creating the £2.1m **MRC-funded MAP/UK partnership** in 2018 (Takats) – bringing together a critical mass of methodological, analytical, and computational platforms. Led by Imperial, the team includes eight specialised research centres (Imperial, Cardiff, Leicester, Liverpool, EMBL-EBI, Aberystwyth) and the UK's two Phenome Centres (Imperial, Birmingham) and aims to apply common standards, methods, and best practices to build a national resource benefiting UK researchers. We have partnered with KCL on the **London Medical Imaging and AI Centre for Value Based Healthcare**, a £16m initiative from DHSC and the **Asthma UK Centre for Allergic Mechanisms** (formerly the MRC/Asthma UK Centre, Director, Johnston). Building on our Phenome Centre and mass spectrometry capability, we co-lead the £16m CRUK Grand Challenge – **Rosetta** (Bunch, Takats). This is a partnership with the National Physics Laboratory, ICR, Barts Cancer Institute, The Beatson Glasgow, AstraZeneca, The Francis Crick Institute and the CRUK Cambridge Research Institute and aims to develop a way to visualise metabolites in cancer cells, mapping their distribution in relation to individual cells' genetics and the overarching tumour structure. We are also key partners in innovative public-private partnerships such as the **Vaccine Manufacturing Innovation Centre** consortium with Oxford, London School of Hygiene and Tropical Medicine, Johnson & Johnson, GE Healthcare and Merck and the GSK funded **Experimental Medicine Initiative to Explore New Therapies** (EMINENT) consortium. This brings together investigators from Imperial College, University College London (UCL), the University of Cambridge, the University of Glasgow, the University of Newcastle, and GSK, with unprecedented access to GSK's unlicensed clinic-ready asset portfolio.

Internationally, our collaboration with NTU in Singapore to create a new medical school, **the LKC School of Medicine**, has flourished and our first students graduated in 2018, awarded a joint Imperial/NTU MBBS degree. We have also built our research partnerships, making key joint appointments and visiting positions between our institutions in strategically important areas for both organisations. LKC currently hosts eight senior faculty from Imperial as Visiting Professors (Chung, Paterson, Rutter, Wedzicha [UoA2], Elliott, Riboli [UoA2], Matthews, Reynolds [UoA4]). In a reciprocal move, eight members of LKC Medicine's faculty have been appointed to Imperial – Prof James Best, Prof Naomi Low-Beer, Prof Michael Ferenczi, Prof Helen Smith, Prof Balazs Gulyas, Prof Bernhard Boehm, Prof Wang Yulan, Asst Prof Sanjay Chotirmall. Some examples of our joint research programmes include:

- Health for Life in Singapore (HELIOS) a large population study of 100,000 Singaporeans to understand the role of diet/lifestyle/physical activity/and diseases led by Chambers, Elliott and Riboli (UoA2) and Assoc Prof Joanne Ngeow (LKC).
- E-Health - using e-health tools and technology for health system innovations for quality improvement (e.g. integrated care), and investigation of management of long-term diseases. Led by Car (dual appointment LKC/Imperial) and Majeed (UoA2).
- Cardiometabolic disease – identifying mechanisms underlying high rates of diabetes and cardiovascular disease amongst South and East Asians and developing new strategies for prediction and prevention – led by Chambers (dual appointment at LKC/Imperial, UoA2).
- Cognitive Neuroimaging Centre – established in partnership with Matthews (UoA4).
- Respiratory Health - The Academic Respiratory Initiative for Pulmonary Health is a unique research initiative established by LKC to improve the lung health of Singaporeans. Chung and Wedzicha both serve on the advisory board and have been investigating a novel Singaporean variant of chronic obstructive pulmonary disease.
- Infectious diseases: a tripartite collaboration with LKC, Imperial (lead, Bangham) and the National Centre for Infectious Diseases (NCID Singapore) has pump-primed three joint research programmes in malaria, respiratory viruses and anti-microbial resistance (AMR).

We are actively growing our international partnerships at Institutional level, with strategic partnerships between Technical University of Munich (TUM), and Centre National de la Recherche Scientifique (CNRS), France funded by the Research England International Investment Initiative. As part of this, we have launched the **London-Munich AI & Healthcare**

**Doctoral Training Clusters** with six projects selected. We are also growing our international research collaborations, for example, a new MRC-funded **Korea-UK consortium** Establishing Precision Medicine in Severe Asthma has been established (PRISM; £1.2m Chung); **MRC/Japanese Agency for Medical Research and Development** funded partnership with Kumamoto University (Bangham) and the EU funded **DIAMONDS** consortium (22.5m Euro, Levin) involving teams in Australia, Austria, France, Gambia, Germany, Greece, Italy, Latvia, Nepal, Netherlands, Slovenia, Spain, Switzerland, and Taiwan.

#### 4.2 Public engagement:

Imperial works with a broad array of stakeholders and audiences. We consider our interactions with the public to be key to our continued success. Across FoM, researchers and students have partnered with the public through a range of initiatives and events.

Public engagement (PE) activity	Individuals	Participations <sup>1</sup>
<b>Staff</b>		
Total staff active in public engagement	275	447
Staff participating in centrally organised PE events or programmes (e.g. Lates, Festival)	157	200
Staff participating in centrally organised PE training, awards or seed funding <sup>2</sup>	142	247
<b>Students</b>		
Total students active in public engagement	78	94
Students participating in centrally organised PE events or programmes (e.g. Lates, Festival)	50	54
Students participating in centrally organised PE training, awards or seed funding <sup>2</sup>	31	40

<sup>1</sup>Figures are provided for both individual members of staff, and instances of participation – recognising that some members may have participated in more than one programme or more than once.

<sup>2</sup>Only those receiving awards or seed funding are counted here (as opposed to all nominated).

Funded through our BRC, PERC is a multidisciplinary group of clinicians, public health specialists, social scientists and public involvement practitioners, with strengths in quantitative and qualitative research methods working together to champion Patient and public involvement and engagement (PPIE). Headed by clinical epidemiologist (Ward) and anthropologist (Day, Goldsmiths, University of London), PERC promotes participatory approaches to improving healthcare and biomedical research. It has established the NIHR Imperial BRC Public Advisory Panel to act as a “critical friend” to the Imperial BRC; the ‘Champion Pairs’ scheme where a PPIE Public Champion is paired with a Public and PIE Theme Champion for each of the Imperial BRC’s research themes to offer advice on PPIE; developed innovative ways to get the public interested and involved in research e.g. PPI Cafés, LOL Labs and Maintains a PPI Resource Hub for researchers to provide guidance and further resource. Since 2017, 641 researchers and students, and 91 members of the public, have participated in public involvement training through PERC. PERC have run four small grant schemes to support Imperial NIHR BRC researchers to undertake public involvement and engagement activities to enhance the translation of biomedical research. PERC also manage VOICE, an online platform for public and patient involvement and Engagement. From January 2019 to November 2020, PERC hosted 106 opportunities on the [VOICE online platform](#) that collectively involved at least 628 public members.

**Infectious, Imperial Lates, November 2019:** Over 80 infectious disease researchers and students worked with Imperial’s Public Engagement team to deliver an interactive evening comprising creative workshops, games, exhibits and talks all themed around the fight against infectious diseases. Over 800 members of the public attended throughout the three-hour evening event.

**Body and Mind Zone, Great Exhibition Road Festival, July 2019:** In our *Body and Mind Zone*, part of the first ever Great Exhibition Road Festival, over 100 medical researchers and students gave public visitors an opportunity to experience the ways science is uncovering the inner workings of our bodies.

**People's Research Cafés:** Designed by five Imperial research centres in partnership with patients and members of the public to give the public a flavour of public involvement by giving them the chance to contribute to real-life research projects. We have undertaken nine People's Research Cafés with over 612 attendees.

**Pop-up shops: Heart and Lung Repair Shop (2014) and The Heart and Lung Convenience Store (2015)** in Hammersmith's Kings Mall, London. Over 30 NHLI scientists collaborated with designers and performers to develop the demonstrations for our shop and interactive exhibits. We received over 5000 visitors over two 2-week periods. Events were funded by the Wellcome Trust, supported by The Kings Mall, Hammersmith, Alivecor, and Digital Health Kitchen Fun Kids. The Heart and Lung Convenience Store featured in a Time Out article about the best pop-ups happening in London in October 2015 as well as other local press.

#### 4.2.1 COVID-19 and Public Engagement:

We ran a "Let's Talk About COVID-19" from June 2020, an [online COVID-19 Q&A series](#), delivered in partnership between Imperial's Public Engagement team, PERC and FoM researchers. 700 people participated live, and over 6,000 have watched the recordings. Since March 2020, PERC have involved 4,812 members of the public in a range of [COVID-19 community involvement activities](#) in order to ensure their views, experiences and needs informed Imperial's research, engagement activity and outbreak response. Online, 420 people responded to a community involvement survey where they shared their views, experiences and unmet needs on COVID-19 to guide research. The report [was published on 3 April 2020](#) and shared by Prevention Web, managed by the UN Office for Disaster Risk Reduction (UNDRR). We organised six Zoom calls with 253 members of the public to conduct online discussions to inform COVID 19 research including digital contact tracing, antibody testing, shielding guidance, how COVID-19 is influencing the health and wellbeing of adults living with HIV in the UK, and issues arising from our human challenge study with coronavirus in the UK.

#### 4.3 Contributions to the sustainability of the discipline:

Since 2014, several members of UoA1 have been rewarded for their services to research:

**Queens Honours** Dame Commander of the British Empire (Fisher, Regan); Commander of the British Empire (Donnelly); Member of the British Empire (Levin); Regius Professor (Holden).

**Fellows of the Royal Society:** Bangham, Bloom, Fisher, Reis e Sousa, Stoye)

**Fellows of the Academy of Medical Sciences:** Modi [Council member], Apperley, Barclay, Belvisi, Bennett, Chilvers, Custovic, Donaldson, Ferrer, Ghani, Hallett, Hill, Holmes, Howes, Johnston D, Johnston S, Kroll, Lloyd, Maitland, Merckenschlager, Miguel-Aliaga, Newman-Taylor, Pennell, Reis e Souza, Rosenthal, Seckl, Shattock, Wedzicha, Weber [Council member; chair SC6], Wilkins, Wilkinson, Williams G, Woodward

**EMBO Fellows:** Freemont, Hajkova, Holden, Miguel-Aliaga, Penades, Scott, Wigley, Zhang

**NIHR Senior Investigators:** Alton, Coombes, Davies, Frost, Holmes, Johnston, Sever, Thursz, Wedzicha.

**Wellcome Trust Investigators** (Aragon Alcaide, Asquith, Bangham, Barclay, Bassett, Botto, Brueggemann, Dorner, Ferrer, Grundling, Holden, Lenhard, Maertens, Rutter, Speck, Strid, Thomas, Wigley (x2), Wigneshweraraj, Williams, Zhang)

**Fellow of the US Institute of Medicine** (Darzi)

**EPSRC Council member** (Darzi).

**Our highly cited researchers (Web of Science, top 1% by citations) include:** Barnes (Cross field 2016, 2018, 2020), Johnston, S (2018), O'Garra (2015), Carling (Biology and Biochemistry 2014), Froguel (Molecular Biology and Genetics 2014-2018), Holmes, E (Pharmacology and Toxicology 2014, 2018 and 2020) and Marchesi (Cross Field 2020).

#### 4.3.1 Participation and contribution to peer review process:

**MRC:** Boards (Brown, Freemont, Bangham, Custovic, Harding Haskard, Miguel-Aliaga, Rutter, Stoye, Withers); Training Panels (Carling, Dhillo, Marchesi, Thursz); Translational panels (Bloom, Delaney, Griesenbach, de Silva, McNeish, Weber); Regenerative Medicine Panels (Wilkins [Chair], Harding); Global Challenge Research Fund (Maitland); AMR: (Holmes, Wigneshweraraj).

**BHF:** Council Member (Wilkins); Project Grant Committee (Carling, Cowie, Mason [Chair], Lyon, Whinnett); Fellowship Committee (Randi, Wilkins); Chairs & Programme Grants Committee (Harding);

**CRUK:** Board Member (Fisher); Clinical Careers Committee (McNeish), Early Detection and Diagnosis Research Committee (Hanna), Prevention and Population Research Committee (Delaney); New Agents Committee (Brown [Vice-Chair]); Clinical Trials Awards and Advisory Committee (Gabra); Science Committee (Coombes)

**BBSRC** Research Committee A (Gardiner, Langford); Research Committee E (Wigneshweraraj); General Pool (Knopfel); Grants Panels C and D (Braga).

**EPSRC** Council member (Darzi)

**Wellcome Trust:** Interview Committees: Clinical (Botto, Maitland), Sir Henry Dale Fellowship (Fisher, Strid), Basic Science (Barclay); Science Interview Panel (Lloyd); Seed Awards Grant Panel (Strid); Expert Review Groups: Belvisi, Ferrer, Grundling, Merckenschlager, Strid, Tybulewicz, Williams, Williams G); International Research Scholars Interview Committee: Asquith

**NIHR** Efficacy and Mechanism Evaluation (Alton [Deputy Chair], Lalvani, Thursz, Weber); Health Technology Assessment (HTA) Programme (Ahmed, Davies, Oliver); Research and Innovation for Global Health Transformation (Maitland); NIHR Infrastructure Training Forum (Dhillo [Chair]); NIHR Doctoral Research Training Fellowships Panel (Dhillo); Research for Patient Benefit London Review Panel (Gale, *Jayasena*, di Simplicio); NIHR Senior Investigator panel (Weber).

**ERC** Consolidator Awards Grant Panel (Apperley [Chair], Botto, Frost, Reis e Sousa, Schneider); Advanced Grant Panel (Rutter); Starting Grant (Emanueli, Frost, Harding, Rosenthal).

**Medical Research Foundation** Grant Panel (Botto [Chair]); Emerging Leaders Prize (Altmann [Chair]); MRC-MRF Meningitis Research Foundation (Levin [vice chair]); AMR Doctoral Training Programme (Altmann)

**Versus Arthritis** (formerly Arthritis Research UK): Haskard, Kelleher, Murphy, Mason [Chair]

**Other:** Academy of Medical Sciences, Newton International Fellowship committee (Botto); Action Medical Research (Johnson, Srisakandan); Bloodwise (Dyson, Farrell, Karadimitris), Crohn's and Colitis UK (Marchesi); Deutsche Forschungsgemeinschaft (DFG), Member of grant review panel (Grundling); Diabetes Research UK (Frost, Froguel, Rutter); Fondation pour la Recherche Médicale (FRM), Funding Committee (Pelicic); Genesis Research Trust (Bennett, [Chair]); Kidney Research UK (Lightstone [Trustee], Tam); National Institutes of Health (Imami McClure, Rueda, Rutter, Shattock); NC3Rs Grant Assessment Committee (Ebbels); Novo Nordisk Foundation Funding Committee on Non-Diabetic Endocrinology (Williams, G); Royal Society Selection Committee Member (Hajkova); Canada Foundation for Research (Adcock); Polish executive government agency of National Science Centre (Wojciak-Stothard).

#### **4.3.2 Contribution to external bodies (NHS, Government, Industry, learned societies, not exhaustive, listed alphabetically by organisation):**

Academy of Finland, Research Council for Health (Ojala); All Party Parliamentary Group on Malaria (Cunnington); American Association of Cancer Research (Auner, Pinato); American Society for Microbiology (McClure); American Society of Colon and Rectal Surgeons (Murphy J); American Society of Virology (White R); American Thoracic Society (Donnelly); American Venous Forum (Davies); Asthma UK (Fleming [Chair]); Biochemical Society (Li J, Maertens, Pardo); Bone Research Society (Bassett [Executive cttee]); British Association for Cancer Research (Ali, Bevan); British Association of Urological Surgeons (Mayer); British HIV Association co-Chair of research and education committee (Fidler); British HIV Association Expert Group on Hepatitis (Cooke [Chair]); British Lung Foundation (Chilvers [Chair]); British Nutrition Foundation (Frost [Governor]); British Orthopaedic Research Society (Abel); British



Paediatric Respiratory Society (Davies [Chair]); British Society for Haemostasis and Thrombosis (Crawley [President]); British Society Haematology (Cooper [Trustee]); British Society for Immunology (Culley [Chair – Finance Sub-committee, Trustee and Treasurer]); British Thoracic Society guidelines for investigation and management of patients with bronchiectasis (Kelleher); Cancer Treatment Research Trust (Pinato); City & Guilds of London Art School (Kneebone); Clinical Advisor to the Chief Medical Officer (Pregnancy and neonates, *Mullins*); Coalition for the Advancement of a Vaccine Against Group A Streptococcus. HRC New Zealand/ NHMRC Australia initiative (Sriskandan); Diabetes UK, Clinical Studies Group (Oliver); European Academy of Allergy and Clinical Immunology (Shamji [Chair - Research and Outreach Committee]); European Association for the Study of Diabetes, Fellow (Andrew); European Association of Urology (Mayer); European Crystallography Association (Chayen [vice Chair]); European Medicines Agency, Guideline on the evaluation of medicinal products indicated for treatment of bacterial infections' (Drobniewska [co-chair]); European Respiratory Society (Donnelly); European Society of Emergency Medicine (*Nijman*); European Society of Intensive Care Medicine (Patel B); European Space Agency (Chayen); Faculty of Clinical Informatics (Mayer); Fellow of the Faculty of Intensive Care Medicine (Antcliffe); Fellow of the Royal Biological Society (Pardo); Fellow of the Royal Society of Chemistry (Rueda); Genetic Technologies Contact Group, Royal Society (Freemont); Genomics England Clinical Interpretation Partnership (GeCIP) for Respiratory Medicine (Shovlin [Chair]); Guideline Development Group for NICE Clinical Guidelines on Non-Alcoholic Fatty Liver Disease (*Mullish*); HSE Biosafety Strategic Forum (Robertson); HSE Scientific Advisory Committee on Genetic Modification (Contained Use; Skinner [Chair]); HSE Workplace Expert Health Committee (Cullinan); International Retrovirology Association (Taylor G); International Society for Human and Animal Mycoses (Armstrong-James); International Society of Magnetic Resonance in Medicine (*Niellas-Vallespin* [Chair]); Invited as an Expert Member on rapid diagnostics - UK response to COVID-19 outbreak, UK Parliament (*Rodriguez Manzano*); Joint Committee on Vaccination and Immunisation (Kroll); Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK, Confidential Enquiry (Sriskandan); Metabolomics Society (Ebbels, [Secretary]), NC3Rs (Langford, Tregoning); National Medical Research Council (NMRC) Singapore (Edwards M); National Institute for Health and Care Excellence (Davies [external advisor]); Pre-exposure Prophylaxis Policy Group (Fidler); Prostate Cancer UK (Bevan); Royal College of Art (Kneebone); Royal College of Obstetricians and Gynaecologists (Regan [President]); Royal College of Pathologists Ethics Committee (Cook T [Chair]); Royal College of Pathologists Joint Committee on Genomics in Medicine (Herberg); Royal Society of Biology (Rankin); Royal Society of Chemistry Fellow (Dumas, Ebbels, *Posma*); Scientific Advisory Committee on Genetic Modification (Contained use), HSE (Langford); Scientific Steering Committee on Antimicrobial Resistance for Academy of Medical Sciences (Holmes); Society for Endocrinology (Bassett [co-Chair], Franks, Murphy Sam); Society for Gynaecological Investigation (Bennett); Society of Critical Care Medicine (Komorowski); The Acid Fast Club (mycobacteria; Robertson [Treasurer]); The Global Agenda Council on the Future of Computing, World Economic Forum (Veselkov); UK Government Health and Safety Executive (Buckle); United Kingdom and Ireland Liver Pathology Research Committee (Goldin); United Nations Convention on Biological Diversity advisor (Freemont); United Nations FAO / World Health Organisation Expert Consultation on Risk Assessment of Food Allergens (Turner); US Centers for Disease Control and Prevention (Dorigatti, Walker); US President's Malaria Initiative (Walker); WHO Committee on Selection and Use of Essential Medicines (Cooke [Chair]); WHO Core Components for Infection Prevention and Control Programmes: Guideline Development Group, (Holmes); WHO Global Outbreak Alert and Response Network (GOARN, Tudor-Williams); WHO Sepsis Alliance (Maitland); WHO Working Group on RSV Vaccine Standardization and Clinical Evaluation (Chiu); World Health Organisation, COVID-19 and Pregnancy Cohort Research Working Group (*Mullins*).

#### 4.3.3 Partnership with other Universities:

Examples of our national and international collaborations are in **section 4.1**. In addition, some examples of **visiting professorships** include: Capital University, Beijing, China, (Bourne T); Kyoto University (Bangham); LSHTM, visiting fellow (*Nijman*); McGill University Canada (Cordeiro); National University of Singapore, (Freemont); Università degli Studi del Piemonte

## Unit-level environment template (REF5b)

Oriente Amedeo Avogadro (Pinato); University of Marseille (Cobb); University of Ioannina, Greece (Tzoulaki); Nanyang Technology University Lee Kong Chian School of Medicine, Singapore Visiting Professor (Chung, Rutter, Wedzicha), Taipei Medical University (Chung), Justus Liebig University, Giessen, Germany - Liebig (Wilkins), Visiting Researcher, Kings College London (*Bernardino de la Serna*).

**4.3.4 Examples of editorships and membership of major editorial boards, include:**

Acta Diabetologica (Dumas); American Journal of Respiratory & Critical Care Medicine (Belvisi, Custovic, Maher, Wedzicha); AIDS (Winston-O'Keefe); Blood (Randi); Blood Coagulation and Fibrinolysis (McKinnon, Editor-in -Chief); BMC Bioinformatics (Ebbels); BMC Developmental Biology (Dean); BMJ (Cooke, Holmes); British Journal of Pharmacology (Coen, MacLeod [Editor]); Cancers (Kypta); Cardiovascular Research (Terracciano); Cell Metabolism (Ferrer); Cellular Biochemistry (*Allsopp*); Clinical Endocrinology (Editor, [Dhillon], Jayasena); Clinical Mass Spectrometry (Want, Editor); Current Opinion in Cell Biology (Braga); Diabetes (Ferrer); European Journal of Immunology (Wilkinson); ESC Heart Failure (*Foldes*); Frontiers in Cell and Developmental Biology (Fisher, Field Chief Editor, *Bernardino de la Serna*); Frontiers in Endocrinology (dos Santos Cebola); Frontiers in Immunology, Molecular Innate Immunity (Botto); HIV Medicine (Cooke, Fidler); ISRN Genetics (Porter); Journal of Allergy and Clinical Immunology (Shamji); Journal of American College of Cardiologists (Cardiovascular Imaging, Pennell); Journal of Biological Chemistry (Rutter); Journal of General Virology (O'Hare); Journal of the American College of Nutrition (*Posma*); Kidney International (Cook T); Lancet Respiratory Medicine (Chung, Maher); The Lancet Child and Adolescent Health (Custovic); Methods (Li, J, Editor); Microbiology (Grundling); Molecular and Cellular Proteomics (Chai); Oncogene (Ali, Stebbings); PLoS One (Auner, *Bernardino de la Serna*, Tregoning, Winston-O'Keefe); PLoS Pathogens (Bangham, Cunnington, Johnston); Radiology (Rockall); Scientific Reports (Auner, Azuara, Coen, Dumas, Johansson, Kyrgiou Quinlan, Stebbings, Weber); Science Immunology (Lloyd); Thorax (Davies, Hopkinson, Jarvis, Quint); Vaccine (Altmann).

**4.3.5 Examples of fellowships, named lectures and awards received by our staff include (not exhaustive):**

American Institute of Ultrasound in Medicine (AIUM), Honorary Fellowship (Bourne); American Thyroid Association Sidney H. Ingbar Distinguished Lectureship Award (Williams, G); British Cardiovascular Society James McKenzie Medal for services to British cardiology (Cowie); British Society Colposcopy and Cervical Pathology, Jordan/Singer Research Award (Kyrgiou); British Society of Gastroenterology, Young Gastroenterologist of the Year (*Vergis*); British Society of Gastroenterology, Young Gastroenterologist of the Year – Clinical & Translational Science (*Mullish*); European association for the study of diabetes, Albert Renold Prize (Ferrer); Helmholtz International Fellow Award (Fisher, Wedzicha); Hong Kong Society of Nephrology (Tam); Honorary fellowship, American College of Obstetricians and Gynaecologists (Regan); Jedlik Anyos Award (Hungary, Takats); NIHR Academic Clinical Lectureship (Patel); Society for Endocrinology Medal (Dhillon); Society for Endocrinology, Early Career Basic Science Prize (*dos Santos Cebola*); Society for Endocrinology, Early Career Prize (*Owen*); Society for Neuroendocrinology, Michael Harbuz Prize For Young Investigators (*Owen*); Society of American Gastrointestinal & Endoscopic Surgeons (SAGES), Gerald Marks Rectal Cancer Prize (*Alexander*); Sylvia Lawler Award 2016, Royal Society of Medicine, 2016 (Pinato); US National Academy of Medicine (Regan); World Summer Davos Conference, 40 World Young Scientists (Li, J); European Federation of Immunological Societies Medal (Openshaw); European Respiratory Society Lifetime Achievement Award (Bush); European Respiratory Society Gold Medal for COPD (Adcock); European Respiratory Society Maurizio Vignola Gold Medal in Asthma (Custovic); Founding Fellow of European Respiratory Society (Alton); Tenovus Medal Lecture for outstanding biomedical science (Boyle); TEDx Talk (Dorigatti); Trudeau Medal, American Thoracic Society (Barnes); Fellowship of the American Thoracic Society (Barnes, Chilvers, Donaldson); NIHR Lead Investigator Award Commercial Trials (Davies J); British Society for Rheumatology, Heberden Oration and Medal 2018 (Mason); Phadia Allergy Research Forum (PhARF) Award (Turner); Fellow of American Association of Physicians (Barnes); Fellowship of the European Society of Cardiology (*Ng, Khamis*); Fellowship of the Academy of Sciences and Arts of Bosnia and Herzegovina (Custovic).

**4.4 Contribution of our clinical colleagues:**

Partnership with the NHS is critical to our mission. Since REF 2014, we have formalised clinical academic training through CATO and, in recognition of their importance to our research, Imperial introduced the title of Professor of Practice in 2016. The Clinical Professor of Practice title recognises outstanding contributions to the College in the field of research and education. We currently have 66 Professors of Practice based within our AHSC partners. In addition, we have 246 honorary staff within UoA1. These are able to apply for research funding through their host department and our NHS honorary staff have raised £48m research income. Some notable examples include Professor Jaspal Kooner who leads the LOLIPOP cohort and South Asia Biobank funded by the Wellcome Trust (£5.2m), Professor Jamil Mayet leads our NHIC cardiovascular programme and Professor Tricia Tan has been funded £2m to study obesity and metabolic medicine (NIHR, NovoNordisk). Our NHS partners also have a wide portfolio of collaborative commercial trials (£16m per year) led by senior clinicians and key opinion leaders and enabled by their patient populations, including nationwide referrals.

As well as the direct contribution to research, their contribution to Faculty life cannot be overestimated. They have been involved in 9 of our impact case studies across the Faculty. Our highly successful CATO is run by Professor of Practice Jeremy Levy, Mary Wells is the Lead Nurse for Research at ICHT and a Professor of Practice in Cancer Nursing at Imperial College, leading the development of clinical academic careers and research in nursing and midwifery.