Institution: King's College London
Unit of Assessment: 1 - Clinical Medicine
1. Unit context and structure, research and impact strategy

1.1 Overview

King's Clinical Medicine (UoA1) research transforms understanding of disease mechanisms and enhances patient care across most medical and surgical specialities, including cardiovascular medicine, infectious diseases, hepatology, gastroenterology, rheumatology, nephrology, urology, transplantation, dermatology and oncology. It operates across scales, from molecular and genetic to physiological and population, and is highly multidisciplinary.

Clinical Medicine includes **181.95 fte principal investigators** (PIs; 191 headcount) with **£293.6m** income and **667.5 fte PhD/MDRes students** in the REF2021 cycle. Building upon previous achievements, strategic new investments in infrastructure, capacity-building and research since REF2014 have delivered internationally-leading outputs and impact relevant to health and disease locally and globally.

1.2 Mission

Our **overall aims** are to deliver world-class bench-to-bedside interdisciplinary research programmes, closely integrated with the clinical services of our partner NHS Trusts in order to accelerate clinical innovation that improves health and supports commercialisation as a route to impact, economic growth and sustainability.

1.3 Context and structure

King's Clinical Medicine is organised into 6 inter-connected sections, focusing on areas of significant unmet medical need and cutting-edge scientific enquiry: **Immunology & Microbial Sciences**, **Cancer**, **Cardiovascular Medicine**, **Genetics**, **Dermatology**, and **Stem Cells & Regenerative Medicine.** Each is based on multidisciplinary teams with relevant critical mass and expertise. These sections are based within the **Faculty of Life Sciences & Medicine** (FoLSM), alongside population health (UoA2), women & children's health and our TwinsUK cohort (UoA3), biosciences (UoA5), and health engineering & imaging sciences (UoA12) – ***Fig.1.1***. FoLSM was formed in 2014 through merger of medical and bioscience faculties to enhance interdisciplinarity and line of sight between fundamental and clinical research. **Research connectivity** among FoLSM groups is driven by an overarching interdisciplinary School structure (***Fig.1.1***).

Our DHSC/NHS-accredited Academic Health Sciences Centre, **King's Health Partners (KHP)** (*Section 4*), is a crucial enabler for Clinical Medicine's research and impact mission. Biomedicine-focused groups including Clinical Medicine are **co-located on the clinical-academic campuses** of Guy's & St Thomas (GST) and King's College Hospital (KCH) NHS Foundation Trusts, which deliver extensive high-quality community and specialist clinical services.

KHP serves an extraordinarily diverse population, from the local densely populated, ethnically diverse and socio-economically deprived South London boroughs to wider networks reaching into Kent. Health challenges tackled by Clinical Medicine are therefore locally, nationally and internationally relevant (e.g. COVID-19 outcomes related to comorbidities/deprivation/ethnicity), with potential for far-reaching impact.

The **broader context** for the work of Clinical Medicine includes **research & commercialisation** activities with industry partners, **pan-London** national and international academic partnerships, and **innovation** within the South London Academic Health Science Network (Health Innovation Network).

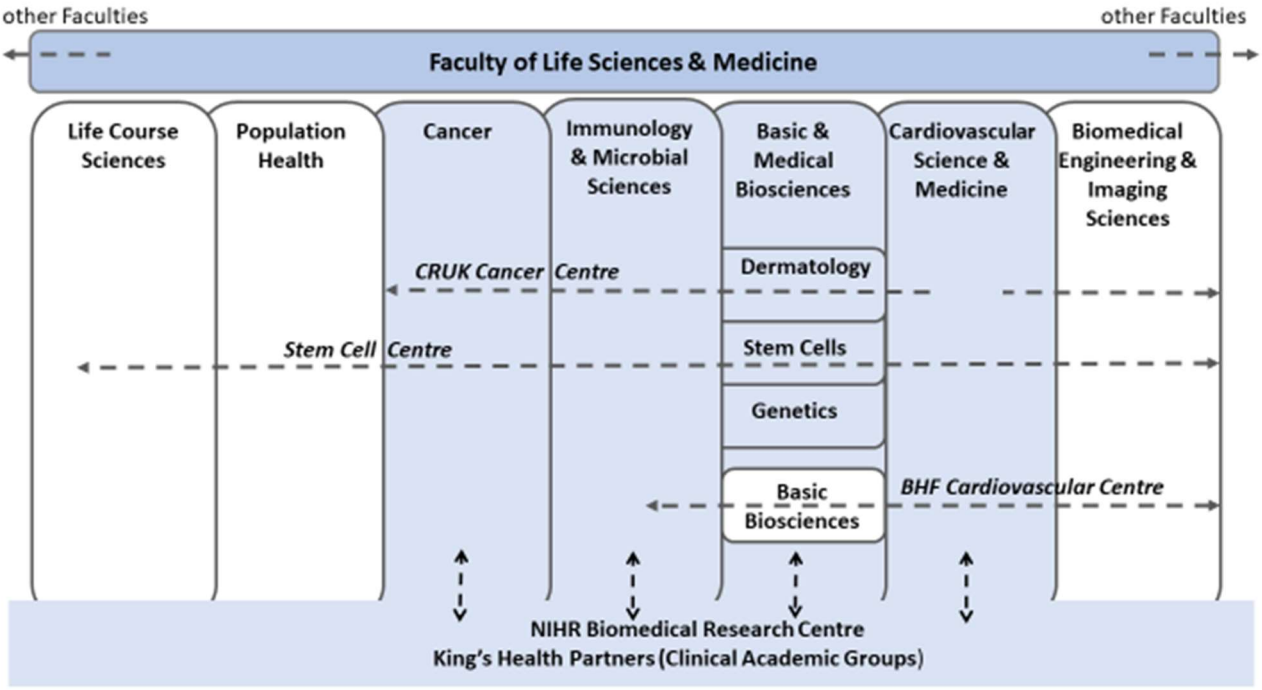


Figure 1.1. Clinical Medicine Sections submitted in UoA1 (blue shading). The Faculty has seven interdisciplinary Schools. Examples shown of Centres spanning multiple sections and UoAs.

1.4 Overarching research and impact strategy

Six pillars (A-F) underpin our strategy for Clinical Medicine. Each of these has benefited from significant investment and strengthening during the REF2021 cycle.

A. Line of sight from discovery research to the clinic.
We emphasise **bi-directional connectivity** between **strong fundamental and translational research** to address major questions and deliver **clinical impact**. Enabling mechanisms include:

- **Co-location of research and clinical services** allow physical proximity between academics, clinicians and patients. For example, genetics laboratories embedded in our hospitals have facilitated rapid introduction of new precision diagnostics; our Comprehensive Cancer Centre combines healthcare delivery with research in a single building.
- **KHP clinical-academic groups/institutes** integrate research with clinical services to generate synergy and foster an academic ethos. They have matured significantly since REF2014, with the Cancer and Cardiovascular Institutes (established 2015) driving operational integration of clinical/research portfolios and facilitating complex clinical trials and strategic appointments.
- The GST-King's **NIHR Biomedical Research Centre** (**BRC,** renewed 2016) is a **major catalyst** to accelerate research translation. Clinical Medicine sections provide the leadership for 6 (of 9) BRC themes.

B. Cross-cutting interdisciplinary collaboration.
Horizontal integration across discipline boundaries within and beyond Clinical Medicine – including biosciences, physical sciences, engineering, computing, social sciences – capitalises on the diverse strengths at King's to add value, build capacity, and increase competitiveness. Enabling mechanisms include:

- **Cross-cutting Centres** provide platforms for synergy. Centres led from Clinical Medicine include the CRUK Cancer Centre (established 2017), BHF Cardiovascular Centre (renewed 2019), Research England (RE) Advanced Therapies Accelerator (opened 2019), Centre for Stem Cells & Regenerative Medicine, and Centre for Inflammation Biology & Cancer Immunology. Centres led from other areas but with strong Clinical Medicine involvement include the Innovate UK AI Centre for Value Based Health Care (established 2019) and the

Wellcome/EPSRC Medical Engineering Centre (renewed 2017). Centres use competitive pump-priming awards to incentivise new collaborations which typically lead to external peer-reviewed awards.

- **BRC Clusters** on Advanced Therapeutics & Experimental Medicine and Precision Medicine (established 2016) bring together researchers based on experimental approaches and technologies, e.g. first-in-human cell therapy trials, PET-based treatment stratification (UoA1 impact case study).
- **Interdisciplinary PhD programmes** enable co-supervisors in different groups and with different expertise to build new collaborations.

C. Sustainable critical mass.
We aim to develop and/or recruit the best researchers and clinical academics at all career stages, stimulate research ownership and independence, and maintain vitality (*Section 2*).

- **Recruitment at internationally-leading level** during the REF2021 cycle includes Trembath (ex-QMUL, genetics, now Vice-Principal), Hubbard (ex-Sanger, bioinformatics, HDR-UK London co-director), Giacca (ex-Trieste, cardiac regenerative medicine, ERC Advanced Investigator), Brown (ex-Queensland, genetics, BRC Director), Ali (ex-UCL, gene/cell therapy, Director of MRC/LifeArc Gene Therapy Innovation Hub), Sasieni (ex-QMUL, cancer prevention, Director of Clinical Trials Unit) and Lawrence (ex-INSERM, cancer/immunology, GSK Immunology Catalyst professorial fellow).
- **Early career researchers (ECRs)**. Equal importance is placed on a robust pipeline of ECRs. During the current cycle, 42 Intermediate (postdoctoral) Fellowships have been supported within Clinical Medicine.

D. Cutting-edge core facilities and infrastructure.
Widely accessible, state-of-the-art core facilities are essential in maintaining a vibrant multidisciplinary environment and enhancing horizontal integration.

- Total investment during the REF2021 period is c.£203.1m, including many facilities supporting Clinical Medicine (*Section 3*).
- New developments led by Clinical Medicine include an MRC-funded single cell functional genomics facility and the Gene Therapy Innovation Hub; mass spectrometry-based targeted metabolomics; expansion of immune-phenotyping; a robotic high content screening facility.

E. Strategic alliances to drive impact.
These are key components in **accelerating progress, fostering commercialisation and delivering impact** (*Section 4*).

- **Institutional alliances** directly relevant to Clinical Medicine include the Frances Crick Institute (Crick) and the pan-London Advanced Therapies consortium (now becoming national).
- **Focused academic alliances**, e.g., a King's-Technische Universität Dresden *TransCampus* (*Section 4.5*), the Comprehensive Cancer Centre with Tata Memorial Centre (Mumbai), and the BHF Centre with the Göttingen Heart Centre (*Section 1.7*).
- **Commercial partnerships**. Our preferred model is to embed partners or spinouts among Clinical Medicine sections in the heart of our campuses. Examples include UCB (cancer immunology), Unilever (cardiovascular/dermatology/regenerative medicine), GSK (oncology/advanced therapies), Celgene (haemato-oncology), Siemens (MRI), GammaDelta Therapeutics (cancer immunotherapy), Quell Therapeutics (Treg therapy).

F. Supportive academic culture.
Underpinning all activities is an emphasis on **inclusion, diversity, staff development and wellbeing** (*Section 2*) which we believe is essential for sustainable high-quality research.

- Clinical Medicine **enhances and embeds** university-wide/FoLSM **policies** in all aspects of academic life through dedicated Diversity, Development and Inclusion (**DDI**) **leads**, driving dissemination of good practice and training.
- Specific mentorship schemes support **female ECRs** and **ethnic minorities**, resulting for example in an increased proportion of female academics promoted to senior positions.

- We provide **leadership training** at multiple levels, including our *Leading Researchers* and *Emerging Researchers* programmes.
- **Public engagement** aligns to the King's Vision 2029 principle of "Service-to-Society". Clinical Medicine researchers undertake diverse public engagement activities, e.g., with local schools with students from minority communities, and through our flagship venue Science Gallery London.

1.5 Progression to impact and delivery

Complementing the six pillars described above, specific measures to enhance impact include dedicated support/funding for IP/licencing and commercialisation; King's-funded industry partnerships managers and translational research managers; and a range of strategic funding schemes such as the Genesis Fund (*Section 3*). The King's Policy Institute (*REF5a*) provides an ideal vehicle for wider impact.

Early success of Clinical Medicine towards generating impact is evidenced by the number of first-in-human and investigator-led clinical trials during the REF2021 period, including >15 Advanced Therapeutic Medicinal Product trials (cell/gene therapy). In total, there were 418 clinical studies initiated, with 837 active studies at census date (***Fig.1.2***).

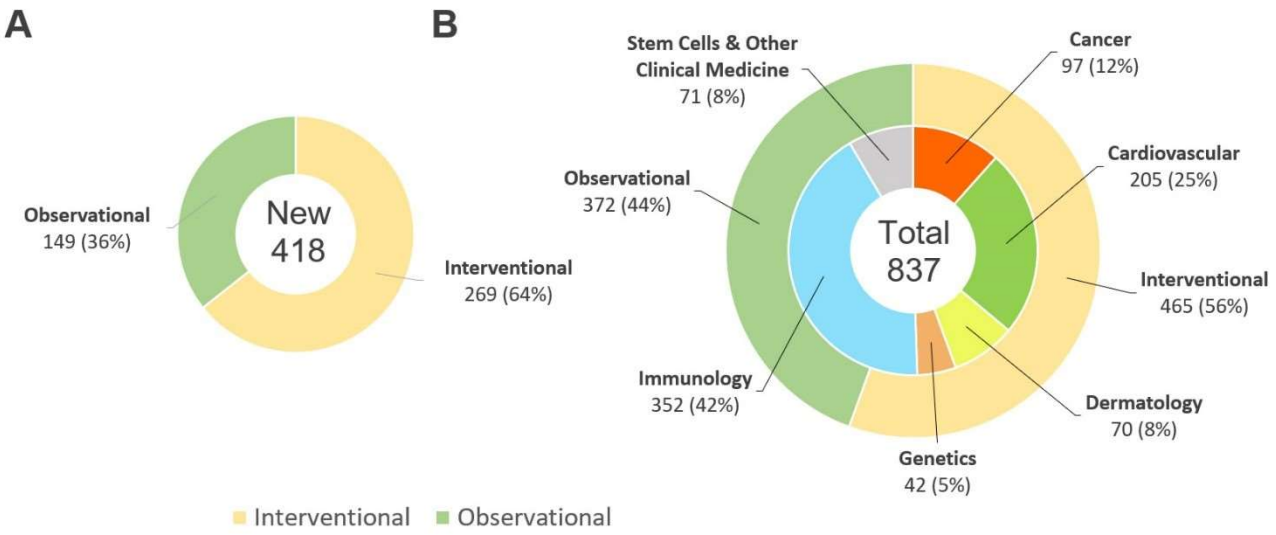


Figure 1.2. Clinical trials that (A) started (B) were active during REF2021.

Success at later stages of the translational pipeline is evidenced in our longlist of 28 candidate impact cases, 10 of which are included in our submission. The submitted cases illustrate contributions of our research to peanut allergy prevention, human papilloma virus screening, reduced HIV transmission, management and control of sepsis, mapping COVID-19 transmission, and control of *Clostridioides difficile*. They also include impact through transformational robotics in urology, bladder Botox treatment, lymphoma imaging and genetic testing for leukaemia. Non-submitted examples relate to cell therapies, gene vector development, breast cancer diagnosis, and wider economic impact through start-up companies.

1.6 Effect of COVID-19 and the response of King's Clinical Medicine to the pandemic

Our specialisms placed us at the centre of the COVID-19 response, which affected >3,000 patients across KHP during the initial outbreak. Clinical Medicine PIs undertook additional **clinical leadership and service responsibilities** (e.g. intensive care, respiratory, cardiovascular medicine, nephrology, general internal medicine) and contributed to **sector-leading outcomes** for the KHP NHS Trusts: GST with the lowest and KCH the third lowest COVID-19 inpatient mortality rate

nationally. Academic staff (Edgeworth/Zuckerman/Neil/Martinez Nuñez/Malim) played a major role in **establishing expanded pillar-1 COVID-19 testing** and KCL student and staff testing (KCL-TEST) as part of the National Testing Strategy, helping deliver a safe environment on KHP clinical-academic campuses.

The collaborative interdisciplinary environment at King's allowed Clinical Medicine academics to **respond rapidly through research** to the major challenges posed by COVID-19, interacting with diverse partners to answer key questions and urgently disseminate the findings to impact promptly on the pandemic response. An example of the agile response was the rapid establishment of an ATCSA schedule 5 containment facility to study SARS-CoV2 infectivity and biology. As of submission date, Clinical Medicine researchers had published **136 peer-reviewed articles on COVID-19** covering the entire spectrum from discovery research and clinical trials to public health policy; the majority were interdisciplinary.

The relationship between **immune signatures and disease severity** was elucidated by a Clinical Medicine/Crick/KHP collaborative effort (led by Hayday/Shankar-Hari/Edgeworth), followed by identification of specific signatures in **cancer patients** (Irshad/Hayday). A **druggable pathogenic mechanism** underlying SARS-CoV2-induced epithelial cell syncitia formation was identified through a multidisciplinary team (led by Giacca). We described the immune-phenotype in children with **multisystem inflammatory syndrome** related to COVID-19 (Shankar-Hari/Malim). The relationship between **ethnicity**, hospitalisation and mortality was dissected in the first case-control study on the topic (led by Shah). We characterised **neutralising antibody responses** (Doores) and the utility of **lateral flow assays** (Edgeworth). A novel in-house **clinical informatics** pipeline (Cogstack.org) was employed to derive ultra-rapid real-world answers to key questions, e.g. the safety of ACE inhibitors (Shah).

Clinical Medicine PIs also established and/or participated in **clinical trials** (e.g. TACTIC [Cope/Galloway], convalescent sera [Shankar-Hari], ACCORD) and advised companies (e.g. UCB, Alexion) on trial design. The global impact of the **"COVID-19 Symptom Study"**, which has recruited >4m people (UK/US/Sweden) is described in a Clinical Medicine Impact case study.

Whilst our research teams mobilised rapidly to contribute to the COVID-19 knowledge base, there was significant **disruption** in other research areas due to government lockdowns, travel restrictions, workplace social distancing, halting of clinical research, disruption of animal work, redeployment to clinical duties, and caring responsibilities. We supported our non-independent postdocs and research assistants through fully paid furlough leave, and research students through stipend extensions, interruptions and other measures. Among 333 postdoctoral research staff aligned to Clinical Medicine, 154 (46.2%) were furloughed for periods up to 5 months. For those not furloughed, 83 (24.9%) interrupted their normal activities to support research/service work on COVID-19.

1.7 Research sections and areas

We describe below the focus, achievements and future plans for each Clinical Medicine section. Although organised by section, there is extensive research connectivity among sections (e.g. 133 collaborative grants [***Fig.1.3***]), and with research in UoAs2/3/4/5/12 (*Section 4*). Most research Centres mentioned below include PIs from multiple sections, including those external to Clinical Medicine. The key research strands that span Clinical Medicine sections are discovery research (molecular, cell biological, genetic, tissue and functional genomics models); precision medicine; human experimental medicine & advanced therapies; and clinical trials, big data & epidemiology.

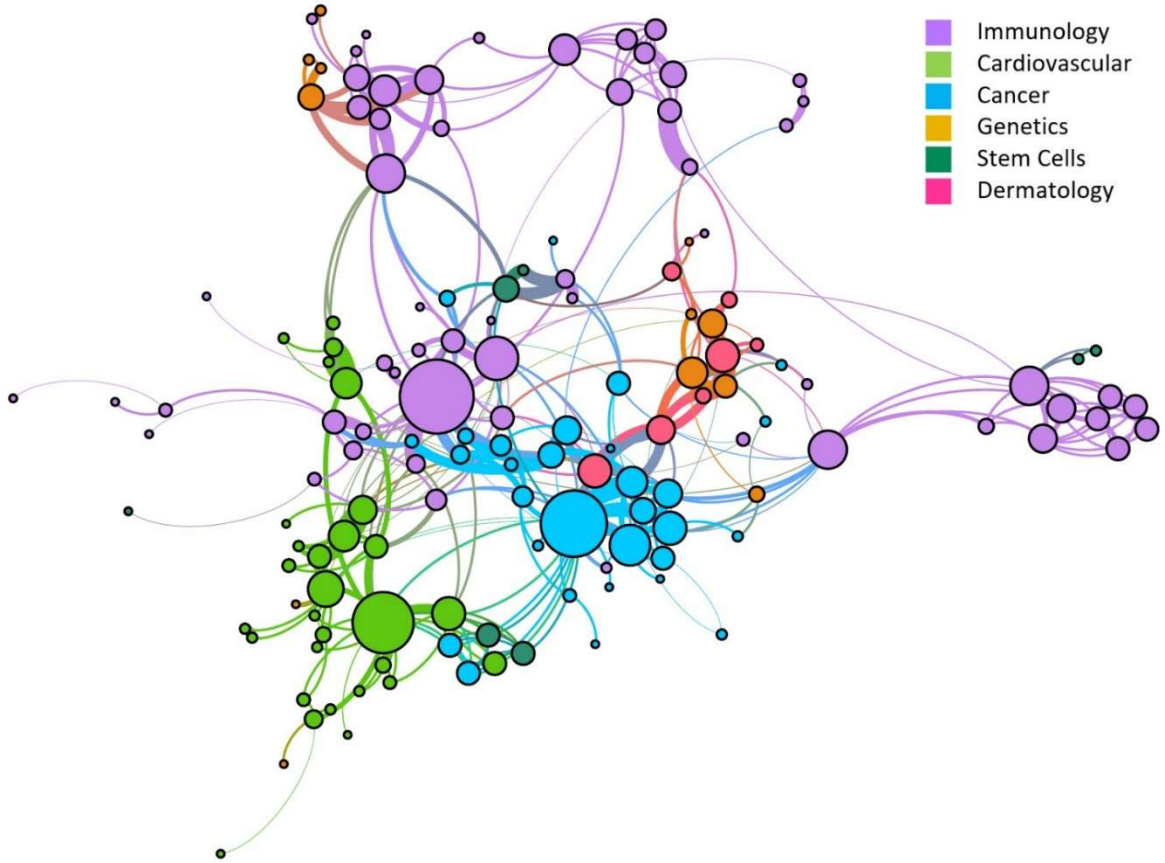


Figure 1.3. Joint research grants across Clinical Medicine sections during REF2021. Threads indicate linked grants, node size reflects number of links. *N.B. BRC collaborations omitted for clarity due to the large grant volume.*

1.7.1 School of Immunology & Microbial Sciences (SIMS)

SIMS (Head, Malim FRS FMedSci) has 63.3 fte PIs. Its programmes integrate basic, translational and clinical research on host-pathogen interactions and the function of the immune system in health and disease. Malim and Sacks are BRC Theme leads for Infection & Immunity and Transplantation, respectively, while Taams is BRC Cluster Lead for Precision Medicine.

Fundamental research within SIMS has significant breadth and depth, including basic mechanisms of viral pathogenesis (Malim/Neil/Doores/Swanson), antigen processing and presentation (Mishto/ Guermonprez/Barral), tissue inflammation and repair (Taams/Sanchez-Fueyo/Santos), autoimmunity (Cope), tumour immunity (Hayday/Lawrence/Spencer) and transplant immunology (Lombardi/Dorling/Sacks). Translational programmes (including clinical trials and outcome assessment) leverage research across these fundamental areas and link to clinical services and specialities through Centres:

- Clinical Infection & Diagnostics (lead, Edgeworth);
- Inflammation Biology & Cancer Immunology (lead, Taams);
- Rheumatic Diseases (leads, Cope/Galloway);
- Asthma & Allergy (lead, Hawrylowicz);
- Nephrology, Urology & Transplantation (leads, Dorling/Sharpe; MRC Centre [2007-19]);
- Liver Sciences (lead, Sanchez-Fueyo);
- Infection & Immunity (lead, Neil).

Notable achievements since REF2014. Fundamental research on regulatory T cells (Tregs) has supported early experimental medicine studies in inflammatory bowel disease (led by Lord/Powell), upscaling of GammaDelta T cell production for therapeutic immunomodulation (Hayday) and forming

related companies - Quell (Sanchez-Fueyo/Lombardi) and Adaptate (Hayday). Category C (CatC) staff contributed highly cited studies on kidney cancer genomics (O'Brien/Swanton) and organ reperfusion techniques (Heaton/Jassem). Investigator-led trials of immune-tolerance induction in Type I diabetes are underway (Tree/Peakman). Programmes on allergy and autoimmunity altered health policy affecting large numbers of individuals at risk of peanut allergy (Santos/Turcanu) or rheumatoid arthritis (Galloway/Cope). Advances in robotic surgery and localised Botox therapy (Dasgupta) involved pioneering work with maths, engineering and cancer departments, and have significantly benefited people with urological disease. Contributions of SIMS investigators to COVID-19 research (e.g., pathogenesis/immunity/diagnostics) are highlighted in *Section 1.6*. SIMS investigators (Lombardi/Sanchez-Fueyo) led the establishment of RE-funded London Advanced Therapies and the RE Advanced Therapies Accelerator (Lord). We have attracted excellent ECRs on personal Fellowships (e.g. Odendall/Warnatsch/Mischo/Safinia/McPhail) or Lectureships (e.g. Kochl/Martinez Nuñez/Galao/Apolonia/Mukhopadhyay/Mishto). We have a programme in the highly-prestigious GSK Immunology Catalyst scheme (Lawrence).

Future direction. We will continue to expand our integrated immunology programme, addressing how subcomponents of immunity interact and are dysregulated in diverse pathologies, including responses to infection, cancer, and the emerging areas of neuroinflammation and chronic disease. Our new ATCSA schedule 5 containment facility will support work to tackle the challenge of emerging virus infections, with enhanced collaboration with Oxford Nanopore Technologies on metagenomics to characterise and track new pathogens of global importance (Edgeworth/Neil). We will complete ongoing investigator-led trials in autoimmune diabetes, transplant rejection, liver, bowel and joint diseases. We will extend cutting-edge cellular imaging to detect and target immune responses in different pathologies (Martin-Serrano/Padilla-Parra/Agromayor/Barral). Our recently awarded Wellcome PhD programme in Neuro-Immune interactions (lead, Taams; linking to internationally renowned King's neuroscience) will drive collaborative research with other King's foci of excellence.

1.7.2 Comprehensive Cancer Centre (School of Cancer & Pharmaceutical Sciences)

The Comprehensive Cancer Centre (CCC; Director, Ng FMedSci) has 36.4 fte PIs. Major transformation since REF2014 includes a purpose-built £160m clinical-academic facility at Guy's (2016) and establishment of a CRUK Centre (Directors, Parker/Hayday; 2017). This complements the NIHR Experimental Cancer Medicine Centre (ECMC, renewed 2016; Director, Spicer), the Breast Cancer Now Research Unit (BCN, renewed 2019; Directors, Tutt/Grigoriadis), and the CRUK/EPSRC Comprehensive Cancer Imaging Centre (CCIC). New partnerships include the CRUK City of London Centre (CoLC, 2018) and the National Cancer Imaging Translational Accelerator (2018).

The CRUK Centre combines core cancer expertise with strengths in immunology, high resolution imaging, artificial intelligence (AI) and advanced therapies. Its focus is on how the tumour microenvironment instructs tumour progression (e.g. Arnold/Ciccarelli/Burchell). BCN focuses on triple-negative breast cancer, work that led to the licensing of PARP inhibitors and new phase III clinical trials of MPS1 inhibitors. The Haematology Institute at KCH (Director, Mufti) focuses on age-related haematological malignancy, with £20m recent funding from Celgene. Other CCC industry partnerships include GSK and UCB. Cancer genomics, epidemiology, cancer imaging and immunotherapy are also areas of focus.

Notable achievements since REF2014. CCC has attracted excellent new PIs including Sasieni, Irshad (CRUK Clinician Scientist), Quek (MRC Clinician Scientist) and Patten (MRC CARP). ECMC has delivered Phase 1 clinical trials of immunotherapies, antibodies and cell-therapies developed at King's. With KHP-CRUK, ECMC is driving development of human engineered T cells (CAR-T) for solid malignancies (Maher, NCT01818323), while CAR-T are also being developed for haemato-oncology. CCIC have identified new mechanisms of treatment-resistance through formation of HER2/HER3 dimers (Parker/Ng), amenable to screening for potential stratification of patient responses (UoA5 Impact Case Study). An imaging technique (MR elastography) developed with UoA12 promises enhanced detection of breast cancer lymphatic spread (Purushotham). The

GMP production of viral vectors for gene therapy in multiple trials across KHP and elsewhere (Farzaneh) has been substantially upscaled. The CoLC award leveraged establishment of a CRUK Radiation Research Unit (£14M) with new recruits (Kong/Ferreira). Cervical screening investigated by the Cancer Prevention Group (Sasieni) has informed UK policy (Clinical Medicine impact case study on HPV typing [Rebolj]).

Future direction. We will blend learning and therapeutic discovery between haematological and solid tumours. Programmes on CAR-T cells and PARP inhibitors will assimilate with immune monitoring in a new focus on early detection (backed by a recent major CRUK award), precision treatment and post-treatment surveillance. The myeloid malignancy team (So/Dazzi) are working with the newly appointed immune monitoring/bioinformatics team (Napolitani/Karimi) to integrate knowledge of solid and liquid tumours treated with immunotherapy. Maher/Arnold are developing hypoxia-activated CAR-T for patients with solid tumours. Collaborations with the Crick on replicative stress/DNA damage response (Parker), nuclear envelope remodelling (Carlton) and exosome release (Ng) will be expanded to inform precision therapy. We have established a partnership with the Institute of Molecular Immunology (Milan) on genome integrity and tumour microenvironment, aiming to develop clinical trials through our Joint Oncology Clinical & Translational Research Hub (KCL-GSK).

1.7.3 School of Cardiovascular Medicine & Sciences (Cardiovascular)

Cardiovascular (Head, Shah FMedSci) has 45.3 fte PIs (including three BHF Professors) and forms the academic core of the KHP Cardiovascular Institute. Shah leads the BRC Cardiovascular Theme and Chowienczyk is Director of our BRC Clinical Research Facilities.

Research activities are anchored in the King's BHF Centre of Research Excellence (competitively renewed 2019-24) which integrates core cardiovascular expertise with state-of-the-art in vivo imaging and bioengineering (UoA12), biophysics (UoA5), computing and informatics (UoA4/12), as well as addressing metabolic and inflammatory mechanisms with other Clinical Medicine sections. A particular focus is to direct non-biomedical and non-cardiovascular expertise to cardiovascular questions. There is ongoing investment in cutting-edge technological platforms (e.g. proteomics/ metabolomics/high-content screening). Research programmes include heart failure (Shah/Otsu/Okonko), myocardial regeneration & protection (Giacca), myocardial ischaemia (Perera/Marber/Redwood), muscle cell biology (Ehler), vascular cell biology (Shanahan/Zampetaki), redox signalling (Burgoyne/Rudyk/Shah), proteomics & biomarkers (Mayr), inflammation (Brain/Ivetic), vascular stiffness (Chowienczyk/Webb), peripheral vascular disease (Smith/Modarai/Patel/Saha) and experimental medicine (Chowienczyk/Shah). There is an increasing focus on clinical informatics (Zakeri/Shah) in collaboration with the Centre for Translational Informatics (UoA4, Dobson). Industry partnerships include Boston Scientific, Unilever, GSK, AstraZeneca and Abbott.

Notable achievements since REF2014. Heart failure discovery programmes identified new mechanisms underlying sterile inflammation (Otsu), stress/survival signalling (Shah) and metabolic reprogramming (Eminaga/Shattock/Nabeebaccus/Shah). Novel blood biomarkers for myocardial ischaemia (Marber) and imaging markers to predict heart failure outcome (Chowienczyk) received BHF Translational Awards for further development. Mayr identified novel miRNA signatures (licenced to TAmiRNA) and a proteomic signature for symptomatic atherosclerotic plaques. Giacca published seminal work on miRNA-induced cardiomyocyte regeneration in pigs *in-vivo*, with high translational potential, adding to prior collaborative work on hypoxia/redox mechanisms (Shah/Giacca, with Sadek [USA]). Human *in-vivo* studies revealed new phenotypes of coronary microvascular dysfunction (Perera). There were extensive productive collaborations in cardiovascular imaging (UoA12), e.g. a clinical trial of MR stress perfusion to diagnose coronary disease (Perera/Shah/Marber). Locally nurtured talent promoted during REF2021 includes Mayr (BHF Professorship), Modarai (BHF Senior Fellowship) and Perera (Professor). We have attracted outstanding ECRs on Personal Fellowships (Stroud/Eminaga/Burgoyne/Rudyk/Zampetaki/

Barallobre-Barreiro/Zakeri/Nabeebaccus; ~50% female). Our BHF 4-year PhD programme and a DFG-funded Joint PhD programme with the University of Göttingen were successfully renewed.

Future direction. A major focus is heart failure (HF), pursuing four inter-related themes: (a) therapeutic targets at the intersection between redox signalling/protein turnover/autophagy/ metabolism; (b) mechanobiological mechanisms, including those relating to inherited disorders (e.g. sarcomeric/nuclear lamina proteins) that may provide insights into "common" acquired HF; (c) novel imaging methodologies to aid patient stratification; (d) clinical signatures/predictors of HF outcome to aid personalised management. External partnerships with the University of Pennsylvania (human HF biobank, heart metabolism) and Göttingen (engineered heart tissue/stem cells) will support this work. The programme in heart regeneration will move towards clinical translation, high content screening discoveries in cardioprotection will be commercialised (2 spin-outs recently launched), and a nascent programme in *in-vivo* gene editing will be expanded (Giacca). We will invest further in data science and harnessing electronic health records to drive our work on personalised treatment. Finally, the recent incorporation of the Royal Brompton & Harefield NHS Trust within KHP significantly increases the scope for clinical impact across the sector.

1.7.4 Molecular & Medical Genetics (Genetics)

Genetics (Head, Hubbard) has 19.95 fte PIs and is a department within the School of Basic & Medical Biosciences (SBMB). Trembath heads the BRC Genomics Theme, Brown is BRC Director, and Ali BRC Deputy Director and Director of the MRC/LifeArc/BBSRC Gene Therapy Innovation Hub.

Research encompasses common complex and rare genetic diseases, epigenetics, gene therapy, and genomic and functional studies in cancer, with rich expertise in statistical genetics, bioinformatics and genomics. Programmes in complex genetics include inflammatory bowel disease (Prescott), lupus (Vyse/Cunninghame-Graham/Morris) and psoriasis (Capon, with Dermatology), with leading roles in international consortia (*Section 4*). The recruitment of Brown has enhanced immunogenetics research, including arthritic/bone disorders. We have continued to build capacity in functional genomics and epigenetics (Oakey) with new recruits working on prenatal growth, imprinted genes, and gene-environment interactions (Charalambous/Holland). Capacity in bioinformatics has been strengthened through national and regional data initiatives (e.g. HDR-UK in 2018; KCL lead, Hubbard). MRC Bioinformatics Career Development Fellow, Hodgkinson, has developed a successful programme in mitochondrial genomics. An HDR-UK Fellow (Dand) works on integration of genetic and clinical data for chronic disease stratification, strengthening work on psoriasis through the BioMAP consortium (Dermatology). The recruitment of Ali brings internationally-leading expertise in gene/cell therapies for retinal disorders and advanced therapies more broadly.

Notable achievements since REF2014. We have facilitated the adoption of whole genome sequencing (WGS) by the NHS through the 100,000 genomes project and Genomics England (Hubbard, 20% seconded). The long-standing collaboration with GST Clinical Genetics Services has progressed to full integration, with GST becoming an NHS Genome Medicine Centre (2014) and hosting one of seven NHS Genomic Laboratory Hubs. This facilitated the integration of research and clinical trials on acute myeloid and promyelocytic leukemia (Dillon/Solomon) with one of the first deployments of WGS for cancer in the NHS. Similarly, we have pioneered interpretation pipelines for clinical exome sequencing, linking to Genomics plc (a Genomics England-sponsored spinout directed by Simpson [0.2 fte]), and collaborations with the Crick (Dias) on rare intellectual disability disorders. Trembath co-leads East London Genes and Health, a large community-based genetic cohort study with a focus on ethnicity and now incorporating the Born-in-Bradford cohort (*Section 4.2.7*). PIs have contributed statistical genetics expertise to studies on large internal/external cohorts, e.g. TwinsUK, UKBiobank (Lewis). Genetics has also made significant contributions to education, e.g. a Health Education England-commissioned Genomic Medicine MSc (Capon/Hubbard).

Future direction. As the identification of causal genetic variants improves, gene therapy will become increasingly important for personalised medicine. The recruitment of Ali and Pearson is linked to the creation of the **Centre for Cell and Gene Therapy** and the newly-awarded Gene Therapy Innovation

Hub. Ali will head the new **RE Advanced Therapies Accelerator** (King's/GST BRC), to deliver a therapeutic pipeline from pre-clinical proof-of-concept to first-in-human studies (including a recent £4m MRC DPFS award for ES-derived photoreceptor transplantation) and commercial development, linking closely to other Clinical Medicine sections. There will be a strategic drive to develop and test polygenic risk scores in common diseases (Brown), collaborating with other UK BRCs and leveraging our co-leadership of East London Genes and Health.

1.7.5 Centre for Stem Cells & Regenerative Medicine

The Centre (Director, Watt FRS FMedSci), also within SBMB, has 11 fte PIs – an increase of 5 from 2014. It provides the nucleus for a network of over 48 PIs across the King's health faculties, connected through access to dedicated core facilities, seminar programmes and a renewed Wellcome PhD programme in Advanced Therapies for Regenerative Medicine (lead, Spagnoli).

The core work of the Centre integrates fundamental stem-cell biology and bioinformatics with translational work on organs including the skin, liver, pancreas, prostate, bone and neuronal systems. It examines interaction between the immune system and stem cells during homeostasis and injury. **Stem Cell Hotel** houses platforms for high-throughput image analysis and phenotypic screens of living single cells and organoids, and dedicated collaborative laboratory space. Physical proximity to the Cell and Gene Therapy Catapult and membership of **London Advanced Therapies** allows scientists, companies, investors and professionals to accelerate innovation for clinical benefit. The Centre hosts a team from Orchard Therapeutics (gene therapy) amongst other collaborations. It offers strategic support to research on the interplay between intrinsic and extrinsic cues that regulate stem cell function during health and disease (e.g. cancer). There are extensive collaborations with material and tissue engineering, chemistry, mathematics and physics.

Notable achievements since REF2014. Outputs with potential for clinical innovation include: Engineering hepatocyte niches to restore liver function (Rashid); Understanding molecular heterogeneity of human iPSC, essential for tissue engineering, disease modelling and use in personalised medicine (Watt/Danovi); Generating nerve-muscle circuits from pluripotent stem cells to model neuromuscular disease (Lieberam); Identifying signalling pathways that control pancreatic progenitor identity, relevant to type-1 diabetes (Spagnoli); Identification of cells that originate pancreatic adenocarcinoma (Sancho); and Characterising new signalling pathways that control prostate cancer cells (Ahmed). The Centre has developed novel technologies resulting in patent applications (Watt/Habib/Ahmed); their clinical development plans include subpopulations of human skin fibroblasts that could improve wound healing (Watt), and Wnt 'bandages' that could promote bone repair and enhanced fracture healing (Habib).

Future direction. The Centre will continue fundamental and translational studies, strengthening interdisciplinary teams, and collaborating with clinicians to develop trials and bring regenerative technologies closer to the clinic. The priorities are: engineering next-generation pancreatic organoids for regenerative-medicine and mapping cell identity during liver and pancreas development; using stem cells to study human placental development and polyploidy in disease pathogenesis; engineering niches of human bone, joints, lungs and liver for drug screening, disease modelling, and cell transplantation to restore organ function; modelling degenerative neuronal diseases; and targeting signalling pathways (e.g. Wnt) in cancer. Our renewed Wellcome PhD programme will, by definition, create new interdisciplinary teams. The skin and bone healing discoveries will enter clinical investigation in wound healing and bone repair, respectively.

1.7.6 St John's Institute of Dermatology

The Institute (Head, McGrath FMedSci) and its 6 fte PIs and associated CatC staff are part of SBMB. Barker heads the BRC Dermatology Theme while McGrath leads the BRC Cluster on Advanced Therapeutics & Experimental Medicine. A recent independent RAND assessment ranked St John's as the leading UK clinical-academic centre for dermatology.

The four key research areas are cutaneous oncology, i.e., melanoma and cutaneous lymphoma (Karagiannis); genetic skin disorders (McGrath/Jackow); inflammatory skin disorders (Barker/DiMeglio/Flohr/Capon[Genetics]); and skin-environment interactions (Flohr/Di Meglio). CatC staff include Whittaker/Smith (cutaneous oncology), Mellerio (genetic skin diseases), Tziotzios (hair diseases), Lynch (cell therapy), Mahil (stratified medicine) and Pink (clinical trials).

An interdisciplinary discovery approach underpins therapeutic targeting and early-phase clinical trials, including biologics and cell/gene therapy. Work on the effect of immune microenvironment on tumour growth and novel therapies has led to spinout companies, e.g. IGEM Therapeutics/Epsilogen (Karagiannis; UoA5 impact case study), and a Research Tissue Bank for skin lymphoma. Likewise, a bioresource has been created for psoriasis (BSTOP) to aid disease stratification. Dermatology has also established international registries for psoriasis and atopic dermatitis, accessible by patients and physicians (PsoProtect and PsoProtectME, SECURE-AD). In epidermolysis bullosa, first-in-human studies of cell/gene-based therapies have led to larger NHSE-sponsored trials. PIs also provide major input into national/international clinical guidelines.

Notable achievements since REF2014. The psoriasis bioresource now has tissue samples from >30,000 patients from >60 centres nationally, used for highly cited outputs describing, e.g. genetic contribution and stratified therapeutic targeting. The discovery of two such targets (IL36, TYK2) led to phase-3 clinical trials (Pink). PIs lead on immuno-modulatory therapies on the UK-Irish register for atopic dermatitis (Flohr) and co-lead the global inflammatory skin disease consortium (BIOMAP, Horizon 2020, Smith/Flohr/Barker). Institute teams identified the molecular mechanisms of 4 new Mendelian skin diseases (McGrath) and contributed to setting up a national rare skin disease diagnostic facility in the GST Genomic Laboratory Hub (McGrath). With Cancer**,** IgE-based immunotherapy for solid tumours has been progressed to early clinical testing (Karagiannis/Spicer). IGEM Therapeutics (Karagiannis) won an OBN Annual Award for Best Start-up Biotech in 2018. The lymphoma group established the functional significance of gene aberrations in T-cell signalling, genomic instability and ultraviolet light on mutational burden.

Future direction. The major focus will be patient stratification, treatment selection and the development of novel therapies incorporating leads from biological and GWAS studies, e.g. in psoriasis (Barker/Smith/Di Meglio/Capon) and acne vulgaris (Barker). Exploitation of personal devices and AI systems will be incorporated into patient assessment/management, initially in psoriasis and atopic dermatitis (collaboration with Lynch). Dermatitis research will incorporate new cross-disciplinary projects on environment-host-skin-microbiome interactions (Di Meglio/Flohr). For genetic skin disorders (McGrath/Jackow), the priority will be to progress gene editing and stem cell mobilisation to early phase clinical trials. The antibody discovery team will complete the IgE trial studies and develop new immune-enhancing antibodies against cancer cells. Researchers will continue to engage with patient groups, e.g. through the Psoriasis Association and Cure EB.

2. People

2.1 Overview of staffing strategy

We aim to maintain international competitiveness by attracting and retaining the best staff and students to work in a fulfilling and supportive environment, with strong focus on mentoring, career development and research culture.

Clinical Medicine takes a proactive approach to **equality, diversity, and inclusion** (**EDI**), recognising this as integral to our success. We build upon a FoLSM **Athena Swan Silver award** (2018; incorporating prior individual awards for Clinical Medicine sections), a King's-wide **Race Equality Bronze Charter Mark** and **Stonewall's Diversity Champions** membership**.** The appointment (2016) of a FoLSM **Vice-Dean for Diversity, Development & Inclusion** (**DDI**, Shanahan), **DDI Director** (Carboo) and creation of **School/section-level DDI committees** (Clinical Medicine leads, Brain/Lempp) has provided a strengthened framework to support enhancement and embedding of DDI principles in our work, as illustrated throughout this section.

We also lead research focused on the relationship between ethnic & socioeconomic diversity and health, e.g. in COVID-19 (*DOI:10.1016/j.eclinm.2020.100574*).

2.2 Workforce

On the REF **census date**, Clinical Medicine had 191 (181.95 fte) Category A (CatA) academics, including 28 ECRs, and 112 CatC academics. Among **CatA** staff, 38.2% were female and 61.8% male, while 20.9% were from minority ethnic backgrounds (minorities). Among **ECRs**, 54% were female and 46% male, with 17.9% minorities.

The proportion of **female** Professors increased from **20.3%** (13/64) in 2012/2013 to **25.4%** (18/ 71) in 2019/2020; female Readers from **31.3%** (5/16) to **46.1%** (12/26); and female Lecturers from 50.0% (12/24) to 52.8% (19/36). The number of minority Professors was unchanged while minority Readers increased from **18.7%** (3/26) to **23.1%** (6/26). We attribute the progress to date to a proactive and structured approach to enhancing DDI within Clinical Medicine, involving multiple complementary initiatives described in the rest of this section. Given our ongoing commitment, we expect to see continued improvement.

2.3 Recruitment, probation and retention

We are rigorous in ensuring all aspects of the recruitment process are fair and inclusive. Recruitment panels must be diverse and transparently constituted, and are monitored systematically to address non-compliant areas. Panel members must have attended **Diversity Matters** training (*Section 2.12*). Clinical Medicine uses the King's Inclusive Recruitment Tool, which guides managers on ensuring inclusivity across the recruitment process, including positive statements in vacancy adverts to attract individuals from under-represented groups. Interviews are structured and documented to avoid bias and provide transparency and accountability.

Recruitment to new/replacement academic posts is governed by strategic fit, opportunity and priority. 72 PIs (incl.43 junior academics) were appointed across Clinical Medicine in the REF2021 period. We are committed to the appointment of junior talent wherever possible, recognising the imperative to strengthen career prospects for talented ECRs (*see also Section 2.6*). FoLSM has formalised a scheme whereby all ECRs on intermediate-level Personal Fellowships can progress to faculty positions based on a transparent assessment process, rather than a vacancy happening to exist – which we believe to be first-in-sector. We have committed to long-term positions for Senior Fellowships. We pursue targeted senior recruitment to strengthen specific research areas (*examples in Section 1.4*), leveraging maximum value by partnering with our NHS Trusts/external funders/local charities.

Probation for new academic appointees is 3 years and follows a standardised process involving regular Performance Development Reviews (PDR) and assigned mentors to guide them (*see Section 2.5*). All probationers progressed to confirmed faculty positions over the REF2021 cycle.

Retention schemes for talented individuals (including junior researchers) cover plans for promotion, tenured contracts and support packages. Flexibility of movement and split contracts have proved effective in retention, e.g. within the food allergy team (Turcanu/Santos) or links with the Crick (e.g. Carlton). Well-judged support for academic excellence without an initial over-riding strategic case has ultimately led to significant research impact, e.g. in surgical sciences (Dasgupta).

2.4 Performance Development Review (PDR)

Performance to maximum potential is essential to our research strategy and for personal development. Clinical Medicine follows the King's **Academic Performance Framework**, which sets out the criteria and expected performance levels within which we operate. Formal annual **PDRs** for each staff-member with their line manager inform ambitions and achievements, set goals, and determine support/training needs. PDRs are informed by transparent workload data, including education contact-hours/responsibilities, research productivity, administrative duties, and service to society. For clinicians, a PDR and job planning process operates with joint university and NHS appraisers according to Follett principles and takes account of clinical duties.

Since 2015, 105 academics (52 women, 53 men) have attended interactive **PDR workshops** designed to create clear and motivating objectives and prepare for a constructive PDR outcome. Our DDI committees consult with research staff regarding the PDR process, mentoring, training and career progression.

2.5 Mentoring

All new academics up to Senior Lecturer are assigned a **mentor** to guide them through the probation period. ECRs and others appointed on **Fellowships** engage in different mentorship schemes, recognising varying requirements and the importance of an informal and positive mentor-mentee relationship. Many Fellows receive external mentoring (e.g. Academy of Medical Sciences, where several of our senior PIs participate as mentors) while others engage in schemes established within Clinical Medicine sections.

Clinical Medicine **research staff** are encouraged to use the King's Centre for Research Staff Development (CRSD) online research **mentoring platform** (launched 2018, following the 2017 Careers in Research Online Survey), which assists with finding internal/external mentors. This has allowed participation in a range of mentoring models (e.g. appointed mentors, voluntary schemes) and mentor training; approximately 1/3 of mentors and mentees come from Clinical Medicine, reflecting the level of engagement of our staff.

We encourage, through Clinical Medicine DDI committees, participation in King's schemes: the **'B-Mentor'** scheme for ethnic minorities; **'More than Mentoring'** which prioritises women, ethnic minorities, LGBTQ+ or staff with a disability; and **Aurora**, which is Advance HE's leadership programme for women and those who identify as female. King's funds three spaces annually to attend **StellarHE**, the national Leadership Development Programme for aspiring minority ethnic academic leaders; from Dec 2020, FoLSM supports an additional four places within the Faculty.

2.6 ECR development

King's commitment to the Concordat for the Career Development of Researchers is recognised by the European Commission's HR Excellence in Research Award, held since 2012. CRSD support for ECRs is described in *REF5a*.

Clinical Medicine ECRs benefit from a range of complementary initiatives designed to maximise development and career prospects.

- The **King's Prize Fellowship** scheme launched in 2017 with Wellcome, London Law Trust and King's funding. It provides outstanding ECRs (internal/external) with up to two years' salary, research funding and mentoring to accelerate transition to independence. The **Professor Anthony Mellows Medal & Fellowship** is awarded annually to an outstanding post-doctoral scientist with potential to become a research leader. Of 41 fellowships awarded across the two schemes during REF2021, **12 (29%) went to Clinical Medicine researchers** (***Fig.2.1***). All nine Clinical Medicine Fellows who so far completed fellowships have transitioned to independence: four Intermediate Fellowships (3 Wellcome Sir Henry Dale [N.Ali/Odendall/Warnatsch], 1 UKRI [Neves]) and five permanent academic posts (King's/external).

- Dedicated **ECR Career Development Fellowships** are awarded by several Clinical Medicine sections (e.g. the CRUK and BHF Centres).

- The **BRC Bridging Fellowship scheme** supports top clinical academics to prepare external applications for advanced fellowships. **BRC Clinical Training Fellowships** (which served as the blueprint for the national **Crick Clinical Fellowship scheme**) provide clinical trainees 12-months support to generate data towards external fellowships (>90% success rate). 25 Clinical Medicine fellows (52% male, 40% female, 8% other; 68% white, 20% minority, 12% undisclosed) participated in these three schemes during REF2021.

- In September 2021, King's launches the **Harold Moody Fellowship** (two/year) to support black candidates with promising research excellence in the transition to academic posts. Each fellowship includes two-years' funding and personalised career-development mentorship.

- The King's **Research Strategy & Development team** (Director, Foulkes) offers guidance on grant writing, mock interviews and communication skills to prepare ECRs for external schemes. Each Clinical Medicine section runs **bespoke events** (e.g. postgraduate symposia, research days, ECR fora), allowing ECRs to develop confidence and network with their peers.

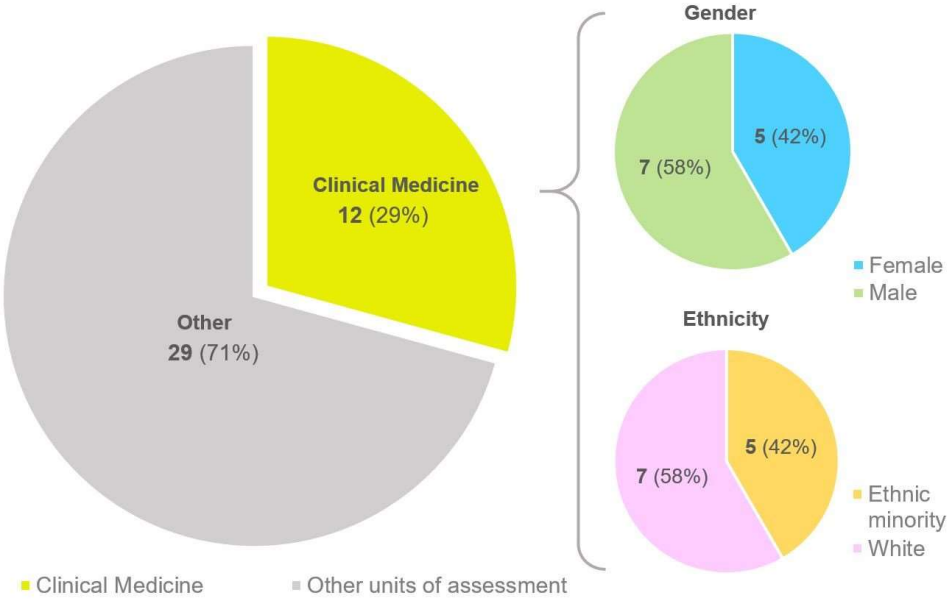


Figure 2.1. Recipients of Competitive Prize Fellowship programmes at King's. Breakdown by gender and ethnicity shown for Clinical Medicine recipients.

The collective success of these schemes is evidenced by ECR career advancement. During REF2021, 42 Clinical Medicine researchers obtained **Intermediate Fellowships** (UKRI

46%/Wellcome 17%/BHF 10%/NIHR 5%) and 5 obtained **Senior Fellowships**. 53% of awards went to females and 56% were to clinical academics.

Launched in 2021, the **Emerging Research Leaders Programme** for recently independent Lecturers/Senior Lecturers develops key skills such as project/team management, how to win grants, and is modelled on the successful Leading Researchers Programme (*Section* 2.7).

2.7 Initiatives for more established researchers

PIs benefit from a range of pump-priming schemes run by King's, including the KHP R&D Challenge Fund (c.£1m/year), King's Together (£1m/year), the Genesis Fund (c.£500k/year), and BRC/BHF Centre/CRUK Centre pump-priming schemes (*Section 3.2*).

The **King's Leading Researchers Programme** (launched 2017) supports rising stars close to Professor-level to establish themselves as research leaders – developing ideas, large strategic awards, taking risks, convening groups etc. Seven Clinical Medicine academics (3 females) have participated and receive 1:1 coaching as part of the programme. "Graduates" of the programme have gone on to lead major strategic initiatives, e.g. the Wellcome Neuro-Immune PhD Programme (Taams).

2.8 Recognition and rewards for research and impact

Promotions. The annual promotions round links to the PDR cycle (*Section 2.4*). Proactive discussion about timing of promotion application and any supportive measures required to maximise success takes place at the PDR. Particular attention is paid to ensure that less confident researchers do apply for promotion. FoLSM **promotion workshops** (introduced 2015) support staff through the process; 97 academics have attended to date. FoLSM also introduced a new structured process (2016) involving feedback by School Promotion Advisory Panels followed by assessment at the Faculty Promotions Panel – both panels constituted following EDI principles.

The success of these measures is evident in a **female** promotion rate that is now higher than males over the REF2021 cycle: an average female success rate across all levels of **90.3%** (28/31) versus **77.4%** (24/31). Females comprised <40% of Clinical Medicine academics but accounted for 50% of promotion applications.

Minority ethnic academics comprise ~23% of Clinical Medicine academic staff but only 12% (8/62) of applications for promotion. Their success rate was **75.0%** compared to **84.9%** for white applicants. Considering these data, the Faculty plans **bespoke promotions workshops** for minority applicants (alongside initiatives highlighted earlier; *Section 2.2*/*2.5*/*2.6*), given that this group is the most underrepresented in leadership positions and previous development programme cohorts. The initial focus will be potential structural barriers to racial/gender equality and intersectional experience.

King's has a supplementary pay award scheme for exceptional performance. The last two **Recognition Pay** periods (2018/2019) saw 18 individuals within Clinical Medicine receive awards: 44.4% (8) female, 55.6% (10) male; 27.8% (5) ethnic minorities, figures proportionate to the workforce profile (*Section 2.2*).

2.9 Succession planning

Leadership roles within FoLSM Schools are of 5 years duration for School Heads and 3 years for other senior roles (e.g. DDI/Research & Impact leads) in order to provide opportunity for emerging leaders to apply. Appointment to roles is by advertisement and open competitive selection. The current gender balance across Clinical Medicine sections for such roles is 56% male/44% female. Where deputising is required, female or junior representation is encouraged to provide exposure to executive decision-making committees.

2.10 Integration of NHS-employed active researchers within partner NHS Trusts

Clinical-academic integration is a core component of our research and impact strategy. King's-employed and NHS-employed researchers are in single KHP organisational structures (CAGs/Institutes; *Section 1.4*). The integration of NHS researchers has been enhanced by the introduction of **Adjunct** appointments (2017) which confer additional privileges on **honorary staff**, e.g. holding King's grants as PI, full administrative support from Clinical Medicine sections. Recognition through Adjunct/Honorary titles also provides credit to these individuals within our partner NHS Trusts. In turn, 39.6 fte CatA clinical academics within Clinical Medicine had at least part-NHS salary funding on the census date. Senior clinical CatA staff all have Honorary Consultant appointments and are integrated within the clinical service.

Clinical Medicine had 112 CatC staff holding Adjunct/Honorary positions on the census date (94% were NHS employees). They included 26 professors, 19 readers, 63 senior lecturers and 4 lecturers. An increase in numbers in 2017-2018 corresponded with the introduction of Adjunct appointments, a trend we expect to continue as more clinical benefits of our research emerge (e.g. in genomics and regenerative medicine).

Close clinical-academic integration also benefits clinical ECRs in coordinating exit and re-entry into clinical rotations, and accessing patients and clinical material for their projects. The opportunities for bright aspiring clinical academics within Clinical Medicine at KHP are exceptional (*see also Section 2.11*). There were 37 NIHR Academic Clinical Lecturers and 77 Academic Clinical Fellows within Clinical Medicine over the REF2021 period.

2.11 Postgraduate research students

Clinical Medicine offers an extensive postgraduate research (PGR) training portfolio that synergises with our academic strengths. We aim to attract the brightest and most motivated students to pursue basic/clinical research training in an interdisciplinary environment, ensuring adherence to EDI in recruitment and training. Trainees pursue diverse projects side-by-side, participate in cohort activities, and benefit from extensive additional educational opportunities. Through this approach, we aim to develop a sustainable pipeline of future leaders and innovators in biomedicine and enterprise, experienced in working across discipline boundaries. The **King's Health Doctoral Training Centre** (established 2014) aims to ensure that all PGR students receive an outstanding training experience, regardless of funding source.

539 full-time and **128.5 part-time PhD/MDRes students** were hosted in Clinical Medicine during the REF2021 period (58.5% female, 41.0% male). 95% of full-time students submitted within 4 years. Our **MRC Doctoral Training Programme** (DTP; Malim) supports 25 students/year, 31% in Clinical Medicine. **DTPs led by Clinical Medicine** include Wellcome 4-year Cell Therapies & Regenerative Medicine (5 students/year; Watt/Lord, now Spagnoli), BHF 4-year Cardiovascular (4/year; Mayr), CRUK 4-year (2/year, Parker), Wellcome 4-year Neuro-Immune Interactions in Health & Disease (6/year; Taams), BHF Centre interdisciplinary (15 students; Shah), Joint DFG-BHF Centre programme on Signalling in Heart Failure (16 students; Ivetic), MRC Transplantation Centre (8 students; Sacks). There were 12 CASE studentships over this period. Students are **also funded by** the Crick/KCL programme, BBSRC London Interdisciplinary Biosciences Consortium (LiDO), EPSRC CDT in Smart Medical Imaging, GST Charity PhD programme, BRC PhD programme, KCL CDT in Data Driven Health, and Marie Curie Training Networks. These purpose-designed DTPs not only attract excellent trainees but also have wider impact, e.g. leveraging additional NHS and local charity support and increasing the attractiveness of the Clinical Medicine environment for staff and students at all levels. Within the overall PhD cohort, Clinical Medicine attracted **99 Clinical PhD Training Fellowships** (MRC/WT/BHF/NIHR and other awards) over the REF2021 period.

PGR training is provided under an overall framework set by the King's Centre for Doctoral Studies (CDS; Dean, Oakey; Associate Dean, Wells). Within each Clinical Medicine area, a **PGR lead** holds responsibility for all students. Appointment to a training programme requires formal interview and School approval. All students have two supervisors, at least one with an established supervision track record. ECRs need to undergo **supervisor training** while experienced supervisors take mandatory regular refreshers. Since REF2014, FoLSM has established a system of **Thesis Progression Committees (TPC)**. Each student's TPC includes the co-supervisors, an independent chair and two independent experts, providing rolling academic and pastoral support, including translational context. The TPC approves the 12-month MPhil-PhD upgrade, which requires a written report, oral presentation and viva. TPC reports are deposited online and provide a robust system for monitoring progress and early proactive management of any problems. **Student-staff liaison committees** ensure a formal mechanism to incorporate student feedback and address concerns.

Student development and skills. While individual PhD projects are decided by students and supervisors, Clinical Medicine has a set of essential requirements for broader PhD training. All PhD students are based in a multi-disciplinary environment and participate in weekly laboratory meetings and regular seminars. Our DTPs all provide structured training in **core transferable skills** during year 1 while students outside DTPs obtain this through the King's Health Doctoral Training Centre. DTPs have additional topic-specific modular **advanced skills training**, e.g. MRC DTP advanced skills workshops, BHF Centre Technology workshops, which provides students with exceptional learning opportunities and exposure to internationally-leading PIs. DTP-based cohort training broadens student horizons and networks, creates peer groups offering mutual support and shared experience, and enhances team skills. The success of our training provision is evident in National Postgraduate Research Experience Surveys (PRES), e.g. 82% satisfaction in 2019.

Research integration in the wider environment is enabled by opportunities to present data to varied audiences, e.g. student-organised PGR symposia, national/international scientific meetings. All Clinical Medicine sections encourage student interaction with external speakers (e.g. 'meet-the-speaker' lunches), entrepreneurial activity (e.g. Dragon's Den competitions), public engagement (e.g. local schools), and interaction with embedded industry partners. The aim to generate confident outward-facing students is also supported by funding schemes at Centre/School/FOLSM/CDS levels. The overall quality of Clinical Medicine PhDs is reflected in numerous national/international prizes/awards, e.g. European Society of Cardiology (2018), International Society for Heart Research (2019), International Society for Magnetic Resonance Medicine (2018), Royal Society of Medicine (2018), Renal Association (2014), British Nuclear Medicine Society (2018). The most recent graduate outcome data (2017/18) showed next destinations in health professions (36%), academia (32%), R&D (11%) and pharma (7%).

2.12 Other Equality, Diversity & Inclusion initiatives

Our commitment to EDI is embedded across Clinical Medicine and FoLSM governance, operations and culture. The King's equality and diversity code has been enhanced during the REF2021 period (*Section 2.3*). The **new FoLSM framework of DDI committees/leads** (*Section 2.1*) has enabled Clinical Medicine to drive the embedding of university-wide EDI principles in all our work, and the dissemination of good practice. Collective senior responsibility for development and inclusion of research staff was affirmed by a FoLSM Executive Board **DDI Pledge** (2018).

As mentioned earlier, FoLSM holds an Athena Swan Silver award while King's holds a Race Equality Bronze Charter Mark, with an ongoing campaign to further enhance equality. Demonstrating its commitment to inclusion of the LGBT+ community, King's became a **Stonewall's Diversity Champion** (2016), consulting on **Trans Matters Guidance** and hosting the 2017 Starting Out Guide launch. This provides workplace resources, a toolkit and a network, used actively by teams across Clinical Medicine.

Central to our approach to ensuring an inclusive environment have been improved work processes and practices at key transition points for all employees, as described in previous sections (e.g.

reviewing induction content, more constructive PDRs, strengthened promotions framework, improved access to flexible working). More equitable practices (e.g. rotating meetings across campuses; holding them within core hours) have become the norm.

To raise awareness, all PIs and those on interview/decision-making panels are required to complete **Diversity Matters** training (replacing Unconscious Bias training, 2017). Clinical Medicine staff are also encouraged through our DDI committees to participate in FoLSM/university-run **Knowledge Beats workshops** (up to 4/month), covering topics such as 'Inclusive Language & Imagery', 'Microaggression' and 'Compassionate Line-Management'. The 2020 programme attracted 300 staff and PhD students across Health Faculties. Alongside this, staff networks developed to enhance the sense of community and participation in strategy-building include: Staff Disability Network & Groups; NEST Parents & Carers Network; Elevate, Gender Equality Network; Race Equality Network; Athena SWAN Network; and Proudly King's-LGBT+ Staff Network (*REF5a*).

Awareness of our commitment to EDI is high across FoLSM. The 2017 King's Staff Survey showed 96% of FoLSM staff were aware of our commitment to EDI; 91% agreed we were committed to an inclusive environment; 92% agreed we acted fairly, regardless of protected characteristics. The 2018 FoLSM Staff survey showed 95% staff-awareness of Athena SWAN. Staff-awareness and EDI-training have increased annually since 2014; by 2018, 86% of staff were aware of Diversity Matters training. Our survey shows an increased proportion of staff taking up informal flexible working (73%); 83% of new starters agreed their induction was welcoming; 77% agreed that development was discussed effectively in appraisals.

Clinical Medicine sections celebrate our achievements and role models, e.g. women in biomedical science speakers, high-achieving ethnic minority academics, Black excellence narratives, and key dates such as International Women's Day and Black History Month.

We convened a representative panel of 18 Clinical Medicine staff to fairly evaluate our REF submission data. 33% of professors on the panel were female (vs. 22% in Clinical Medicine at census date) and 22% minority ethnic (vs. 19% in Clinical Medicine at census date). Among non-professorial panel members (~half), 41% were female and 24% were minority ethnic compared to their respective proportions of 38% and 21% in Clinical Medicine.

2.13 Provision for parents and carers

Parents and carers within Clinical Medicine have access to a King's online hub, a Parents & Carer's Network, and nursery facilities on our main campuses. The Flexible Working Group acts as an advocacy group for flexible work practices. FoLSM holds regular workshops on topics such as shared parental leave and flexible working.

The **Parents' & Carers' Fund** (up to £10k/person) supported six Clinical Medicine researchers during REF2021, enabling maintenance of some research activity while on leave and mitigating adverse impact on career progression. **The Carer's Career Development Fund** helps parents and carers with the additional care costs while attending conferences/networking events outside normal working hours. Individual Clinical Medicine sections also allocate funds for ECRs on parental leave, e.g. support for temporary research assistants or childminder to permit research continuity.

2.14 Bullying and Harassment (B&H)

Clinical Medicine DDI committees have placed major focus on B&H, in line with guidance set out in the **King's Code of Practice** and **updated B&H policy.** Workshops (e.g. Knowledge Beats) provide training in recognising and reacting to intimidation in the workplace. The King's **Anonymous platform** allows staff/students to report experiences of B&H, enabling monitoring of trends and taking proactive measures. Clinical Medicine has extended this through a **Confidential Advisors Service** (2019) offering non-judgmental advice and support for staff/students experiencing or

witnessing B&H. We are currently launching an in-house **mediation service** for conflict-resolution assistance.

2.15 Open research (OR) environment

King's is strongly committed to OR and a member of the UK Reproducibility Network (*REF5a*). Clinical Medicine sections require researchers to upload full texts of outputs in the King's repository system 'Pure' and use King's OA block-funding to publish in OA journals where possible. We also actively post on preprint servers, share source code for data analysis on GitHub, are involved in Citizen Science projects, and provide guidance through experience on editorial boards, e.g. the EMBO-press peer-reviewed preprint platform 'Review Comments'.

2.16 Research Integrity (RI)

King's is a signatory of the Concordat to support Research Integrity (2019) and has appointed a Vice-Dean (Martin-Serrano) and leads (Barral/Ivetic/Carlton covering the Clinical Medicine sections) to advocate RI across FoLSM. They act as a conduit for queries on research (mis)conduct and liaise confidentially with the RI team. A proactive training programme in RI practice for PhD students and staff is about to be launched, building on a successful pilot in Cardiovascular covering topics such as data management, research ethics, biobank management, resolution of co-authorship, conflicts of interest and misconduct.

3. Income, infrastructure and facilities

3.1 Metrics and Major Awards

King's Clinical Medicine researchers received **£293.6m in new research awards** (£1.6m/fte/PI) in the REF2021 period. **Female applicants** were PI/co-I for 427/1093 (39.1%) and **ethnic minority applicants** for 288 (26.3%) of awards. Our interdisciplinary approach means that UoA1 academics also play a major role in strategic awards led by other UoAs, particularly UoA3/4/5/12. A further £109m in investment funding was received for King's start-up companies, highlighting strengths in cell therapies, new biologics, cancer and immunology. We have also received £25m in capital awards from RE (UKRPIF) in cancer and advanced therapies.

In line with our strategy to diversify research funding, we have increased UKRI/Government and industry funding cf. charities to create the balanced distribution shown in ***Fig.3.1***.

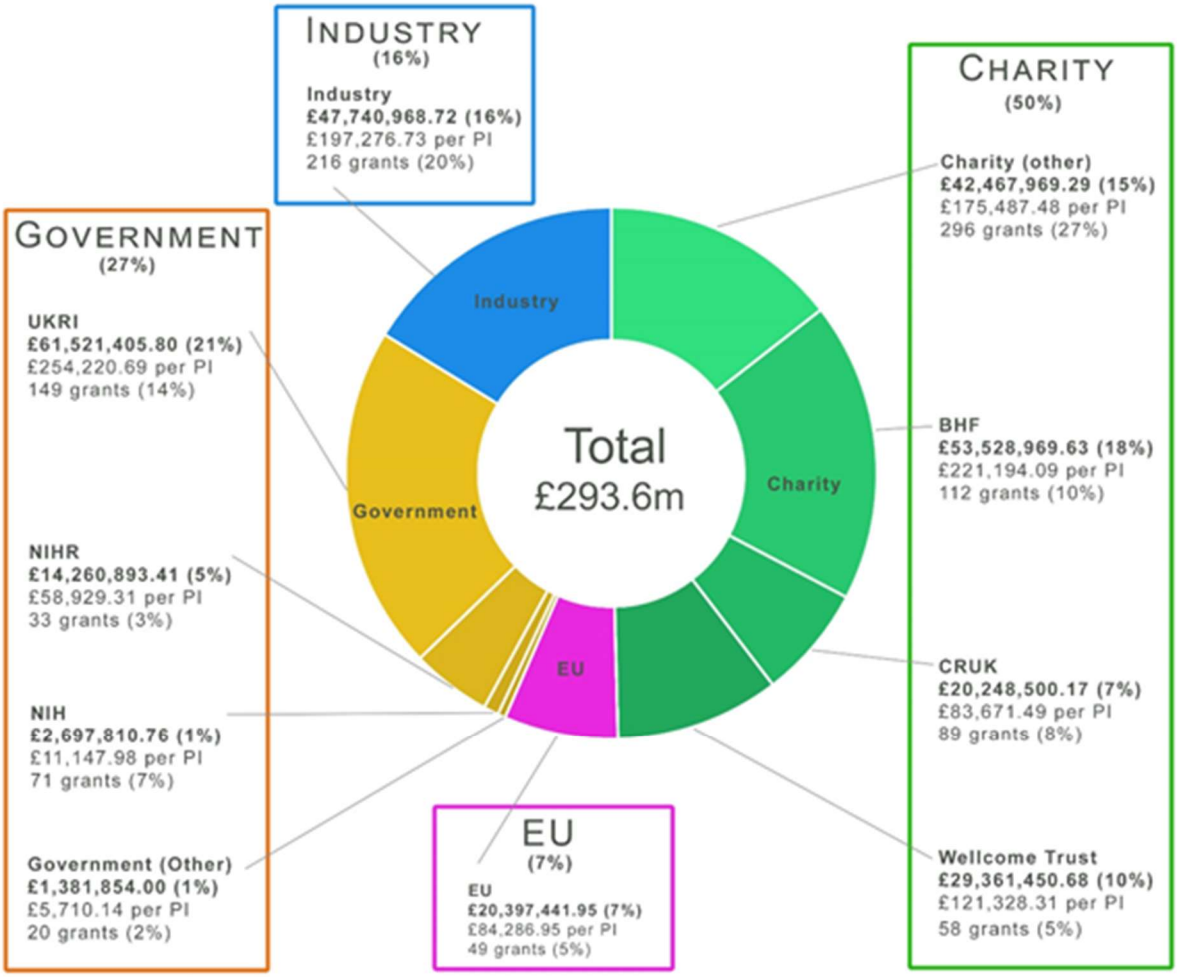


Figure 3.1. Value and number of grants awarded to Clinical Medicine during REF2021.

UoA1 research received philanthropic donations of £5.86m, including three donations of >£1m each (prostate cancer, cardiovascular, head & neck cancer).

We have also received significant commitments of c.£50m for future investment from industry, particularly through our strategic partnerships with GSK (cancer/functional genomics), UCB (cancer/ rheumatology), Celgene (haematology) and Unilever (stem cells) – described in *Section 4*.

Our research capabilities have been enhanced through strategic awards for major research centres and research infrastructure. Highlights include:

- GST/King's NIHR BRC (Lord with 8 Clinical Medicine PIs, £64m)
- MRC/LifeArc/BBSRC Gene Therapy Innovation Hub (Ali, £6m)
- RE Advanced Therapies Accelerator (Lechler, £10m + £20m from industry incl. GSK/Celgene) to support pre-clinical development facilities for cell/gene therapy
- RE Research & Innovation Hub in Cancer (Parker, £15m + £30m matched funding from charities), to support clinician-researcher collaboration and enable translational cancer research
- CRUK Cancer Centre (Parker, £5.5m), Experimental Cancer Medicine Centre (Spicer, £2m) and City of London Centre (Ng, £14m to UCL/King's/QMUL/Crick)
- British Heart Foundation Centre of Research Excellence (Shah, £6m)
- Global research centres including NIHR Global Health Unit and 2 UKRI "Growing Capabilities" centres (Sullivan) (total c.£30m)
- London Advanced Therapies (RE, £5m + £2m), now expanding nationally
- Health Data Research UK London Site (Hubbard, MRC, £7m with UCL/IC/QMUL/LSHTM)
- MRC Single Cell Functional Genomics Facility (Peakman/Parker, £2.4m)
- RE investment to create MedCity, a cross-London activity to attract industry and investment in life sciences (£7.1m).
- Multiple PhD programmes (*Section 2.11*)

Relevant awards led by UoA12 include the InnovateUK London AI Centre for Value-based Healthcare (Razavi, £10m + £16m), Wellcome/EPSRC Medical Engineering Centre (Razavi, £12m), London 7T MRI Clinical Research Facility (Hajnal, £4m) and RE London Institute for Healthcare Engineering (Ourselin, £16m + £32 from industry) – which have large cardiovascular, cancer and surgical themes.

We have seen success with large (>£1.5M) **personal funding awards**, including 9 Wellcome Investigator Awards, 3 ERC Advanced, 1 ERC Consolidator, 4 BHF Professorships, 8 MRC Programmes (or equivalent), and 3 Wellcome Senior Fellowships. For example, an ERC Advanced grant to Giacca enabled the development of miRNA-mediated endogenous cardiac regeneration, now approaching human studies; Wellcome/MRC funding to Malim, Neil and Doores supported major insights into HIV host responses, alongside intensive investigation of Ebola and COVID-19 immunopathology.

In line with our objective to support ECR development, our portfolio of **externally-funded fellowships** has significantly increased. 47 Fellowships were obtained since 2014 (including MRC/ Wellcome/BHF/CRUK), enabling our most promising ECRs to develop independence and senior fellows to develop into international leaders. Examples of research topics supported include molecular virology (Neil, Wellcome, £1.9m), inflammation (Warnatsch, Wellcome, £1.1m), immunology-stem cells (N.Ali, Wellcome, £1.4m), cell therapy/vascular remodelling (Modarai, BHF, £1.2m), membrane biology (Carlton, £1.8m), heart failure (Barralobre-Barreiro, BHF, £0.7m), and optical imaging in cancer (Poland, UKRI Future Leaders, £1m).

We have received substantial **translational research** funding including several MRC DPFS awards (e.g. Ali £4.2m, retinal cell therapy), NIHR EME (e.g. Shawcross £2.5m, fecal microbiome transplant in liver disease), Wellcome (e.g. Maher £0.8m, phase 1 trials of CAR-T therapy), BHF Translational Awards (e.g. Lombardi £0.25m, cell therapy in heart transplant), and others.

3.2 Research Funding Strategy

Over the current REF cycle, we have successfully focused on the following **top-level objectives**:

- Success in major national "strategic investment" competitions (e.g. the recent MRC/LifeArc/BBSRC Gene Therapy Innovation Hubs call).
- Increasing post-doctoral personal fellowships to ensure we support the next generation of research leaders.
- Obtaining strategic investment to drive multidisciplinary research (e.g. our interdisciplinary PhD programmes).

- Increasing joint funding with our NHS partners (e.g. the AI Centre).
- Increasing the proportion of income from UKRI/NIHR and reducing funding from QR-ineligible charities.

We combine an open, supportive approach to individual applicants that encourages freedom and creativity with a coordinated approach to major/strategic opportunities – ensuring that we bring our full synergistic strengths to bear rather than internal competition.

Individual applicants benefit from Clinical Medicine section internal review and mentoring (for ECRs). Strategic applications are coordinated through a "task-and-finish group" approach, assembled according to research area. This ensures optimal expertise and support across applications, with maximal collaboration (after internal triage, where required).

Clinical Medicine academics benefit from two PhD-qualified Faculty-level **Research Development Managers**, who support major grants and mid-to-senior fellowship applications. These form part of King's Research Strategy & Development function, reporting to the Director of Research Strategy & Development who oversees the largest applications and maintains relationships with all major funders. Flexible support includes access to previous successful applications, review/editing, specific advice, mock interviews, and overall funding strategy.

We also provide dedicated support for translational research funding and management, with 5 experienced **Translational Research Managers** (3 funded by a Wellcome Institutional Translational Partnership Award, 2 BRC-funded).

Pump-priming funding schemes to encourage and de-risk innovative research, of direct relevance to UoA1, include:

- **KHP R&D Challenge Fund** (c.£1m/year) supports translation of discovery research. About 50% of funding is won by Clinical Medicine researchers and generates a >10x leverage. Major UoA1 outcomes include the spinouts Quell Therapeutics, Gammadelta Therapeutics and Leucid Bio.

- **King's Together** is a £1m/year seed-fund to support multidisciplinary collaborations across the university. Clinical Medicine academics are involved in >50% of awards. Since inception (2016), it has funded 25 grants to Clinical Medicine investigators (38% female, 62% male). In March 2020, 6 additional awards went to Clinical Medicine researchers to support urgent COVID-19 projects.

- The **Genesis Fund** (c.£500k/year) supports initial transition between translational research and commercial development; it is funded from Wellcome (iTPA and revenue retention) and university.

- BRC/BHF Centre/CRUK Centre pump-priming schemes and King's Prize Fellowships are described in *Section 2.6-2.7*.

University-level actions have also enhanced UoA1 research in the current REF period:

- A new position of Vice-Principal (Research), Faculty Vice-Deans for Research, and equivalent positions for each constituent School.
- Creation of the *Leading Researchers* training programme (*Section 2.7*).
- Investment in new systems and processes to reduce administrative burden in handling research funding.

3.3 Research Infrastructure and Facilities

Recognising that excellent research infrastructure is essential for cutting-edge, high-impact research and attracting outstanding researchers, **£203.1m** has been invested during the REF2021 period (£160.9m from external sources).

We increasingly operate research infrastructure in a "core facility" model, to ensure that it remains state-of-the-art, has excellent technical capabilities, and is financially sustainable through critical

mass in the user community. This also lowers barriers to use for less experienced researchers, increasing impact. Each facility has an academic director/steering group to ensure continued alignment with academic priorities. Major facilities include:

- The **GST-King's NIHR Biomedical Research Centre** (renewed 2016, £64m) has Research Platforms in advanced therapeutics, genomics, big data analysis, imaging, immune phenotyping and training. Clinical Medicine is the largest grouping, providing both overall leadership (Lord/now Brown) and theme/cluster leads (*Section 1*). The BRC is transforming the throughput of our basic research to clinical innovation. Future plans build on increasing cross-BRC collaboration to underpin national initiatives.
  - Examples of BRC-supported impact include development of a new immunotherapy for type 1 diabetes: Metabolic and immune effects of immunotherapy with proinsulin peptide in human new-onset type 1 diabetes, *DOI:10.1126/scitranslmed.aaf7779*; and the development of Treg cell therapy for kidney/liver transplantation: Regulatory cell therapy in kidney transplantation (The ONE Study), *DOI:10.1016/S0140-6736(20)30167-7*

- **Clinical Research Facilities (CRFs;** lead, Chowienczyk**).** We operate CRFs at each major campus: Guy's (MHRA Phase 1-accredited, incorporating CRUK Experimental Cancer Medicine Centre), St Thomas' (including medical imaging, dedicated cardiometabolic, and paediatric CRFs), and KCH (MHRA Phase 1-accredited). Clinical Medicine teams included c.48,000 patients in research studies over the REF2021 period (20% phase 1, 30% experimental medicine).
  - Examples of studies include: First-in-human study of systemic neuronal nitric oxide synthase inhibition, *DOI:10.1161/HYPERTENSIONAHA.116.08792*; Large-scale precision nutrition study, *DOI:10.1038/s41591-020-0934-0*; Phase 1 trials for MOv18 IgE therapy (cancer); *DOI:10.1158/1538-7445.AM2020-CT141*

- **The BRC Experimental Medicine Hub** at Guy's provides a unique co-location of multiple state-of-the-art facilities for experimental medicine. It includes the Guy's **CRF**, a **GMP Pharmacy Manufacturing Unit** with facilities for formulation of small molecules for first-in-human use, and the **BRC Research Platforms** mentioned above – with advanced flow cytometry, CyTOF, imaging mass cytometry, single cell functional genomics and integrated data analysis.
  It also houses our **Cell & Gene Therapy Production Facilities** which provide GMP (clinical grade) cell therapies (with FACS sorting), gene-modified cell therapies (e.g. CAR-T), and gene therapies (lentivirus, retrovirus, AAV launching imminently) for clinical and pre-clinical studies. The linked **Advanced Therapies Accelerator** offers pre-GMP laboratory facilities for cell/gene therapy development.
  - Examples of research conducted in the Hub include: Peripheral immunophenotypes in children with multisystem inflammatory syndrome associated with SARS-CoV-2 infection, *DOI:10.1038/s41591-020-1054-6;* A dynamic COVID-19 immune signature includes associations with poor prognosis, *DOI:10.1038/s41591-020-1038-6*; Treg cell therapy trial for inflammatory bowel disease (MRC-funded;TRIBUTE), *NCT03185000*.

- **Stem Cell Hotel** (lead, Watt) enables industrial partnership and exploitation of regenerative medicine techniques, and includes a pluripotent stem cell and gene editing facility.
  - Example: MRC programme (Malim, Danovi, £1.6m): *Using iPSC variation to define HIV-1 regulatory networks*; Extrinsic versus intrinsic drivers of variation in cell behavior in human iPSC lines, *DOI:10.1016/j.celrep.2019.01.094*

- In collaboration between the King's **London Medical Imaging & AI Centre for Value-Based Healthcare** and **Nvidia,** we will have access to the UK's most powerful supercomputer, Cambridge-1, alongside in-house AI capabilities (Nvidia DGX-2) and expert support.
  - Examples of projects: Mapping the entire healthcare pathway for heart failure and stroke.

- **King's medical imaging facilities** are comprehensive and nationally-leading, including 1.5T/3T/7T MR, PET/MR (+ cyclotron), XMR, PET/CT and embedded chemistry, for both clinical and pre-clinical studies.
  - Clinical Medicine research examples: Identification of phenotypes of coronary microvascular dysfunction and myocardial ischaemia, *DOI:10.1161/CIRCULATIONAHA.119.041595*; A randomised clinical trial of magnetic resonance perfusion in coronary disease, *DOI:10.1056/NEJMoa1716734*.

- Our **Genomics and Biomarker Facility** is a CSPro-certified provider of Illumina platforms, and includes state of the art robotics and LIMS tracking.
  - Example: Genome-wide association study in frontal fibrosing alopecia, *DOI:10.1038/s41467-019-09117-w*

- King's **Biological Service Unit** facilities for animal work include breeding, comprehensive genome manipulation and state-of-the-art invasive/non-invasive phenotyping. They are extensively used by Clinical Medicine sections.

- The **Nikon Imaging Centre** (one of 10 worldwide) provides an outstanding range of light microscopy techniques and is the Nikon European super-resolution microscopy centre of excellence. Our **Centre for Ultrastructural Imaging** offers advanced electron microscopy capability with some of the most advanced equipment in Europe, in partnership with JEOL.
  - Examples: An evolutionarily conserved ribosome-rescue pathway maintains epidermal homeostasis, *DOI:10.1038/s41586-018-0032-3*; T helper 1 immunity requires complement-driven NLRP3 inflammasome activity in CD4+ T cells*, DOI:10.1126/science.aad1210;* Reactive oxygen species regulate axonal regeneration through exosomal NADPH oxidase 2 complexes*, DOI:10.1038/s41556-018-0039-x.*

- Our work on pathogens is supported by a new **ATCSA schedule 5 containment facility** (opened 2020), alongside Wellcome-funded virology-dedicated equipment, which will unlock opportunities for research on viral pathogens relevant to human disease (Malim, Neil*).*
  - Example: Neutralization potency of monoclonal antibodies recognizing dominant and subdominant epitopes on SARS-CoV-2 Spike is impacted by the B.1.1.7 variant, *DOI:10.1016/j.immuni.2021.03.023.*

- A **robotic high-content high-throughput screening facility** (opened 2019; lead, Giacca) supports translational research deriving from Clinical Medicine discoveries*.*
  - Example: Drugs inhibiting TMEM16 proteins block SARS-CoV-2 Spike-induced syncytia, *DOI:10.1038/s41586-021-03491-6*

- The **Centre of Excellence for Mass Spectrometry** provides liquid/gas chromatography, a range of mass spectrometers and advanced data analysis. We also offer a dedicated **proteomics facility** (lead, Mayr), and **Nuclear Magnetic Resonance Facility (NMR)** with state-of-the-art spectrometers configured to address biological questions.
  - Examples: Extracellular proteomics defines molecular signature of symptomatic carotid plaques, *DOI:10.1172/JCI86924*; Blood pressure–lowering by the antioxidant resveratrol is counterintuitively mediated by oxidation of cGMP-dependent protein kinase, *DOI:10.1161/CIRCULATIONAHA.118.037398*

- The **King's Clinical Trials Unit (KCTU)** is UKCRC-registered and receives NIHR funding. It supports academic-led trials across KHP and externally, providing expertise in statistics, health economics and operational support.
  - Examples: Clinical efficacy of intravitreal aflibercept versus panretinal photocoagulation in diabetic retinopathy, *DOI:10.1016/S0140-6736(17)31193-5*; Effect of omalizumab on severe pediatric atopic dermatitis, *DOI:10.1001/jamapediatrics.2019.4476*; and many others in *Section 1*.

- The **KHP Clinical Trials Office (CTO,** established 2007**)** is a joint initiative between King's and KHP NHS trusts to provide a single interface for all clinical trials, increasing quality and delivery including regulatory compliance. Many examples of UoA1 trials are included in *Section 1*.

Technical and support staff

Our technical and support staff community facilitates the operation of research infrastructure. This skilled workforce (~5% of our staff) underpins our essential laboratory and biological services, and specialist expertise in areas as diverse as digital and advanced imaging technologies to stem cell and neuronal circuit methodologies. The development and maintenance of research infrastructure also involves essential expertise in I.T., estates and facilities teams.

The King's Centre for Research Staff Development provides bespoke training, mentoring and career counselling for technical staff. As part of King's Professional Strengthening initiative, a Technical Services Network has been established to allow our technical community to share best practice, facilitate professional development and provide peer support.

The King's Research Grants and Contracts Team provides dedicated professional service support for all research funding, including preparation and submission of applications; negotiation where required; post-award project management, claiming and reconciliation. The International Research Funding Office provides support for grants from the European Commission and funders such as NIH and is especially valuable for larger multi-partner awards. The Contracts Team offer specialist expertise for direct industry funding, consultancies, material transfer agreements and non-disclosure agreements. As part of FoLSM reorganisation, Clinical Medicine Schools/sections now have embedded Research Operations Managers who are a dedicated point of contact for PIs on all grant issues and liaise with the central King's teams, allowing highly efficient interaction. Since 2019, King's has deployed a new grants management system (Worktribe) to further improve research support and provide a more streamlined approach to grant management.

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

A wide spectrum of partnerships and collaboration are fundamental to the delivery of the Clinical Medicine mission, enhancing our research, driving impact, and ensuring that it is both relevant to society and informed by public and patient voices. We strive to create strategic, long-term relationships to increase mutual understanding and opportunities for synergy.

Our strategic partnerships prioritise:

- **Interdisciplinary/multidisciplinary collaboration** within and beyond King's to bring together diverse skillsets and approaches to solve major societal challenges (*see REF5a*).
- **Local/national academic collaborations** focused on our research priorities (e.g. advanced therapies) to coordinate efforts, increase critical mass and enhance research capabilities.
- The **NHS and our AHSC** (King's Health Partners [KHP]) to enable outstanding translational research and deliver improved healthcare capabilities nationwide and globally.
- **The pharmaceutical, biotech and medtech industry** (including SMEs), engaging from the earliest stages of research to support rapid translation, using our capabilities to add value to industry objectives and drive economic outcomes (e.g. major partnership with GSK in oncology).
- **Global/LMIC partners**, including universities, governments, healthcare providers and NGOs to enhance the developmental context to our research and achieve impact through true partnership.
- **Patients and the public**, to ensure that our research is relevant to societal (particularly healthcare) needs, reflects patient perspectives, and is conducted in an ethical and transparent manner.

4.1 Interdisciplinary/multidisciplinary collaboration

Collaboration across disciplines is central to King's *University Research Strategy*. In Clinical Medicine, this is embodied by substantial interactions within and beyond UoA1, including beyond Main Panel A disciplines (*Section 1*). Indeed, many of our most productive and highest impact research activities are fundamentally multidisciplinary.

Examples of major interdisciplinary research interfaces led by or involving Clinical Medicine staff include:

- Clinical medicine/engineering/technology: e.g. the *Innovate UK London AI Centre for Value-Based Healthcare* and *Wellcome Medical Engineering Centre* (with UoA12&4) – which have large cardiovascular and cancer themes.
- Clinical medicine/neuroscience & mental health: e.g. the *KHP Mind and Body programme* (NHS/university commitment to joining mental and physical healthcare research, including mental health assessment in clinical services, with >50,000 patients in acute Trusts), and our *Wellcome PhD Programme in Neuro-immune Interactions* (Director, Taams), with UoA3&4.
- Clinical medicine/social sciences: e.g. the *UKRI GCRF Research Unit for Health in Conflict* (Director, Sullivan) with UoA3 and several Main Panel C UoAs.
- Clinical medicine/biological sciences: e.g. the *CRUK Cancer Centre* (Director, Ng) and *BHF Cardiovascular Centre* (Director, Shah), with UoA5&12.

The impact of Clinical Medicine research has been significantly enhanced by these interfaces. This is evident in our impact case studies, e.g., PET-based cancer stratification, robotic surgery, understanding COVID-19 via app-based population-level research. Table 4.1 summarises collaborative research funding awards between UoA1 researchers and other UoAs at King's.

Table 4.1. Collaborative awards between Clinical Medicine and other UoAs at King's.

Collaborating UoA	Collaborative Awards*
2: Public Health, Health Services and Primary Care (Panel A)	48
3: Allied Health Professions, Dentistry, Nursing and Pharmacy (Panel A)	148
4: Psychology, Psychiatry and Neuroscience (Panel A)	77
5: Biological Sciences (Panel A)	72
12: Engineering (Panel B)	80
Other	49
Total	**476***

*374 unique collaborative awards

4.2 Local and national academic collaborations

We partner with academic/research institutions across the UK, ensuring that our research is placed in an optimal context and adding value to national research capability. From 2014-2020, King's co-authored almost 30,000 publications with 650 UK institutions in the *Times Higher* category of "Clinical, Pre-Clinical and Health" (SciVal/SCOPUS analysis). Our highest-volume collaborations in this category are with UCL, Imperial, Oxford, QMUL, Cambridge, Manchester, LSHTM, Nottingham, Edinburgh, Bristol and Newcastle.

Fig.4.1 depicts the pan-London initiatives that we lead or partner in. A selection of our strategic local/national partnerships are described below.

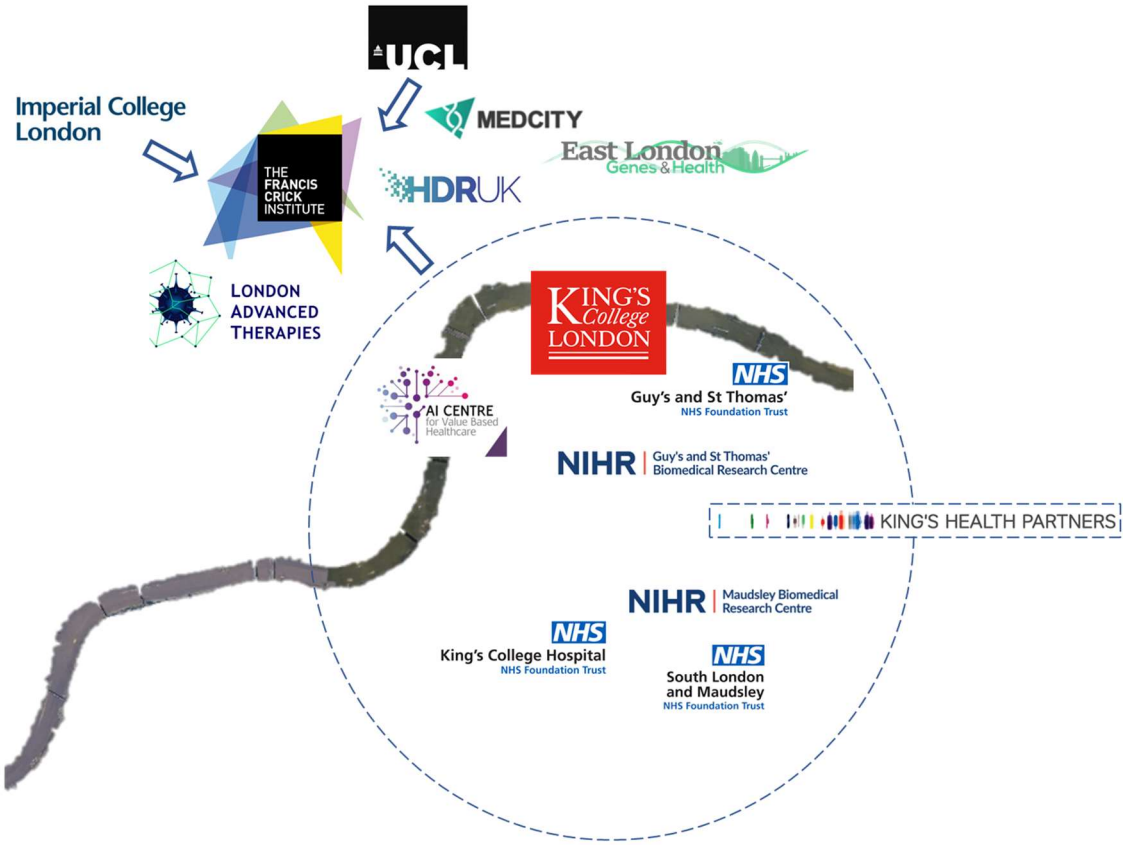


Figure 4.1. Schematic illustrating pan-London collaborations described below.

4.2.1 The Francis Crick Institute

https://www.crick.ac.uk/partnerships/university-partnerships

King's is a founding academic partner of the Crick, Europe's largest biomedical research facility and offering a world-class environment to enhance discovery science capabilities. Uncovering the

biology underlying human health is key in improving prevention, diagnosis and treatment of human disease. King's has c.80 staff (39 linked to Clinical Medicine) attached or seconded to the Crick.

Cancer (Parker) and Immunology (Hayday, Crick Assistant Research Director) have dual appointments at King's/Crick. Four Clinical Medicine group leaders (Carlton, Cicarelli, N.Ali, Barral) have obtained 6-year secondments to relocate entire labs to the Crick. Conversely, Crick group leaders can access our capability in patient-orientated research, through joint appointments at King's (e.g. in Immunology [Calado] and Cancer [Behrens]); and talented ex-Crick ECRs have taken up posts at King's (e.g. Warnatsch in Immunology). The strength of this partnership is already evident by our joint work to define novel COVID-19 immune variants linking viral infection with lethality (*see Section 1.67*). This level of integration is cemented by joint funding of programmes (e.g., CRUK Programme Foundation Award [Ciccarelli/Scaffidi], CRUK City of London Major Centre Award [Ng/Treisman]), new partnerships with major pharma (AstraZeneca, GSK), and initiating spin-out companies (e.g. Gamma-delta Therapeutics [Hayday] and Adaptate Therapeutics).

The Crick partnership provides a network to stimulate integration of biomedical science and translational research across London – Table 4.2 and ***Fig.4.2*** below (data is 2014-2020).

Table 4.2. Collaborative publications between King's Clinical Medicine academics and researchers at the Crick, Imperial or UCL.

Collaborating institution	Publication count*
Imperial College London	244
The Francis Crick Institute	68
University College London	343
Total	**655**

*publications with >10 authors excluded

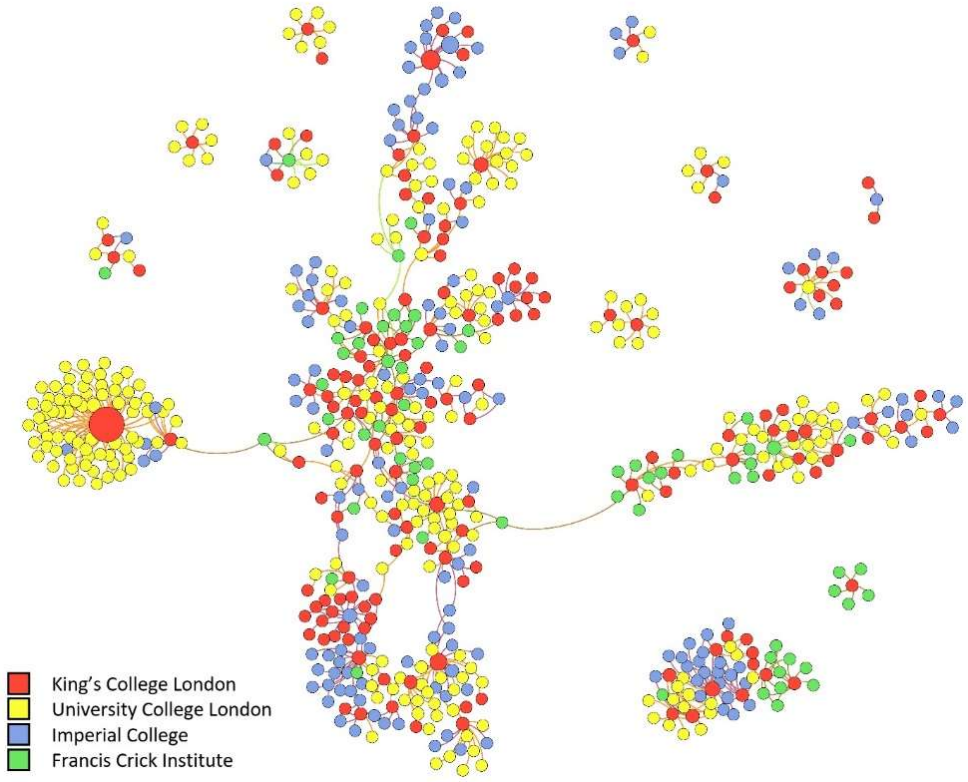


Figure 4.2. Network of research collaborations between King's and London partner institutions. Lines represent joint publications, coloured according to institutional affiliation.

4.2.2 London Advanced Therapies (now UK Advanced Therapies)

https://www.medcityhq.com/advanced-therapies-network/

Led by King's, London Advanced Therapies is a RE-funded programme to bring together London's strengths in cell and gene therapy, through increasing collaboration in research and innovation and aligning efforts on commercialisation and training. It has been a remarkable success, leading to substantial further investment (e.g. MRC/LifeArc/BBSRC Gene Therapy Innovation Hub). We have now received a further RE award to expand this network across the UK, building on our MoU with Manchester in advanced therapies and partnership with the N8 northern universities through MedCity (below). Clinical Medicine academics including Ali, Farzaneh, Dazzi, Lombardi, Hayday and Maher lead this network.

4.2.3 MedCity

https://www.medcityhq.com/

King's is the grant-holding partner of MedCity. Funded by RE, the European Union and the Mayor of London, MedCity is the cluster organisation for the health and life sciences sector in London. It aims to drive growth and investment for the health and wealth of the population, particularly through commercial investment from venture capital and large companies. It acts as an international ambassador for the partners and supports development of life sciences SMEs. MedCity operates in formal partnership with the N8 Research Partnership of research-intensive universities in northern England (jointly funded through a single award).

4.2.4 Health Data Research UK

HDR-UK is the UK's national institute for health data science. Its vision is to use large scale data and advanced analytics to enhance research and clinical/health outcomes. King's is a key partner in HDR-UK London, leads the Trusted Research Environment workstream of the UK HDR Alliance and chairs the HDR Infrastructure Advisory Group (Hubbard).

4.2.5 Innovate UK London AI Centre for Value-Based Healthcare

King's leads this Centre, which incorporates 4 universities, 6 industry partners, 11 SMEs and 11 NHS Trusts across the South-East, and has significant Clinical Medicine involvement. The Centre aims to bring the power of AI to transform healthcare pathways, providing both patient and economic benefit, and has received c.£40m investment from Innovate UK, Office for Life Sciences and industry.

4.2.6 Regenerative Medicine Platform (UKRMP)

In 2014, we formed the UKRMP Immunology Hub (https://www.ukrmp.org.uk) to address potential immune barriers to stem-cell-based therapies (Watt/Sacks/Lombardi/Dazzi/Ali). This enabled the generation of tools, protocols and resources for the wider research network to advance UK's position to lead and make rapid progress in using stem cells for tissue repair/regeneration. We are contributing to the second phase of UKRMP funding (2018-23) through membership of the Stem Cell Niche hub (Watt/Lombardi/Dhawan) and the Safety & Immunology Panel of the Smart Materials Hub (Sacks/Ali). Our long-term clinical deliverables include improved efficacy of photoreceptor cell therapy for blindness, regeneration of damaged heart tissue, and improved survival/functionality of transplanted hepatocytes as an alternative to liver transplantation.

4.2.7 Genes & Health

Genes & Health (joint lead, Trembath) is a large (c.100,000), long-term community-based health outcomes study, focused on people of Bangladeshi and Pakistani heritage. Started in East London, it now includes communities in Bradford and Manchester, and is a partnership led by QMUL with MRC/Wellcome/NIHR/RE funding. Major insights include the assessment of participants with

homozygous gene "knockouts", identified at increased frequency from parental relatedness and across a broad range of phenotypes (*DOI:10.1038/s41467-019-12283-6);* evaluating drug targets (*DOI:10.1038/s41586-020-2267-z*); elucidating genetic risk factors for severe COVID-19 (*DOI:10.1038/s41586-020-2818-3*).

4.3 NHS Collaborations

Clinical Medicine at King's is fundamentally integrated with healthcare delivery, to our mutual benefit. Our research directly informs and improves clinical care (e.g. 7 of 10 impact case studies) while clinical-academic integration informs research questions, facilitates experimental medicine, and the clinical "pull" for translational research.

4.3.1 King's Health Partners

KHP, one of 8 UK AHSCs accredited by DHSC/NHS England, is our primary vehicle for close NHS engagement. It comprises King's as the academic partner and GST, KCH, and South London & Maudsley NHS Trusts. KHP aims to accelerate the translation of leading-edge research, new technologies and treatments into advances in patient care throughout the sector.

KHP has c.5 million patient contacts/year and >600 clinical trials in delivery. It is structured around clinical-academic groups (CAGs) and Institutes, promoting clinical-academic cohesion across all Clinical Medicine areas. Clinical Medicine academics lead 4 CAGs (Purushotham/Hayday/ Sacks/Shah). Our achievements are differentiated by pioneering work integrating mental and physical healthcare across specialities, research-intensive cardiovascular and haematology institutes (Directors: Shah and Mufti, respectively), and integrated prevention programmes in key areas that most impact on the health of our local community, e.g. tobacco smoking, hypertension, obesity, alcohol. The contributions to these areas are detailed in outcomes books authored by CAGs:
https://www.kingshealthpartners.org/resources?utf8=%E2%9C%93&category=Outcomes+Books&commit=Filter#article_filter

KHP led the creation and delivery of the South London Genomic Medicine Centre (hosted by GST), part of the 100,000 Genomes Project. The centre aims to improve disease prediction and prevention, enable more precise diagnostic tests, and aid personalisation of therapy based on specific genetic variants. KHP has also been fundamental to the creation of the Innovate UK London AI Centre for Value-Based Healthcare, which is able to access full NHS data sets across our partnership (and beyond).

In response to COVID-19, KHP secured £1.2m philanthropic funding for immunological sciences (Malim/Hayday) and has worked with the Academy of Medical Sciences to make recommendations on mental health outcomes, leading to a UKRI funding call. It is to the credit of our CAGs that research contributed to the local validation of new NHS typing platforms for emerging pathogens (*Section 1.8.4*) and patient stratification (*Section 1.11.1*).

4.3.2 The GST-King's NIHR Biomedical Research Centre

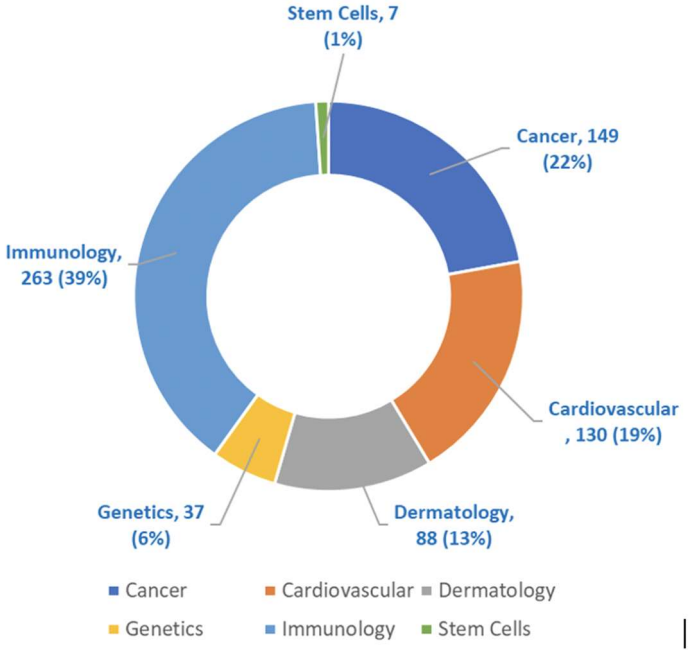
King's is the academic partner in the GST NIHR BRC, which provides critical infrastructure for translational research and experimental medicine. Clinical Medicine provides overall BRC leadership (Lord/now Brown), theme leadership in Infection & Immunity (Malim/Taams/Hayday), Cardiovascular medicine (Shah/Giacca), Cancer (Parker), Regenerative medicine (Watt), Genetics (Trembath/now Hubbard), Cutaneous medicine (McGrath), Transplantation (Sacks), and Clinical Research Facilities (Chowienczyk). The importance of the BRC is described in ***Sections 1.4/1.7/3.3***; it contributes to wider partnerships (e.g. the RE Advanced Therapies Centre, commercial partnerships), the delivery of clinical translation, and providing a market-orientated route to health and economic benefit.

4.3.3 Interaction with clinical "Category C" staff in our research *(see also Section 2.10)*

CatC staff make up over a third of research-active staff in Clinical Medicine (Table 4.3), reflecting the clinically-embedded nature of our research and substantial efforts to support and integrate NHS staff with research interests, e.g. Adjunct appointments and opportunity for promotions (*Section 2.10*).

Table 4.3. Number of Category A and Category C staff, by Clinical Medicine theme.

	Immunology	Cardiovasc	Cancer	Genetics	Stem cells	Dermatology	Total
CatA	65	46	41	22	11	6	191
CatC	51	20	33	3	1	4	112
Total	116	66	74	25	12	10	303



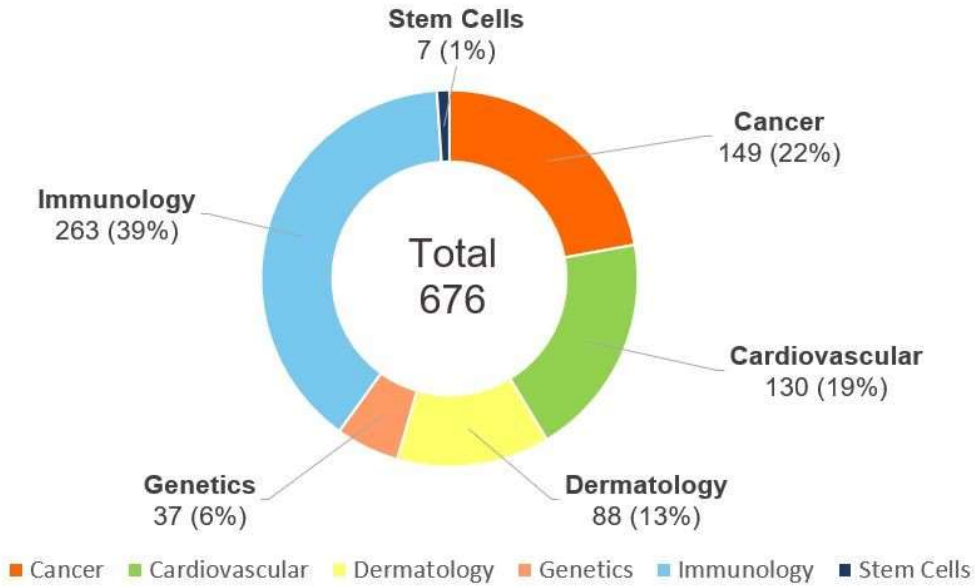


Figure 4.3. Breakdown by discipline of 676 joint publications between Category A/B and C researchers between 2014-2020; shown as number and percent of the total.

Engagement with CatC staff is enhanced by joint meetings/seminars/workshops, joint grants and publications (***Fig.4.3***). For example, CatC staff led a recent paper on the feasibility of using allogeneic, genome-edited CAR-T cells to treat patients with aggressive leukaemia (*https://doi.org/10.1016/S0140-6736(20)32334-5*); other CatC staff made critical progress in validating an immune signature that predicts rejection ahead of conventional markers (*https://doi.org/10.1016/j.ebiom.2019.01.060*); others described feasibility and safety of Treg therapy for kidney transplant patients (*https://doi.org/10.1016/S0140-6736(20)30167-7*).

4.4 Collaboration with industry

We partner with industry to enhance our research and accelerate translation into patient (and broader) benefit. Our strategy for engagement with industry is based on two approaches: (1) forming lasting strategic partnerships, often across multiple topics and encouraging embedding of staff to strengthen the depth of collaboration, and (2) working in partnership with SMEs to accelerate their growth. Together, this creates an ecosystem where small companies benefit from the expertise and support of large multinationals, and large companies benefit from the innovation and agility of SMEs – and both contribute to our research and impact mission.

4.4.1 King's/KHP South London Innovation District

We strongly favour co-location of industry partners within our clinical-academic facilities. This approach is embodied in our Innovation District concept of three academic-clinical-industry hubs: Biomedical & Experimental Medicine Hub (Guy's), MedTech Hub (St Thomas') and Neuroscience/Mental Health Hub (Denmark Hill). The Biomedical & Experimental Medicine Hub (***Fig.4.4***) is primarily relevant to Clinical Medicine, and incorporates strategic partnerships with:

- **GSK**: focused on cancer, data science, medical imaging and advanced therapies, and including secondment of a senior GSK director to manage the partnership (c.£10m commitment).
- **UCB**: focused on cancer, rheumatology and neurology, with an on-site "UCB Hub" at Guy's (c.£2m investment).
- **Unilever**: broad partnership including stem cells, dermatology and cardiovascular, including on-site research presence (annual investment c.£2.5m over last 5 years)
- **Celgene**: strategic partnership in haematology and advanced therapies, including on-site research labs at KCH (c.£20m commitment)
- **Nikon**: Imaging Centre of Excellence located at Guy's, supporting cutting-edge advanced optical microscopy and operating as a beta test site (c.£3m commitment).
- **Innovate UK Cell & Gene Therapy Catapult**: co-located with our experimental medicine facilities.

Clinical Medicine academics are also firmly engaged in strategic partnerships with **Siemens**, **Medtronic** and **Nvidia**, led by UoA12 researchers and focused on medical imaging, healthcare engineering and AI/data science.

4.4.2 Spinouts and SMEs

King's offers a complete system from idea through to (well-funded) spinout/commercial licensing. Initial translation is supported by "impact accelerator" funding, including our KHP Challenge Fund *Section 3.2*; biomedical focus), alongside resources and expertise from the BRC, King's Policy Institute and more. King's Research Development supports academics to obtain substantive translational funding from UKRI, Wellcome and similar sources. Our IP & Licensing team provide dedicated expertise and management of IP protection, licensing/spinout and associated commercial/venture fundraising. This team also undertakes a series of activities to ensure

awareness of commercialisation opportunities. The KHP Clinical Trials Office is responsible for overseeing contract negotiations and regulatory scrutiny on clinical trials of investigational products.

Figure 4.4. Schematic of the Experimental Medicine Hub at Guy's.

Clinical Medicine researchers have spun out a range of exciting companies, for example:

- Gammadelta Therapeutics (Hayday): Gammadelta T cells to treat cancer; up to $100m investment from Abingworth and Takeda.
- Quell Therapeutics (Lombardi/Sanchez-Fueyo/Lechler): Tregs for autoimmunity and transplant; >£61m investment led by Syncona.
- Leucid Bio (Maher): CAR-T cells to treat cancer; >£2m investment from Epidarex
- IgEM Therapeutics/Epsilogen (Karagiannis): IgE antibodies to treat cancer; £5m investment led by Epidarex.
- Forcefield Therapeutics (Giacca): Novel cardioprotective agents; £5m investment led by Syncona.
- Adaptate (Hayday): Therapeutic antibodies designed to modulate the activity of a patient's own cytotoxic gamma delta T cells *in situ*; investment from Abingworth and Takeda.

We have also played a significant role in the development of Autolus (UCL-King's collaboration) and Orchard Therapeutics (part-embedded at Guy's).

4.5 Global Partnerships

King's Clinical Medicine academics lead and participate in partnerships across the world, including major universities and industry in high-income countries (particularly US, Europe), and universities, governments, healthcare providers and NGOs in Low- and Middle-Income Countries to embed our research in "development" settings and achieve impact through true partnership. Since 2014, King's academics have co-authored >40,000 publications with 5,705 collaborating institutions in the *Times Higher* category "*Clinical, pre-clinical & health*". This includes >36,000 publications with >2,500

European institutions, >10,500 publications with >1,000 US/Canadian institutions, >1,500 publications with 274 African institutions, >1,800 publications with 249 South American institutions, >7,500 publications with >1,200 Asia-Pacific institutions, and >1,900 publications with 364 Middle-Eastern institutions.

A summary of the strength and range of our collaborations, measured by co-authored publications, is shown in ***Fig.4.5***.

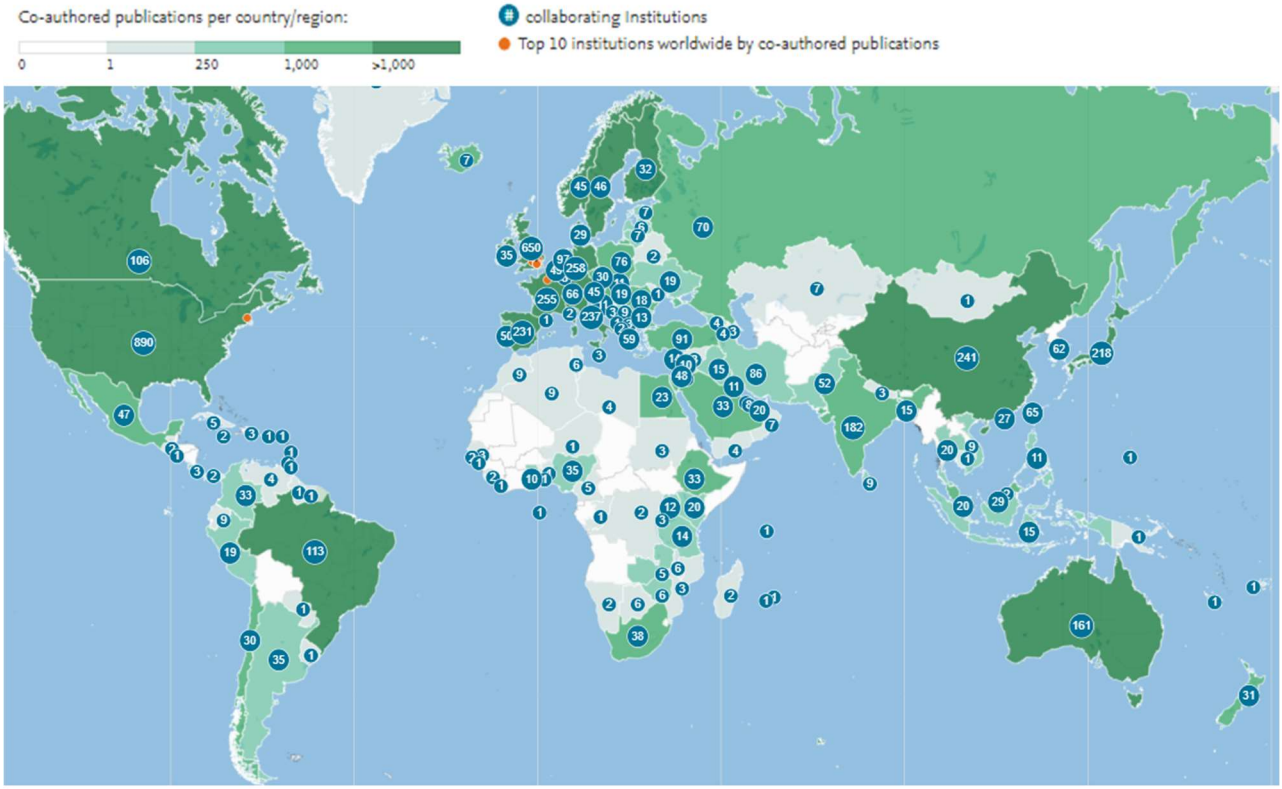


Figure 4.5. King's College London Collaborative publications 2014-2020 in the THE Category "Clinical, pre-clinical & health" (SciVal)

The appointment of Vice-Dean International (Dazzi, Cancer) in FoLSM and International Leads in each School during the REF2021 period has greatly enhanced the ambition for global healthcare impact of our research and innovation strategy.

In Europe, we operate a formal partnership with Technische Universität Dresden, to form the King's-Dresden *TransCampus* (Dazzi/So/Farzaneh/Watt and more), supported by c.€50m research funding alongside PhD programme funding.

In the US and Australia, we operate the PLuS Alliance with Arizona State University and University of New South Wales.

We have recently created a strategic partnership with UPenn that has translated into 2 initiatives. The first has been a call to fund COVID19-related projects developed in collaboration between the 2 universities. The second is a collaboration on Advanced Therapies, including a new Summer School. UPenn are also a formal collaborator in our BHF Cardiovascular Centre.

In 2019, King's formed a major strategic partnership with China's Southern University of Science & Technology (SUSTech) in Shenzhen, an emerging research-driven organisation. The partnership builds on the integration of science, engineering and medicine to tackle key healthcare challenges.

Our strategic partnerships with India include the creation of a laboratory at the Indian Institute of Science Bangalore (https://www.iisc.ac.in/) by our international lead in SIMS (Vyakarnam), which

drives immunogenetic research on the association between HIV and TB in poor communities and promotes exchange of knowledge and skills with one of India's premier research centres, further enhanced by rising stars from India taking up appointments at King's (e.g., Mukhopadhyay, Shankar-Hari). This link has recently led to MRC funding for work on COVID-19, ethnic background and cardiovascular comorbidity across India and the UK (Hayday/Neill/Shah/Mayr/Shankar-Hari/Chowienczyk/Vyakarnam). Coherent with this focus, the clinical-academic lead (Purushotham) in Cancer (International Lead, Grigoriadis) has led a research and training programme with the Tata Memorial Centre (TMC) Mumbai since 2007. From 2017, Purushotham has led the National Cancer Programme in India to develop policy on managing Cancer nationally and enhance patient recruitment to clinical trials in partnership with TMC.

We lead the UKRI/GCRF Centre for Research in Health in Conflict (Director, Sullivan), developing research capabilities in the middle and near East, including Syria.

The King's Institute for Cancer Policy (Director, Sullivan) continues to inform national and international policy in India, the Middle East and North Africa, and to lead authoritative Lancet and Lancet Oncology commissions during the REF2021 cycle (supplementing his WHO role on the global burden of disease).

In sub-Saharan Africa (SSA), our HIV team (Fox, see Impact Case Study) leads the CHAPS research programme concerned with the prevention of HIV transmission. Focused on pre-exposure intervention trials with international collaborators, the research is on course to deliver reduced transmission of HIV.

This work aligns with the NIHR Global Health Research Unit *CARE-SSA* (led from UoA2/3). Healthcare across sub-Saharan Africa (SSA) reaches too few of those in need and does not achieve the best possible results. Resources are limited, so non-specialists provide most treatments. The Unit brings together surgeons, obstetricians, midwives, psychiatrists, public health dentists, palliative care and general healthcare specialists to work with social scientists, health economists, information technologists and implementation scientists, to find practical and equitable ways to improve the coverage and quality of care. It operates across three care platforms – surgical care, maternal care, and integrated primary healthcare for chronic diseases – in Ethiopia, South Africa, Sierra Leone and Zimbabwe.

4.6 Engagement with key research users, beneficiaries and audiences

Public, patient and community engagement is vital to our success and at the heart of our research. Uniquely positioned among some of the UK's most disadvantaged communities, we take particular care to ensure engagement with sections of society most likely to benefit. Our aims range from building patient/public confidence in our research to inspiring young people from local communities (many with underprivileged backgrounds) to consider biomedical career options (e.g. our flagship Extended Medical Degree Programme).

Clinical Medicine PIs benefit from central (2.8 fte), KHP (1.5 fte) and local (2 fte) expertise to support effective engagement activities, maximise benefits to the public, and ensure that a wide range of perspectives enhance our research. We also have support from King's central seed funding (e.g. Wellcome ISSF) and strategic priority teams on Service-to-Society and London. The King's Engaged Researcher Network (KERN) runs regular public-patient engagement training, e.g. recent fully-booked sessions on engagement via digital media.

The following examples underline the breadth and depth of our contribution to three priority audiences as well as highlights of evaluation used to continually improve practice.

4.6.1 Engaging with patients

All Clinical Medicine disciplines run regular events to promote understanding of science for patient benefit and encourage patient participation in research. The **Stem Cell Centre** has a dedicated patient engagement officer who, with student advocates, promotes sharing of research stories with patient groups representing a broad range of diseases (***Fig.4.6*** *left/centre panels*). **SIMS** has patient advocates on the Renal Research Board alongside our investigators to advise on clinical projects and report back to the local Kidney Patients Association (who then fundraise, informed by agreed priorities). For patients with autoimmune disease, we run online education workshops with consistent positive feedback; a recent event on lupus had 578 attendees (Morris/Vyse). The **BHF Centre** runs regular engagement events for patients and BHF volunteers, e.g. meet-the-researcher, CPR training, visualise-your-heart. The **Cancer Centre** has a bespoke research zone where our researchers give monthly updates to patients. An annual Cancer Survivors day includes patient-focused research talks from current academics. The Centre itself was supported by public fundraising events (£1.1M), e.g. Guy's Urban Challenge. We host stands at annual Clinical Trial days at the KHP hospitals, which are popular with patients and relatives (***Fig.4.6****, right panel*). For hospitalised children, we run outreach lessons (e.g. how tissues repair themselves) from the St Thomas' Hospital Evelina School.

Figure 4.6. Learning to engage.

4.6.2 Engaging with Schools

This is a thriving area of our work that we prioritise to inspire the next generation and provide rewarding experiences to our researchers. Collaboration with the **Social Mobility Foundation** affords our researchers the chance to give local schoolchildren hands-on experience, e.g., in transplant immunology research, where the kids later expressed their observations through rap and art (2017). We participate in the **Mayor's Fund for London STARS** programme, which supports entry of school students to university and employment (since 2018). We engage with the **Mayor's Fund for London Access Aspiration** scheme, e.g. online stem cell workshops to 130 underserved young Londoners from 20 schools, with 100% reporting learning something new (2020). Through the **Native Explorers programme** we contribute outreach sessions (>100 students to date) in the heritage languages of children, aiming to promote diversity in science. **Regional school visits** cover topics such as how big data and epidemiology are enabling progress in cancer prevention/treatment (Van Hemelrijck) or bringing alive cell biology by 'stepping inside the cell' (Wells). Our support for the **In2scienceUK** scheme allows us to connect young people with world-class

scientists/technologists to boost diversity in the sector. We host A-level students from local schools in **summer placement programmes** within Clinical Medicine sections.

4.6.3 Engaging with the wider public

Our researchers also engage with the wider public and contribute to important discussions around research in society – face-to-face, in collaboration with artists, and on digital platforms with global reach.

Our podcast and YouTube presentations on **vaccine development** from 2015 onwards attracted >36,000 views worldwide, pre-empting the need for accurate and clear messages to stimulate vaccine uptake (Klavinskis). In 2018, we contributed to '**The Virus Within: Hearing HIV'**, using original music to convey to audiences how cutting-edge research on HIV has moved from lifelong treatment to cure (Swanson). We run regular events on **translating research for clinical benefit**. The most recent one on organ donation (2017) used drama, research artefacts and patient stories to explore the notion that organ donation and medical research are mutually beneficial to society; this led 40% of the audience to report a change of opinion. We leverage the expertise of **Science Gallery London** (SGL, opened 2018) to connect 15-25 year old's with research through events/exhibitions that combine art and science. SGL is a free-to-visit space at London Bridge that has programmed seasons around clinical research, e.g. hosting 'SPARE PARTS' themed on organ transplantation and tissue regeneration (Watt). With attendance of >2,500 members of the public each week over three months, 80% of attendees reported acquiring new knowledge on the future of tissue repair.

We routinely present research to lay audiences, e.g. at an All-Party **Parliamentary Group meeting** on cancer screening and pancreatic/neuroendocrine tumours. To reach a different audience, our researchers contribute to **'Pint-of-Science'** by sharing scientific discoveries in venues such as pubs or cafés. Growing 3D tissues outside the body (Habib, 2017), new drugs for heart attacks (Curtis, 2019), understanding cell division (Carlton, 2018), and preventing transplant rejection (Howard, 2019) have shown these audiences how activities in their local AHSC improve lives in the local community. At the **Great Exhibition Road Festival 2019,** our Asthma UK Centre explored the relationship between air pollution, inflammation and asthma with c.1,000 members of the public. We work with international audiences to promote public understanding; e.g. **EuroStemCell** online meetings addressing questions from the public and patients; COVID-19 webinars; Stem Cell Awareness Day, leading to 3,500 full video views on YouTube and 34,000 viewers on Twitter (#OpenUpStemCells); **Science in the City** festival (Trieste, Italy) on the potential of cardiac gene therapy (Giacca).

4.7 Wider contributions through research leadership and strategy

We strongly support our academics to take leadership roles in support of the national and international research community. The following examples reflect the range and balance of leadership contributions to research and society during REF2021, including PIs at all career stages.

Major national/international leadership roles

- Lechler, *President, Academy of Medical Sciences*
- Watt, *Chief Executive, Medical Research Council*
- Malim, *Vice-President, Academy of Medical Sciences*
- Avkiran, *Associate Medical Director, British Heart Foundation (BHF)*
- Giacca, *President, International Society for Heart Research (European Section)*
- Barker, *President, European Society for Dermatology Research*

Fellowships

- 4 Fellows of the Royal Society (Watt, Malim, Hayday, Parker)
- 15 Fellows of the Academy of Medical Sciences (Hayday, Lechler, Lombardi, Lord, Malim, Mathew, McGrath, Ng, Otsu, Sacks, Shah, Solomon, Trembath, Tutt, Watt).

Editorships

- Malim, *Editor-in-Chief, PLoS Pathogens*
- Taams, *Editor-in-Chief, Clinical & Experimental Immunology*
- Dasgupta, *Editor, British Journal of Urology International*
- Sullivan, *Editor-in-Chief, Journal of Cancer Policy*
- Watt, *Founding Deputy Editor, eLife*
- Associate Editorships include: *American Journal of Physiology - Heart&Circ* (Shah), *British Journal of Dermatology* (Barker), *British Journal of Pharmacology* (Curtis), *BMC Cancer* (Van Hemelrijck), *Cardiovascular Research* (Giacca, Shah), *Frontiers in Immunology* (Kordasti)

International/National Awards and Prizes

- *EMBO Young Investigator* (Carlton, 2016)
- *Eugene Farber Oration, Society for Investigative Dermatology, USA* (Barker, 2017)
- *Janice Pfeffer Distinguished Award, International Society for Heart Research* (Shah, 2018; Giacca 2020)
- *American Academy of Allergy, Asthma & Immunology Distinguished Scientist Award* (Lack, 2016 UoA1/3)
- *European Academy of Allergy & Clinical Immunology Daniel Bovet Award* (Lack, 2018 UoA1/3)
- *International Trial of the Year award, Society for Clinical Trials* (Santos, 2015 with Lack/LEAP investigators)
- *European Federation of Clinical Chemistry & Laboratory Medicine HyTest award* (Kaier [ECR], 2017)
- *ANZICS Intensive Care Global Rising Star* (Shankar-Hari, 2016-17)
- *Parker Webber Oration, Royal College of Physicians* (Barker, 2016)
- *St. Peter's Medal, British Association of Urological Surgeons* (Dasgupta, 2020)
- *Cunningham Medal, British Division of International Academy of Pathology* (Pinder, 2019)
- *GSK Immunology Catalyst Professorial Fellow,* Lawrence

Other selected committees/society/national roles

- Sullivan, *WHO Advisory panel on NCD*
- Lechler, *BHF Trustee*
- Pinder, *Chair, National Coordinating Committee for Breast Pathology, Royal College of Pathologists/UK NHS Breast Screening Programme*
- Sacks, *Lead, Complement UK*
- Malim, *Co-Lead, Genotype-to-Phenotype UK National Virology Consortium (G2P-UK;2020)*
- Wells, *Chair, Life Sciences Committee, Royal Microscopical Society*
- Hubbard, *Chair, HDR-UK Infrastructure Advisory Group*
- Perera, *Lead, Working Group on Coronary Microvasculature, UK NIHR-BHF Partnership*
- Spicer, *Lead, Immunotherapy Theme, National Experimental Cancer Medicine Centre*
- Trembath, *Executive Board member NIHR BioResource Centre*

National and international funding body panels (selected)

- *MRC/Royal Society:* Brain, Marber, Malim, Sullivan
- *BBSRC:* Pfuhl
- *NIHR:* Dorling
- *Wellcome:* Klavinskis, Malim, Shah, Shattock
- *CRUK*: Hayday, Spicer
- *BHF:* Brewer, Eaton, Marber, Mayr, Modarai, Redwood, Shanahan, Shattock
- *ERC:* Giacca
- *INSERM*: Oakey
- *Health Research Board Ireland*: Brain, Taams
- *Medical Research Council Norway*: Oakey, Shah

MRC Clinical-academic Research Partnership (CARP) awards to CatC staff

- Irving (2019), Mahil (2020), Nebbia (2019), Patten (2019)