Institution: The University of Leeds

Unit of Assessment: 1 (Clinical Medicine)

Section 1. Unit context, research and impact strategy

1.1. Overview

Our submission represents research activity from 161 staff (154.8 FTE) within the School of Medicine (SoM). Our research strategy is driven by an ambition to improve outcomes for patients using approaches spanning discovery and translational science, experimental medicine and clinical trials, biostatistics, epidemiology and data science. Translation of research findings to clinical evaluation, adoption, and implementation is supported by academics working collaboratively within the SoM and across other UoAs (including 2-5, 7-12, and 24).

Our **interdisciplinary** research focuses on improving patient outcomes in **Cancer, Cardiometabolic Disease, Musculoskeletal Disorders** and **Rare Diseases**, and is facilitated by cutting edge innovation in **Healthcare Technologies (HealthTech), Imaging,** and **Data Science**. Our UoA has a critical mass of investigators tackling health challenges that have a global impact; £180M income from programme, project and infrastructure funding; a track record of internationally impactful publications; internal investment of £3.74M over the REF period to support early career researchers; and externally funded fellowships totalling £26.8M. Our commitment to academic excellence is embedded within a culture which values **equality, diversity, and inclusion** (EDI), as evidenced by our **Gold Athena SWAN** award.

Research highlights include:

- Major **infrastructure awards** with substantial **interdisciplinary collaborations**, including partnerships across the Faculties of Engineering and Physical Sciences, Biological Sciences, and Medicine and Health: the National Pathology Imaging Co-operative (£41.5M), MRC/Leeds Medical Bioinformatics Centre (£7.0M), NIHR Leeds Biomedical Research Centre (BRC) and NIHR Clinical Research Facility (CRF) (£7.45M) and MRI Scanner (£1M), Leeds Cancer Research UK Centre of Excellence for Radiotherapy Research (£3.5M), Cancer Research UK Clinical Trials Unit (£1.9M), NIHR Global Research Group for Surgical Technologies (£2.0M), British Heart Foundation Experimental and Preclinical Imaging Centre (ePIC) (£1.9M), NIHR Leeds Surgical MedTech Cooperative (£1.4M), NIHR Leeds In Vitro Diagnostics Co-operative (£1.4M) and the National Centre for Clinical Translation of Hyperpolarised Magnetic Resonance (£4.6M);
- **Total grant income** of £213M, including 69 programme level awards or grants > £1M;
- **4800 reviewed papers** published by UoA1 staff, of which 54% were in the top 10% journals by CiteScore Percentile (SciVal) and over half of which were co-authored with international collaborators;
- Success in **supporting and developing our early career researchers,** with 30 University Academic Fellows (UAF) securing £4.3M in external fellowships and 122 externally funded PhDs.

1.2. Research and Crosscutting Themes

Research in UoA1 is concentrated around **four diseases**, with research groups geographically aligned with hospital sites within Leeds Teaching Hospitals NHS Trust (LTHT; Figure 1). Research in these

areas is underpinned by **three crosscutting technology themes**: HealthTech, Imaging and Data Science. We are at the forefront of today's technologies in addressing grand clinical challenges by aligning our research priorities with clinical need, ensuring these strengths will deliver clear benefit to patients. Our research is key to driving inclusive economic growth, supported by our £40M NEXUS centre that fosters joint academic-industry co-creation and ensures rapid commercialisation (REF5a). The quality and impact of our research is enhanced by our close and interdisciplinary working across UoAs.

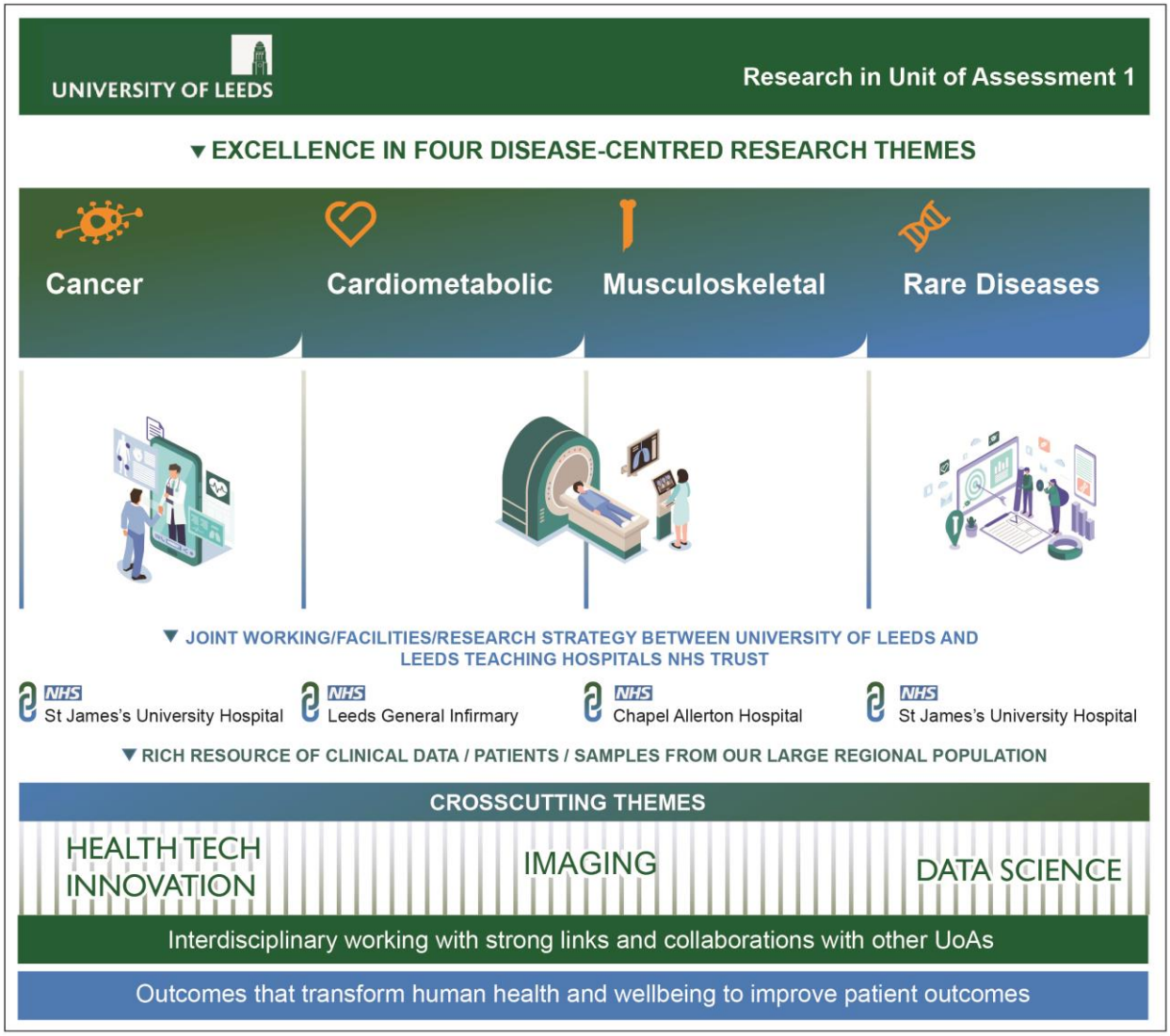

Figure 1: Research in UoA1. Our research targets grand clinical challenges in four distinct disease areas, co-localised with LTHT hospital sites, supported by cross-cutting technologies

Research and impact within UoA1 are facilitated through our partnership with LTHT, one of the UK's largest acute NHS trusts, with which we have a formal research framework agreement and a shared research strategy. Providing local and specialist services for a population of 770,000 and regional specialist care for up to 5.4M people, with 170,000 admissions and 1.2M outpatient attendances each year (pre COVID-19), LTHT represents a unique resource of patients, clinical samples and healthcare data, underpinned by one of the UK's most advanced connected digital health record systems. Our research is facilitated by the co-location of essential infrastructure, including laboratories, imaging and clinical research facilities, and five UoL/LTHT-hosted NIHR centres (collectively known as NIHR@Leeds) led by UoA1 academics. Activities are overseen by the Joint Partnership Board, co-

chaired by the University's Vice Chancellor and the Chief Executive of LTHT. Our wider civic role is ensured through leadership of the Leeds Academic Health Partnership to ensure we address local health demands, partner across the entire health and social care and, in partnership with AHSN, rapidly adopt innovation for the population of Leeds and Yorkshire & Humber.

The UoL/LTHT partnership co-hosts **our centres of excellence** (Section 3.2), which work across research themes to deliver research excellence with a clear path through to impact (Figure 2).

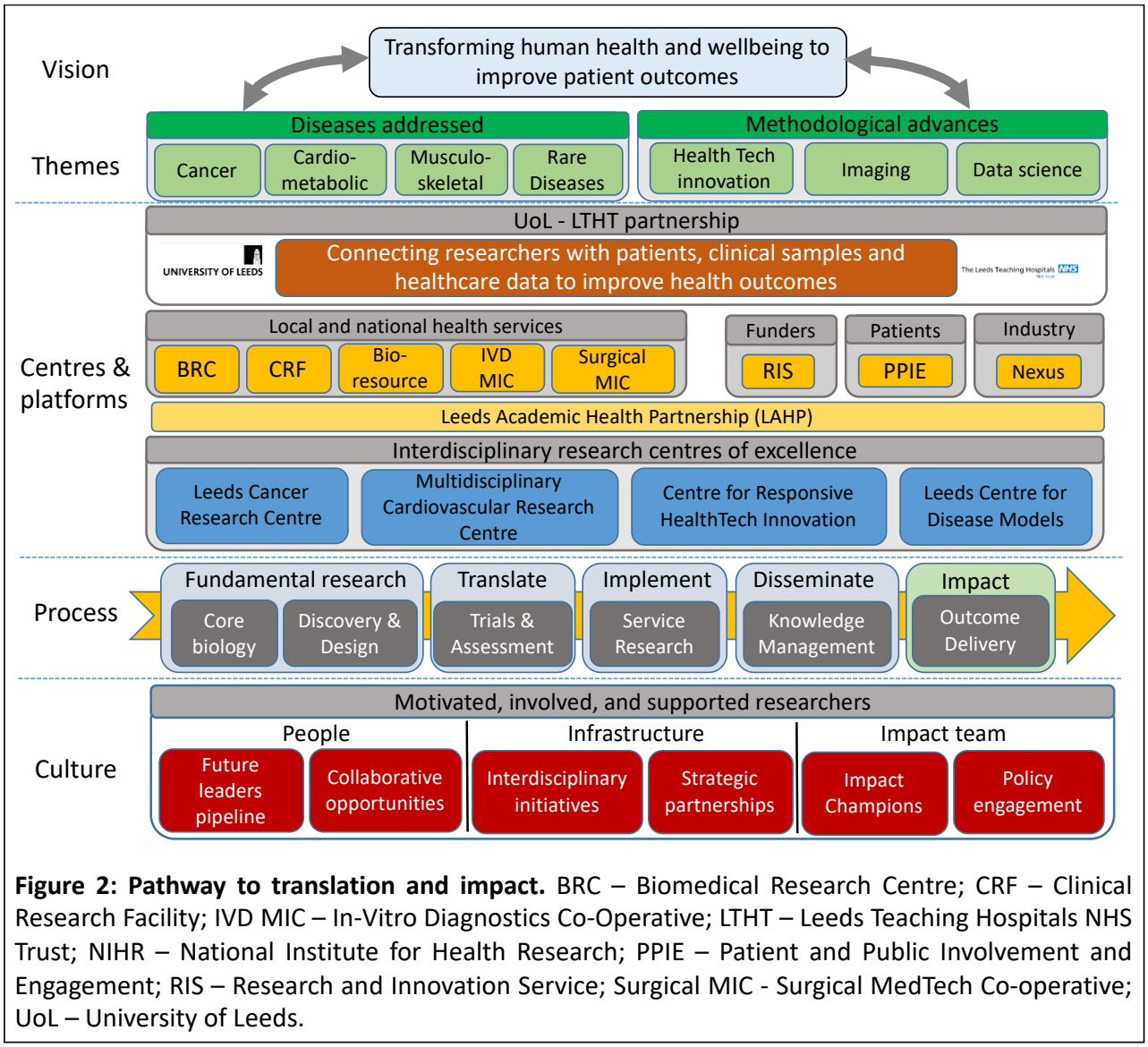

Figure 2: Pathway to translation and impact. BRC – Biomedical Research Centre; CRF – Clinical Research Facility; IVD MIC – In-Vitro Diagnostics Co-Operative; LTHT – Leeds Teaching Hospitals NHS Trust; NIHR – National Institute for Health Research; PPIE – Patient and Public Involvement and Engagement; RIS – Research and Innovation Service; Surgical MIC - Surgical MedTech Co-operative; UoL – University of Leeds.

We foster a dynamic R&I environment by actively pursuing research as a mechanism to improve patient outcomes. Our vision is realised through a focus on specific diseases, underpinned by Centres and Platforms of excellence. We create a culture of motivated researchers and have well developed processes to translate research excellence to impact (Figure 2).

1.3. Development of our Research Environment since REF 2014

Notation for staff names:
Staff returned in UoA1: **bold**
Returned retired or former staff with visiting status: ***bold italics***
Staff returned in other UoAs: underlined
Non-returned UOL or NHS staff: *italics*

Our REF2014 environment statement outlined ambitious plans for research in UoA1. To realise these ambitions, we have cultivated a thriving and inclusive research culture in each of our areas of research excellence. Detailed for each theme in Section 1.5, the **vitality** and **sustainability** of research in UoA1 is demonstrated by our major scientific discoveries, meaningful **impact** generating positive change for the health and wellbeing of the population**,** investment in infrastructure, vibrant culture of **interdisciplinarity** and our commitment to recruitment, training, development and mentorship of future academic leaders in an environment which prioritises **EDI**. We are proud to be the **first SoM** to receive an Advance HE **Athena Swan Gold Award**. We have instituted policies that have supported professional and personal development (Section 2) resulting in **40 UoA1 staff promoted** and award of 35 personal fellowships.

Cross-faculty **interdisciplinary working** is exemplified by several initiatives which include researchers across medicine, biology, engineering, physical sciences, artificial intelligence and computing (Sections 3.2 and 4.1). We have close working ties with the Astbury Centre for Structural Biology (£19M recent investment, Wellcome Trust) and Engineering & Physical Sciences (£96M investment in Sir William Henry Bragg Building) and have 21 UoA1 academics embedded in the Leeds Institute of Data Analytics (LIDA). Interdisciplinarity is key to our **early career researcher development,** exemplified by cross-faculty appointments of four University Academic Fellows in UoA1, our 4-year BHF-PhD programme in Cardiovascular Disease and Diabetes (16 Fellows across Medicine and Biology, £2.4M), our UKRI Centre for Doctoral Training in Artificial Intelligence for Medical Diagnosis and Care (50 PhD students spanning Medicine and Computing, £5.9M), and Wellcome and MRC consortia Doctoral Training Platforms (Sections 2.3.4 and 2.6).

Exemplars of **emerging research strengths** as a direct result of interdisciplinary working include:

- The National Pathology Imaging Co-operative (NPIC, *Treanor*, **Quirke** £41.5M UKRI Industrial Strategy Challenge Fund and NHS) initially with 27 partners including 9 NHS Trusts, 8 Universities and 10 Commercial partners. NPIC drives implementation of digital pathology in 15 Hospitals in the north of England, and a further 20 nationally, creating a National Digital Pathology system and generating over 3 petabytes of image data/year, enabling the NHS to lead on the development and use of artificial intelligence;
- Our commitment to tackling real-world challenges and global priorities is embedded in our cross-Faculty impact strategy, where the University has considerable strength in **global health**, receiving the UK's third highest number of GCRF awards (84 awards totalling £46.8M). Working with researchers across the University and key international collaborations, UoA1 academics have contributed to this success through surgical innovations in Sierra Leone and rural India (**Jayne**), combatting bacterial resistance in Europe (*Clostridium difficile* infection) COMBACTE-CDI (**Wilcox**) and tele-rehabilitation to improve quality of life in individuals with disability in Nepal (**Sivan**).

We responded quickly to the global **coronavirus pandemic** by mobilising our researchers to frontline clinical care; COVID research, which was delivered by the BRC and CRF working with LTHT; and

strategic advisory and outreach roles. Our response to COVID-19 illustrated both our research agility and the commitment of our staff to embrace new responsibilities, including secondments to the Alderley Park Lighthouse Lab and Loop-mediated Isothermal Amplification testing at UoL.

UoA1 senior academics holding national research leadership roles during the COVID-19 crisis include **Wilcox** (SAGE member and CMO Senior Clinicians Group), **Simpson** (Urgent Public Health Group member as CRN National Lead for O&G), **Hull** (UPH Group and Chair of UPH Aerosol-Generating Procedures Research Group), **Markham** (Non-Executive Director UKRI Medicines Discovery Catapult, establishing the national UK Lighthouse Labs Network) and **Stewart** (Vice President Academy Medical Sciences, winter planning, immune targets, workforce and impact on careers).

UoL researchers have secured 14 grants for COVID-19 research with the following led by UoA1:

- **Wilcox** and *Messenger* : NIHR CONDOR, £1.3M involving the NIHR Leeds In Vitro Diagnostics Co-operative (Section 3.2.1);
- **Greenwood**: COVID-HEART (£0.8M UKRI/NIHR), a UK multi-centre study employing MRI to investigate the effects of SARS-COV-2 on the heart;
- **Sandoe** (PEACH - £0.7M) investigation of procalcitonin in the evaluation of antibiotic use in COVID-19 hospitalised patients.

The UoL/LTHT infrastructure provided a responsive environment to address the pandemic, notably re-prioritising BRC-CRF activity to COVID-19 experimental medicine candidates. Within five days of the first COVID patient being admitted to LTHT, we recruited into nationally prioritised studies (e.g RECOVERY), led on critical SARS-CoV-2 testing infrastructure and recruited 684 patients in 26 UPH intervention trials, and over 800 patients into vaccine trials (highest single site recruiter to the Novavax trial). UoA1 researchers published 153 peer reviewed publications in the REF period in response to the pandemic.

1.4. Research and Impact (R&I) Strategy

1.4.1. Development since REF2014

Throughout the REF period, our goal has been to improve patient outcomes and reduce health inequalities at local, national and international levels through the delivery of research excellence and impact. Our strategy is predicated on exercising judgement, focusing on areas of international excellence that encompass the full translational pathway from discovery science to applied health research.

Our funding successes, infrastructure investment and strategic appointments have driven the evolution of the themes we returned in REF2014 (Cancer and Pathology, Cardiovascular, Musculoskeletal Disease and Genes and Development) as illustrated in Figure 1. Our strategy is driven by the aim of improving health and wellbeing through **research** and **innovation** in biomedicine and health services embedded within a structure that promotes and values its **people** and **impact**.

Our vision is that we will transform human health and wellbeing to improve patient outcomes across cancer, cardiometabolic disease, musculoskeletal disease and rare diseases.

Led by the Dean (**Kearney**), the SoM developed a bold, new strategy, *Medicine Redefined*. This employed an innovative staff consultation and cultural change programme which enabled us to build on our plans for research excellence and, critically, to embed activities in an ethical, vibrant, and supportive culture which promotes **scientific rigour, collaborative working** and **improved patient**

outcomes. At the core of *Medicine Redefined* was academic excellence underpinned by our commitment to EDI. Led by **Jayne**, the *UoL-LTHT Shared Research and Innovation Strategy for 2020-2030* was developed, promoting regional partnership working to transform health and wellbeing with a commitment to closing the gap on **health inequalities**, embedding research within **local communities**, supporting **outstanding patient care through research**, driving sustainable **innovation for inclusive growth** and equipping our researchers with **skills for the future**.

Integrating our previous strategy with *Medicine Redefined*, we have:

i. ***Focused our disease-based research themes to address grand clinical challenges***. Within our society anyone over the age of 40 years has a 1 in 5 chance of developing heart failure, a 1 in 2 chance of developing cancer and an almost universal likelihood of developing osteoarthritis, whilst rare diseases affect the lives of 3 million people in the UK. Our research themes respond to these major clinical challenges;
ii. ***Optimised our research strengths.*** All our disease-centred and cross cross-cutting technology themes have strong collaborations across the UoL and externally to meet the demands of tomorrow's healthcare professionals and the global population. Such strategic partnerships increase the efficiency, quality and impact of our research;
iii. ***Developed a cohesive strategy to deliver impact***. To achieve our ambition to use research as a mechanism for enabling positive societal change, we have adopted a 'push, pull, link and exchange' approach. This ensures that academics disseminate knowledge to the relevant users and stakeholders (*push*), actively stimulate a demand for knowledge amongst potential users (*pull*) and organise activities to bring researchers and interested parties together (*link and exchange*). The integration of this approach within our research cultivates and fosters a positive impact environment. We appointed 10 Impact Champions across the Faculty (**Morrison** and **McGonagle** in UoA1) to drive systematic realisation of impact and engagement with stakeholders. They ensure that impact is prioritised, based around identifying key opportunities for research excellence and providing capacity, as well as the motivation for academics to thrive. R&I strategy is delivered through dedicated staff based within the Faculty, including a Professorial Impact Lead (Mon-Williams UoA4) and a full time Impact Support Officer. They both sit on the University Impact Group that provides central support and strategic direction for impact activity across the campus. Impact roadshows and bespoke workshops are delivered alongside the University's centralised Organisational Development and Professional Learning service;
iv. ***Instilled an open research environment embedding a culture of research integrity and ethical governance.*** Research in UoA1 is conducted according to the principles of academic excellence, community, integrity, inclusiveness and professionalism. We share research data openly and publish through the White Rose Research Online database or open access publication (REF5a). We are committed to responsible practices in research evaluation aligned with the UoL's signature of the San Francisco Declaration of Research Assessment (DORA).

1.4.2. Research and impact plans for the next five years

We will strengthen our ambition to transform health in areas of major societal challenge through our domains of research excellence via:

- Responding to the changing patterns of human health and the increasing burdens of **aging** and **multimorbidity** by developing and harnessing **new technologies** and driving further advances in **imaging science**;
- Maximising our partnerships to interrogate big data sets to improve patient outcomes and identify new opportunities in the **HealthTech** and **AI** spheres in our research themes;

- Promoting **interdisciplinary research** through our flagship platforms (Section 3.2);
- Leveraging the infrastructure and capacity of **significant investments**, by securing grants from major government, research council, charity and industry funders and targeting longer and larger UKRI awards to ensure sustainable research income. Our plans include applications for more ambitious Leeds BRC (led by **Conaghan** and **Stewart**), a progressive NIHR CRF, a Cancer Research UK (CRUK) Centre, a CRUK Experimental Cancer Medicine Centre and new Doctoral Training Platforms across Wellcome, BHF, MRC and EPSRC;
- Capitalising on the £600M **Leeds Hospitals of the Future** programme, the largest healthcare capital investment detailed in the government's Health Infrastructure Plan. As the first digital-by-design hospital in the UK, plans include new Adult and Children's Hospitals in 92,000m^2 of focused healthcare space, with the opportunity to extend our NEXUS industry community through the Leeds Innovation district;
- Continuing to grow our **research infrastructure** to provide seamless pathways to achieve **impact**.

We will further develop our thriving **research and environment** by:

- Leveraging policy-maker, professional, public, industry and academic **partnerships** to maximise the **relevance, reach and impact** of our research;
- Working across the UoL-LTHT partnership, embed our **strategic approach to public and patient engagement** (Section 4.3) across the UoL-LTHT partnership, by building sustainable partnerships with existing groups, increasing diversity, and developing novel methods of involvement;
- Identifying and developing **future research leaders** by winning high quality doctoral, postdoctoral and senior training fellowships and mentoring our cohorts of earlier career researchers, University Academic Fellows, and clinical academic trainees;
- Building on our Athena SWAN Charter Gold Award to promote a **diverse, equitable and inclusive research culture**.

1.5 Research Disease Themes

1.5.1. Cancer Research Theme

Cancer represents one of the biggest global challenges. In 2020 there were 19.3M new cases and 9.9M cancer deaths (WHO 2020). The incidence is predicted to rise to 27.5M new cases by 2040 (CRUK) with 1 in 2 men and women being diagnosed with the disease during their lifetime.

Our grand challenge is to bring together scientists and clinicians from across discipline boundaries to deliver world-leading cancer research that improves outcomes for patients with cancer.

The cancer research theme is strongly aligned with the recently established, interdisciplinary Leeds Cancer Research Centre (LCRC - Director **Sebag-Montefiore**). LCRC research excellence and state-of-the-art infrastructure in discovery biology, physical sciences, engineering, artificial intelligence and clinical research to unlock new insights in cancer biology and accelerate the translation of exciting new treatments and technologies to improve the prevention, diagnosis and treatment of cancer.

Theme strengths cover the breadth of interdisciplinary cancer research including cancer biology, prevention, early diagnosis and detection, treatment and optimisation. Strengths in translational and clinical research include cancer and digital pathology, clinical trials, surgery and robotics and

radiotherapy, with disease strengths in anal, brain, colorectal, haematological, liver, lung and urogenital cancers.

Our clinical trials deliver outcomes-focused research, defining new standards of care that have changed clinical practice through national and international guidelines resulting in global socio-economic benefit. For example, clinical trials demonstrated improved survival for patients with chronic lymphatic leukaemia [UOA1-1299] and myeloma [ICS#UOA1-4] and reduced risk of bowel cancer in patients with Lynch syndrome treared with aspirin [ICS#UOA1-1]. The largest randomised trial performed in colorectal cancer demonstrated similar outcomes for robotic surgery when compared to laparoscopic surgery [ICS#UOA1-2].

Research Groups

i. Tumour biology

Understanding the cellular and molecular causes of cancer is vital to developing new therapies and to improve detection and diagnosis. Research areas of this group include cell signalling and cancer genomics (***Knowles*, Riobo-Del Galdo, Lorger, Mavria, Wurdak**), computational cancer biology and bioinformatics (**Stead** – UKRI Future Leaders Fellow), biomarker development (***Banks***), novel *in vivo* therapeutics such as microbubbles and nanorods (**Coletta**), oncolytic virus immunotherapies (**Griffin, Cook,GP**) and translational oncolytic viral trials (**Samson** - CRUK Clinician Scientist).

ii. Cancer prevention

Research in this group focuses on the early (endoscopic) diagnosis of mucosal lesions (**Grabsch**) and their prevention by endoscopic removal (**Subramanian**) or chemoprevention (**Hull, Bishop** -Turing Fellow).

iii. Digital pathology and cancer informatics

Quirke (NIHR Senior Investigator) and *Treanor* (LTHT) pioneered digital scanning and virtual histology which has enhanced cancer diagnosis. *Treanor* leads the National Pathology Imaging Co-operative (£41.5M UKRI/NHS/Industry funding) which applies AI to cancer diagnosis. **Hall,G** and **Markham** provide national leadership in cancer informatics through their roles at Health Data Research UK and our MRC Medical Bioinformatics Centre.

iv. Systemic Therapies

Working closely with the Clinical Trials Research Unit (UoA2), LTHT and NIHR Leeds CRF, this group (***Selby*, Twelves, Seymour, Perren, Vasudev, Seligmann)** focuses on novel treatments and translational clinical trials in patients with breast, gastro-intestinal and kidney cancers.

v. Radiotherapy Research

Sebag-Montefiore leads the Leeds CRUK Centre of Excellence for Radiotherapy Research. This group focuses on personalised, adaptive and novel strategies for brain, liver and pelvic radiotherapy for primary and recurrent cancer with a focus on patients with brain, liver and anorectal cancers (**Sebag-Montefiore, Short,** Frangi (UoA11)**, Henry, Appelt, Murray, Gilbert**-CRUK Clinical Trials Fellow).

vi. Precision Cancer Surgery

Jayne directs the NIHR In Vitro Diagnostic Co-operative including a focus on patients with colorectal (**Jayne**) and hepatobiliary cancers (*Toogood*). **Jayne** and Valdastri (UoA12) specialise in novel robotic and engineering approaches for precision surgical treatments and **Mathew** in Neurosurgery.

vii. Haematology and Immunology

The international strengths of this group include clinical and translational research in B-cell haematological malignancies (**Hillmen, Tooze, Cook,G**), melanoma (**Newton-Bishop**), cancer genetics and epidemiology (**Bishop**), and molecular and cellular immunology (**Cook,GP, Klein**). **Cook,G** directs the NIHR Surgical Technologies Medical Technologies In Vitro Diagnostics Co-operative.

viii. Host-microbial interactions

Quirke, Wilcox, Kirby, Hull, Ford, Sandoe have major strengths in understanding the role of the microbiome in cancer risk and treatment efficacy as well as hospital-acquired infection and anti-microbial resistance research**.** There are strong links with Electronic & Electrical Engineering (UoA12) for the development of novel sensors.

Research and Impact Highlights

Bishop demonstrated that aspirin prevented the development of colorectal cancer in patients with Lynch syndrome [UOA1-356; ICS#UOA1-1]. **Grabsch** reported intratumoural heterogeneity of gene expression in gastric biopsies in relation to metastasis [UoA1-4607]. **Hull** reported in a randomised trial that aspirin and EPA have chemopreventative activity in high risk patients in the first intervention trial in the Bowel Cancer Screening programme [UOA1-592]. In colorectal cancer, **Quirke** identified patients with tumours overexpressing and amplifying the HER2 gene as an alternative driver of MEK–AKT pathway activation [UOA1-37]. **Jayne** demonstrated that robotic assisted surgery resulted in similar rates of conversion to open surgery as laparoscopically assisted surgery [UOA1-586; ICS#UOA1-2]. **Sebag-Montefiore** demonstrated improved functional outcome and high rates of organ preservation in early stage rectal cancer when compared with radical surgery [UOA1-4614]; and identified 26 weeks as the best time to determine complete response in the largest global randomised trial of chemoradiotherapy for anal cancer [UOA1-486; ICS#UOA1-5].

In B cell malignancies, **Hillmen** demonstrated that Ibrutinib improved overall survival, compared with ofatumumab in patients with previously treated Chronic Lymphatic Leukaemia [UOA1-1299] and **Cook,G** demonstrated that high-dose melphalan and salvage autologous stem cell transplantation improved overall survival in the Myeloma X relapse trial [UOA1-1345; ICS#UOA1-4]. **Klein** established a pivotal role for NF-κB subunits in the contribution of regulator T cells to anti-tumour immune responses [UOA1-3657] and germinal centre B cell maintenance [UOA1-3656].

In brain cancer, **Stead** demonstrated that when glioma cells were stressed by cancer therapies such as radiation and chemotherapy, tumours evolved randomly instead of proceeding down predictable paths [UOA1-2157]. **Wurdak** reported targeting of HSPD1-dependent metabolic pathways as an effective strategy for treating brain cancer [UOA1-2496]. **Mavria** identified a novel Rho-family GTPase activation cascade during angiogenesis [UOA1-2304]. **Twelves** and **Short** led the first, early phase randomised trial of cannabinoid treatment in cancer, in patients with glioblastoma multiforme.

Glaser together with Stark in UoA2 identified poor treatment outcomes in young patients with cancer leading to policy change and introduction of specialised NHS cancer services for teenagers and young adults [ICS#UOA1-3].

Treanor developed digital pathology software and interface (Leeds Virtual Microscope) which transformed pathology practice in LTHT and is improving cancer diagnosis worldwide (major industry partnerships including Leica and Roche) [ICS#UOA1-7].

Banks investigated the genomic architecture of clear cell renal cell cancer across Europe, identifying a potential environmental carcinogen [UOA1-106]. **Samson** demonstrated that the intravenous infusion of oncolytic human reovirus led to infection of tumour cells and up-regulated the PD-1/PD-L1 axis in tumour [UOA1-2140]. **Samson** treated the world's first patient with the oncolytic virus TG6002 administered by intrahepatic artery infusion in colorectal cancer with liver metastases. **Bishop** and **Iles** carried out large, international genetic meta-analysis to identify new cutaneous melanoma risk loci [UOA1-1772].

Key funding awards

Centre and Strategic / Infrastructure awards: Leeds Yorkshire Cancer Research Early Phase Clinical Trial Unit (Brown J (UoA2) with **Twelves & Sebag-Montefiore** £0.9M**)**; Leeds Cancer Research UK Clinical Trial Unit (Brown,J with **Sebag-Montefiore & Cook,G** £1.9M); Leeds Cancer Research UK Centre of Excellence for Radiotherapy Research (**Sebag-Montefiore** £3.5M); National Institute for Health Research In Vitro Diagnostics (**Cook,G** £1.35M) and Surgical Medical Technologies (**Jayne** £1.35M**);** Northern Pathology Imaging Co-Operative (*Treanor* LTHT £41.5M); Centre for Doctoral Training for Artificial Intelligence and the early detection diagnosis and treatment of cancer (Hogg (UoA11) with **Hall,G** £5.9M); Yorkshire Cancer Research University Academic Fellowship programme (**Stewart** £4M).

Programme funding: Cancer Research UK: **Bishop** (£4.9M); Morris (UoA2) with **Seligmann, Seymour** and others (£2.9M); **Tooze** (£0.6M); Ladbury with **Quirke** (£1.5M). Yorkshire Cancer Research: **Quirke** (£1.5M)**;** ***Knowles*** (£1.4M); Velikova (UoA3) with **Hall,G** (£0.5M). Brain Tumour Charity: **Short** (£1.4M).

Major National and International Collaborative Awards: Cancer Research UK: International Grand Challenge OPTIMISTICC (**Quirke** £2.5M); DATA-CAN Hub for Cancer Data (**Hall,G** £1.3M).

Clinical trials funding >£1m: Cancer Research UK: **Cook,G** Myeloma XII (£1.3M), Myeloma XIV (£1.3M) and Myeloma XV (£1.5M)**; Hillmen** CLL FLAIR (£1.0M); **Sebag-Montefiore** PLATO Personalising Anal cancer Radiotherapy Dose (£1.6M)**.** Yorkshire Cancer Research: *Callister (*LTHT) Lung cancer screening trial (£7.7M); **Hull** EMT 2 trial Omega 3 colorectal prevention trial (£1.5M); **Jayne** InTAct: intra-operative fluorescence angiography to prevent anastomotic leak in rectal cancer surgery (£1.9M). EU: ***Selby*** Novel cancer vaccines with virus based cDNA libraries and monitoring for resistant tumour cell populations in prostate cancer (£2.0M); Transgene: **Samson** Virus-based immunotherapies for the treatment of cancer (£2.8M).

1.5.2. Cardiometabolic Research Theme

Cardiovascular diseases are the largest cause of death globally, leading to the loss of 17.9M lives each year. Diabetes affects >415M people worldwide with changing lifestyle and patterns of nutrition generating an anticipated increase to 624M people by 2040. Cardiovascular disease and diabetes together represent a deadly combination leading to ~15 years reduction in life expectancy.

Our grand clinical challenge is to discover new principles for detecting and treating cardiovascular complications of diabetes.

This theme hosts 46 researchers including two British Heart Foundation (BHF) Professors (**Kearney**, **Plein**) and three Wellcome Trust Investigators (**Ariens**, **Beech**, **Schneider**). Our fundamental cardiometabolic research has led to advances in understanding of vascular insulin sensitivity, blood flow sensing, fibrin biofilm, myokine release, G protein signalling, heart failure and mitochondrial failure. Our discovery science feeds translational research aimed at developing new diagnostics and medicines

– e.g. novel anticoagulants (**Philippou**). In clinical science, we have demonstrated the utility of magnetic resonance imaging in coronary heart disease diagnostics and established a protective role for vitamin D in left ventricular dysfunction.

Research Groups

An interdisciplinary structure within this theme provides a boundary-free climate for cardiovascular research facilitated by seminars and an annual research retreat to promote collaboration. Our research is undertaken through three dynamic groups:

i. Discovery and Translational Science

We undertake high-calibre basic and translational studies in areas including ion channels (**Beech, Bon, Bailey, Shi, Kalli**), endothelial biology (**Kearney, Wheatcroft, Cubbon, Sukumar, Meakin, McKeown**), thrombosis (**Ariens, Philippou, Naseem, Macrae)**, metabolism (**Roberts**), myocardial biology (**Turner, Drinkhill, Saha, Maqbool**), reproduction and development (**Picton, Huntriss, Forde, Forbes**) and vascular inflammation (**Morgan**);

ii. Biomedical Imaging Science

Plein, Greenwood, Schneider, Frangi (UoA11) and UAFs **Dall'Armellina, Bissell, Levelt** have improved our understanding of normal physiology, mechanisms of myocardial disease and cardiovascular treatment effects through the development and application of precise biomedical imaging techniques;

iii. Clinical & Population Science

We conduct interdisciplinary clinical research in cardiovascular risk/thrombosis in diabetes (***Grant*, Ajjan**), maternal diabetes (**Scott**), nutrition (**Hardie**), cardiovascular epidemiology (**Hall,AS, Hall,M** with Gale UoA2) and personalised heart failure/device therapy (**Gierula** with Witte UoA24).

Research and Impact Highlights

In basic/translational science, **Beech** discovered that the ion-channel PIEZO-1 is critical in blood vessel architecture, function and response to exercise [UoA1-1654; UoA1-272]; **Roberts** identified factors inducing browning of adipose tissue in relation to cardiometabolic risk [UoA1-3519; UoA1-3520]; **Kearney** defined the role of endothelial insulin-signalling in vascular function and repair [UoA1-1852]; **Cubbon** identified the modulatory influence of endothelial metabolism in angiogenesis and vasoprotection [UoA1-1843; UoA1-1844; UoA1-1845]; **Ariens/Macrae** identified a novel property of fibrin in forming a biofilm in wound healing/infection [UoA1-2536] and **Naseem** showed that oxidised lipids activate platelets [UoA1-956].

In clinical science, **Greenwood/Dall'Armellina** demonstrated utility of cardiovascular MRI in coronary artery disease [UoA1-1281; UoA1-3565; ICS#UOA1-6] and aortic valve disease [UoA1-1277]; **Schneider** pioneered pre-clinical MRI in assessing experimental cardiac injury/recovery [UoA1-3562; UoA1-3560]; **Scott** examined continuous glucose-monitoring and demonstrated improved control with closed-loop insulin delivery in pregnancy [UoA1-1551; UoA1-1547; UoA1-1548]; **Hall,M** identified factors associated with improved mortality from myocardial infarction [UoA1-2309]; **Gierula** showed that personalised rate-response programming of cardiac pacemakers improves exercise capacity in heart failure [UoA1-2554,UoA1-2555]. **Gierula, Kearney** and Witte (UoA24) demonstrated that vitamin D improves functional status in cardiac failure [UoA1-1853].

Key funding awards

Strategic & Centre awards: A BHF Strategic Initiative (£1.9M – matched funding from UoL) to **Plein** supported the development of a state-of-the art Experimental and Preclinical Imaging Centre (ePiC). A £4.6M MRC Award to **Plein** funded the Centre for Clinical Translation of Hyperpolarised Magnetic Resonance. BHF chairs were awarded to **Kearney** (£1.4M) & **Plein** (£1.0M). A £2.4M BHF award (**Beech, Cubbon**) supported our 4-year PhD programme in Cardiovascular Disease & Diabetes. A £0.45M award to **Kearney & Cubbon** from Medtronic funded a clinical PhD programme in Cardiovascular Science.

Programme awards: include BHF Programme grants to **Kearney** (£1.4M), **Plein** (£1.0M), **Naseem** (£0.9M), **Ariens** (£1.1M), **Beech** (£1.4M). Wellcome Trust Investigator Awards to **Beech** (£1.8M), **Ariens** (£0.7M) and **Schneider** (£1.8M). Wellcome Trust Seeding Drug Discovery Initiative Award (£3.0M) and Innovate UK Award (£1.3M) to **Philippou**.

1.5.3. Musculoskeletal Research Theme

Musculoskeletal (MSK) conditions are **the single most common cause of chronic disability** and one of the most expensive to treat. The global burden of MSK diseases has increased by 25 % over the past decade. This research theme focuses on world class research in **immune mediated inflammatory** diseases (IMIDs) and **osteoarthritis** (OA) and their consequences.

IMIDs affect the immune response of the body and include a number of inflammatory arthritic conditions, (such as rheumatoid arthritis, spondylarthropathies and polymyalgia rheumatica), inflammatory connective tissue conditions (such as scleroderma and systemic lupus erythematosus) and the vasculitides (such as giant cell arteritis and Behçet's Syndrome). IMIDs affect over 5% of the population and result in joint damage, physical disability and reduced life expectancy. Effective treatments exist and some are expensive, emphasising the importance of a personalised and stratified approach.

While not as aggressive, OA presents a wider challenge; worldwide estimates of OA indicate that one in ten men and one in five women aged over 60 years have symptomatic OA and treatment options remain poor. The prevalence of OA will increase with changing ageing and obesity rates, with an expected increase in joint replacement surgery in younger people who will subsequently be living longer with their replacements.

Our grand clinical challenge is to ensure healthy ageing and provide a pain-free and independent lifestyle to patients presenting with musculoskeletal problems.

The theme's strength is in translational and basic science research in musculoskeletal diseases, assessing pathologies through integrated study of:

- **structure** (centring on ultrasound and MR imaging);
- **function** (motion analysis and novel imaging techniques);
- **impact of disease** (including outcome measure validation and biomarker discovery and development);
- **causes** and **pathological** events (cellular & molecular) leading to musculoskeletal diseases;
- developing, testing and validating new **treatment modalities** for musculoskeletal problems.

The theme has EULAR Centre of Excellence status and has held NIHR BRC funding since 2008. MSK research excellence at Leeds has been highlighted in an independent RAND report as having the

greatest number of highly cited publications in England for musculoskeletal disease of any HEI and LTHT having the greatest number of publications for any NHS Trust.

Research Groups

i. Immune Mediated Inflammatory Diseases

Our research in IMIDs brings together expertise in **inflammatory arthritis throughout its continuum**; from at risk individuals, to pre-clinical disease through to remission or resistance (**Emery, Ponchel, Mankia**); **autoimmune connective tissue disease** which focuses on laboratory, imaging and outcomes approaches to understand overlapping systemic diseases resulting in inflammation in multiple organs (**Vital, Wittmann, Del Galdo, Mackie**); **dermato-rheumatology***,* identifying triggers of conditions which affect the skin and musculoskeletal compartment (**Wittmann, Shams**); and **autoinflammatory diseases** investigates the genetic basis and mechanisms of impaired responses to biologics therapy in rheumatoid arthritis and the pathogenesis of systemic autoinflammatory disorders and primary immunodeficiencies. *(***McDermott, Savic**). The group works closely with **Wilcox** and dentistry (Devine, UoA3), exploring the human microbiome in the prevention of immune mediated disease.

ii. Osteoarthritis

Bringing together researchers committed to improving the treatment and consequences of OA, this group comprises expertise in **Non-inflammatory Musculoskeletal Disease,** which aims to improve the treatment and outcomes of people with common disorders such as OA, tendinitis and multisite joint pain (**Conaghan, Kingsbury**); **Orthopaedics & Trauma Science** conducts translational and basic science research in the fields of fracture and its sequalae, OA – aetiopathogenesis, diagnosis and treatment (**Giannoudis, Pandit, van Duren, Howard**); **Regenerative Medicine** investigates the biology of human mesenchymal stem cells in health and pathological conditions including OA and bone fracture (**McGonagle, Jones,E**); and **Rehabilitation Medicine** which focuses on developing and testing treatments that restore people's independence, dignity and quality of life (**O'Connor, Sivan**).

Underpinning both groups are our capabilities in **imaging** (**Conaghan, Wakefield, Tan**), which have been instrumental in developing the use of modern imaging, especially MRI and ultrasound, to study pathogenesis, stratification for intervention, outcome measurement and care pathway evolution across the rheumatic and musculoskeletal disorders (Section 1.6.2).

Research and Impact Highlights

Emery, Conaghan, Ponchel & Wakefield developed imaging scores and biomarkers in rheumatoid arthritis to optimise remission induction and allow safe discontinuation of drugs when in remission [ICS#UOA1-8]. **Conaghan** conducted randomised trials demonstrating benefit of secukinumab in psoriatic arthritis [UoA1-623], cathepsin K inhibition in OA [UoA1-621] and excluding the utility of acupuncture in chronic knee pain [UoA1-625]. **Del Galdo** revealed a novel mechanism involving BRISC–SHMT2 assembly by which metabolites regulate inflammatory signalling [UoA1-2384]. **Emery** demonstrated that hematopoietic stem cell transplantation improved event-free survival in systemic sclerosis [UoA1-424], secukinumab reduced signs and symptoms in ankylosing spondylitis [UoA1-425], upadacitinib monotherapy improved outcomes in methotrexate-unresponsive rheumatoid arthritis [UoA1-423] and tapering of etanercept resulted in better disease control in rheumatoid arthritis [UoA1-422]. **Helliwell** showed that the established benefits of early intervention and tight control of inflammation in rheumatoid arthritis were also achievable in psoriatic arthritis [UoA1-518]. **Mackie** found risk alleles in plasminogen, P4HA2 and the HLA Class II Region associated with giant cell arteritis [UoA1-1630] and used meta-analysis to identify informative clinical and laboratory features in its diagnosis [UoA1-1631]. **McGonagle** established the importance of enthesitis as a key pathological

lesion in the pathogenesis of spondyloarthritis conditions, including psoriatic arthritis [UoA1-1288]. This has resulted in a shift towards early therapy, inclusion of enthesitis as an outcome measure in psoriatic arthritis trials, and widespread adoption of ultrasound in clinical practice for the evaluation of the entheses as a cause of joint pain in psoriatic arthritis.

O'Connor has reviewed orthotic management of instability of the knee related to neuromuscular and central nervous system disorders [UoA1-1768]. **Pandit** demonstrated lower occurrence of complications, readmission, and mortality, following uni-compartmental knee replacement surgery compared to total knee replacement [UoA1-3610]. **Ponchel** established the value of a flowcytometry test for the management of early rheumatoid arthritis [UoA1-678], has transferred this technology to the NHS and established an industrial collaboration to develop a kit for worldwide use. **Stewart** has linked across cardiometabolic and MSK research themes defining the detrimental effects of glucocorticoids [UoA1-2840, UoA1-2841, UoA1-4710]. **Vital** discovered that non-hematopoietic cellular sources, rather than plasmacytoid dendritic cells, are responsible for interferon production prior to clinical autoimmunity in systemic lupus erythematosus [UoA1-1777].

Key funding awards

Centre / Strategic / Infrastructure Awards: NIHR Leeds BRC award (**Emery** £6.7M). Leeds Cares BRC MRI Scanner Equipment Grant (**Emery/Conaghan** £1M + £1M matched funding by UoL). x 3 Wellcome Trust Institutional Strategic Support Fund across REF period (**Stewart** £1M)

Personal Awards: NIHR towards UK poSt Arthroplasty Follow-up recommendation: UK SAFE (**Conaghan** £1.1M). NIHR ALPHA (**Wittman** £2.1M). NIHR HTA grant for assessing safety and efficacy of knee distraction in treating knee OA (£1.6M **Pandit**). Several partnerships in EU consortia (**Emery, Ponchel, McDermott, Jones,E, Giannoudis, McGonagle** total award of £2.4M) and MRC-ABPI consortium (**Emery, Ponchel, McDermott** £3.5M). ERC advanced grant PRECORT (**Stewart** €2.5M). Several academics in this theme held NIHR personal fellowships (**Mackie, Tan, Del Galdo, Vital** £3.4M**)** and our staff have been integral to the success of 6 NIHR Integrated Clinical Academic Fellowships (4 doctoral and 2 post-doctoral awards £2.4M).

1.5.4. Rare Diseases Research

Our Rare Diseases theme combines research in "rare" inherited and acquired disorders, using **clinical genetics, bioinformatics** and **functional studies** to exploit our rich resource of **genomic data** and **human tissue samples.** There are currently over 6000 inherited rare diseases which affect 30 million people across Europe. The genetic basis of only around half of these diseases has been discovered to date, with identification of the remainder along with genotype-phenotype associations remaining a major challenge.

Our grand clinical challenge is to improve clinical management and patient outcomes for rare diseases through accurate and rapid diagnosis and the development of innovative treatments.

Research in inherited rare diseases builds on our long-standing strengths in **clinical genetics, phenotyping** and the identification of the **molecular causes** of rare inherited disorders which were highlighted in REF2014 sub-panel feedback as one of the strongest aspects of our outputs submission. Customary consanguineous marriage in surrounding communities increases the prevalence of recessive disorders: this creates challenges for the **diagnosis** and **clinical management** of patients and families but means that research findings often address immediate and local clinical needs.

The focus on **gene discovery** and delineation of **genotype-phenotype** correlations is complemented by population-level epidemiology through the "Born in Bradford" MRC cohort study and by our capabilities in big data, facilitated by the Leeds Institute for Data Analytics, described in detail in our crosscutting Data Science theme. UoA1 researchers in inherited rare diseases have identified >100 new disease genes leading to accurate **molecular diagnosis**, carrier testing for families, genetic **counselling** and **new therapies** [ICS#UOA1-9]. Our research in rare diseases is supported by the acquisition of samples through the NIHR Leeds BioResource Centre (Director **Savic**) described in Section 3. UoA1 academics lead on the Primary Ciliary Dyskinesia (**Peckham**) and the Autoimmune Vasculitis (**Morgan**) components of the Rare Diseases cohort.

Research groups

Researchers in inherited Rare Diseases bring together expertise in molecular genetics, functional genomics and bioinformatics spanning a wide range of conditions with focus on the following:

i. Neurodevelopmental and developmental conditions

Sheridan, Bonthron, Bond, Johnson, Peckham focus on molecular genetics and functional genomics as applied to a range of developmental conditions including ciliopathies and centrosomopathies. *Poulter* (UKRI Future Leaders Fellow) is investigating potential therapeutic strategies of mTOR inhibition for megalencephaly and haematological malignancies;

ii. Neuromuscular and muscular dystrophies

Sheridan, Johnson, Shaw focus on inherited neuromuscular disorders and muscular dystrophies. **Hopkins** leads the National Centre for Malignant Hyperthermia Research;

iii. Inherited retinal dystrophies and structural eye disorders

Toomes, Ali with Inglehearn (UoA4) and NHS ophthalmologists *McKibbin* & *Khan* focus on inherited eye disease including aniridia and anterior segment dysgenesis;

iv. Bioinformatics, data analytics, genomic innovation

Bonthron, Sheridan, Markham and **Carr** have developed widely used programs that make analysis and visualization of next generation sequencing and functional genomics data accessible to non-specialists;

v. Primary immunodeficiencies

Savic, McDermott, Doody focus on diagnosis and novel therapeutics for primary immunodeficiencies;

vi. Acquired rare diseases

This links with our Cancer, Musculoskeletal and Cardiometabolic Themes, with strengths in auto-inflammatory disorders (**Savic**), autoimmune vasculitides including giant cell arteritis (**Morgan**), scleroderma (**Del Galdo**) and paroxysmal nocturnal haemoglobinuria (**Hillmen**);

The new Leeds Centre for Disease Modelling (DiMo) (**Johnson** with Ladbury UoA5) brings together clinical and basic biological researchers in Rare Diseases. The aim is to enhance studies that are clinically relevant using new methods such as gene editing, and to enable clinicians - working in the areas of inherited retinal disease, macular degeneration, clinical genetics and paediatric neurology - to move their research into studies in basic and translational bioscience.

Research and Impact Highlights

Sheridan identified a range of disease-causing genetic mutations leading to enhanced diagnosis [UoA1-1116; UoA1-1115; UoA1-1117; ICS#UOA1-9]. **Johnson** identified genes implicated in ciliogenesis and disease-causing ciliopathies [UoA1-1958; UoA1-1959; UoA1-1960; UoA1-1961]. **Carr** developed m6aViewer, a cross-platform application for identifying methylated residues in transcriptome wide-profiling (RNA). **Bonthron** & **Carr** developed Gene TIssue Expression Ranker (GeneTIER), a web-based application for candidate gene prioritisation in next generation sequencing [UoA1-844]. **Hillmen** has undertaken extensive research to improve lives and transform services for paroxysmal nocturnal haemoglobinuria. **McDermott and Savic** identified responsiveness to the IL-1 receptor antagonist Anakinra in inflammatory diseases leading to its clinical use in a range of rare inflammatory and autoimmune disorders. **Doody** implicated IRF8 in dendritic cell development and immundeficiency due to deficiency of natural killer cells [UoA1-1193; UoA1-4605].

Key Funding Awards

Infrastructure Awards: MRC Infrastructure for Collaboration award funded the Leeds MRC Medical Bioinformatics Centre (**Markham** £7M). MRC clinical infrastructure funding for Sequential Isolation, Manipulation, Observation and Analysis of Single Cells-SIMOA (**Bonthron** £1.1M).

Programme/Project Awards: Sir Jules Thorn Biomedical Award for Translational Research for gene discovery and molecular diagnosis in local communities (**Johnson** £1.2M). MRC award for functional genomics of ciliopathy (**Johnson** £0.6M).

1.6. Cross Cutting Themes

1.6.1. HealthTech Innovation

Working collaboratively across UoAs including close links with **physical sciences, computing** and **engineering,** researchers in UoA1 lead major initiatives to drive innovation and deliver impact through a range of Healthcare Technologies. Supported by NIHR infrastructure including our Surgical Technologies (**Jayne** and **Quyn**) and In Vitro Diagnostic Co-operatives, and aligned with a Leeds City strategic priority, the SoM has strategically invested in in this theme through **cross-faculty appointment** of senior academics (Frangi (UoA11) appointed jointly by SoM/School of Computing). Continued strategic investment in Health Technologies by UoL is reflected in the launch in 2020 of a new Centre for Responsive HealthTech Innovation (Directors: **Jayne**, Frangi) with the vision '*to transform Leeds into one of the most connected, innovation-driven, and challenge-led Healthtech ecosystems worldwide from where to drive global transformations in healthcare'.*

A wide spectrum of Healthcare Technology innovation is delivered by UoA1 academics spanning **innovative devices** and **novel diagnostics**. We foster the development of news talent through our interdisciplinary PGR funding streams (such as the UKRI Centre for Doctoral Training in Artificial Intelligence for Cancer Diagnosis and Care). Pathways to impact include dissemination through the NHS via our NIHR infrastructure; global reach is assured by initiatives including the £2M NIHR Global Health Research Group in Surgical Technologies, led by **Jayne**, which addresses unmet surgical needs in low- and middle-income countries including North India and Sierra Leone.

Research and Impact Highlights

Kearney and **Hall,AS** clinically validated a portable magnetometer device for the detection of cardiovascular disease, invented by Varcoe (UoA9), leading to the UoL spin-out company Creavo

Medical Technologies Ltd. **Jayne** (with Brown,J (UoA2)), showed in the international ROLAAR randomised trial that robotic surgery is comparable to conventional laparoscopic approach for curative rectal cancer surgery [UoA1-586; ICS#UOA1-2]. They developed an International Surgical Trials Toolkit available to the global research community to guide the design and delivery of surgical trials. **Mathew** is the neurosurgical lead of the Surgical MIC, investigating devices and immersive technologies in brain tumour surgery. **O'Connor** with Dehghani-Sanij (UoA12), Richardson (UoA12) and Mon Williams (UoA4) employ robotics and immersive technologies in assisting humans and rehabilitation. **Pandit** and **van Duren** are using AI and biosensors in arthritis and orthopaedic surgery. **Plein** and Frangi (UoA11) apply computational approaches and artificial intelligence to refine cardiovascular magnetic resonance imaging (MRI). Valdastri (UoA12) (Director of Storm Lab UK) and **Jayne** have developed a magnetic flexible endoscope to allow safer, easier and more affordable investigation of the large intestine – first in man trials are planned in 2021. **Wilcox** received £2M funding from PHE for TARGETED AMR, using cutting edge technology to improve the speed and accuracy of diagnostics and infection modelling. Other areas of strength in medical diagnostics technologies led by UoA1 include digital pathology (**West**), molecular cancer diagnostics (**Quirke**) and cancer chemotherapy (**Seymour**, **Seligmann**). PinPoint Data Science Ltd (based in NEXUS) has developed and is validating an AI-based decision support tool for the early detection of cancer (Chair of Scientific Advisory Board: ***Selby***).

1.6.2. Imaging

Research in imaging applied to the **detection, treatment and surveillance** of human disease spans our disease-specific areas of research focus and has strong links with computing (UoA11) and the Clinical Trials Unit (UoA2). Our strategic investment in imaging infrastructure is described in Section 3 and includes the Advanced Imaging Centre (AIC) incorporating the National Centre for Hyperpolarised MRI, the experimental Preclinical imaging Centre (ePiC) and the £2M Leeds BRC Imaging Centre (£1M Leeds Care funding, matched by UoL investment).

Research and Impact Highlights

Plein (£1.1M BHF Chair, £1M BHF Programme, £4.6M MRC Centre) develops and validates novel MRI methodologies with focus on myocardial perfusion assessment [UoA1-1242] and the effects of diabetes on the heart. **Greenwood** led the BHF-funded CE-MARC [ICS#UOA1-6] and CE-MARC-2 studies [UoA1-3565] which established cardiovascular MRI in assessment of suspected coronary artery disease – incorporated in the 2019 international guidelines of the European Society of Cardiology. **Dall'Armellina** is developing novel cardiac diffusion MRI techniques to risk-stratify people with hypertrophic cardiomyopathy (£192K Heart Research UK). **Bissell** is developing 4D flow MRI in congenital heart disease [UoA1-3505]. **Levelt** uses MRI to study early metabolic remodelling of the heart in diabetes [UoA1-3840]. **Conaghan** focuses on musculoskeletal imaging (especially MRI) for detailed studies of pathogenesis and disease stratification for intervention. **Wakefield** has pioneered the use of ultrasound technology in MSK medicine [UoA1-1225; UoA1-1226; UoA1-1227] - his work has contributed to guidelines used worldwide. **Tan** is investigating quantitative MRI in muscle imaging in inflammatory arthritis [UoA1-1611]. **Sebag-Montefiore** and Frangi are using artificial intelligence analysis of MRI scans to personalise radiotherapy for patients across a range of cancers (£3.5M CRUK – part of the UK-wide RADNET radiotherapy network).

1.6.3. Data Science

This theme utilises bioinformatic, epidemiological and analytical approaches to exploit large and complex health datasets spanning cancer, cardiovascular disease, nutrition and multimorbidity. Benefitting from close collaborations with colleagues in UoAs 2, 4, 11 & 14, Data Science research in UoA1 is hosted in the interdisciplinary environment of LIDA – co-directed by **Markham**, Birkin (UoA14)

and Gale (UoA2). Described further in Section 3.2, LIDA brings together >150 researchers and data scientists and hosts the Leeds components of the Health Data Research UK Northern site (HDR UK North) and the Hub for Cancer Data (DATA-CAN). Moreover, LIDA leads the University's partnership with the Alan Turing Institute, with 26 Turing Fellows including UoA1's **Bishop** and **Morris**.

Research and Impact Highlights

Glaser focuses on quality of survival in people living with and beyond cancer [UoA1-1341; UoA1-1342; UoA1-1343]. **Hall,AS** identified genetic variants associated with coronary heart disease [UoA1-248; UoA1-249]. **Hall,G** leads the HDR UK-funded activity within LIDA. He combines research in cancer informatics and data analytics [UoA1-849] with leadership of the informatics strategy at LTHT including the Leeds integrated digital health and social care record. **Hall,M** (Sir Henry Wellcome Fellow) applies advanced analytical techniques to electronic healthcare data, with a particular focus on survivorship and multimorbidity [UoA1-2311; UoA1-2312; UoA1-2313]. **Iles** designs and analyses population-based genetic epidemiology studies and carries out methodological research related to genetic epidemiology [UoA1-1770; UoA1-1771; UoA1-1772]. **Morris** (UAF, Turing Fellow and Director- ESRC Strategic Network for Obesity) uses new and emerging forms of data to study spatial and social variations in diet, lifestyle and health [UoA1-2510]. **Rowe** – academic hepatologist investigates outcomes of patients with cirrhosis and of patients undergoing liver transplantation [UoA1-3306].

LIDA is committed to training a new generation of scientists who will apply health informatics and artificial intelligence to clinical medicine, and hosts the UKRI Centre for Doctoral Training in Artificial Intelligence for Medical Diagnosis and Care. LIDA also hosts an MSc in Health Data Science and an MRes in Data Science and Analytics for Health - developed in partnership with the Data, Insights and Analytics Directorate at NHS Digital.

Section 2. People

Staffing and academic staff development

2.1. Overview

Our strategy invests in people to deliver excellence in biomedical, translational and clinical research (Figure 1). We have achieved a **core of world-leading investigators** in each of our research focus areas through prioritising strategic recruitment, retention, and career development. Integration and **team science** are evidenced by clinical academics working alongside biomedical and applied health scientists across all our research areas. We have an ongoing commitment to EDI in UoA1 and across the University as a whole. Managerially, and for purposes of research governance, staff development and support, our students and staff are organised into six Institutes with themed research occurring across Institutes, Schools and Faculties.

2.2. Recruitment and Promotion

We have sought new external appointments (Table 1) and supported career progression of our home-grown academics in each of our research themes. Key to this success has been the **University's Academic Fellowship** (UAF) scheme (REF5a), committed to recruiting 250 future academic leaders to a five-year tenure track development scheme leading to a permanent Associate Professor post.

Table 1: new appointments to UoA1 during assessment period

Research Theme	Appointment[ab]	Name of recruit	Area/Expertise
Cancer Research	Chair	**Klein**	Immunology & Haemato-oncology
	UAF	**Seligman**	Colorectal cancer outcomes
	UAF	**Matthews**	Nuclear receptors
	UAF	**Papa**	Programmed cell death
	UAF	**Mitra**	Microbial bioinformatics
	UAF	**Chilton**	Antimicrobial resistance
	Lecturer	**Ilett**	Oncolytic viruses
	Lecturer	**Newton**	Haematological disorders
Cardiometabolic Research	Chair	**Naseem**	Platelet biology
	Chair	**Morgan**	Vascular inflammation
	Chair (*Wellcome Trust Investigator*)	**Schneider**	Pre-clinical MRI
	UAF (*Sir Henry Dale Wellcome Fellow*)	**Hall,M**	Survivorship and multimorbidity
	UAF (*Sir Henry Dale Wellcome Fellow*)	**Macrae**	Biofilms and infection
	UAF (*BHF Intermediate Basic Science Fellow*)	**Meakin**	Amyloid in vascular biology
	UAF (*BHF Intermediate Basic Science Fellow*)	**Shi**	Endothelial ion channels
	Clinical Research Fellow	**Levelt**	Cardiac MRI/energetics
	Research Fellow *(AMS Springboard)*	**Tiganescu**	Wound healing, diabetes.
Musculoskeletal Research	Chair (*NIHR Senior Investigator*)	**Pandit**	Orthopaedic Science
	Associate Professor	**Mankia**	Rheumatology
	Associate Professor	**Sivan**	Rehabilitation Medicine
	Associate Professor	**Shams**	Inflammatory skin disorders
	Associate Professor (*NIHR Career Development Fellow*)	**Del Galdo**	Scleroderma
Rare Diseases Research	Chair	**Peckham**	Primary cilia dyskinesia; cystic fibrosis and medical informatics
	UAF (*UKRI Future Leaders Fellow*)	*Poulter*	Neurodevelopmental disorders
Others	Chair	**Houghton**	Neurogastroenterology

a. UAFs recruited and subsequently promoted to Associate Professor are included in Table 2
b. We have supported recruited staff in successful bids for independent fellowships (*italics*)

We have provided career development support and mentorship to secure promotion of academic staff in UoA1 (Table 2). Of the thirty UAFs in UoA1, **ten** have been **promoted** to Associate Professor and **eight** have secured **independent research fellowships**.

Table 2: promotions in UoA1 during assessment period

Research theme	Promoted to	Name	Research area
Cancer Research	Chair	**Cook,GP**	Molecular and cellular mechanisms of immunity
		Hall,G	Cancer informatics and data analytics
		Tooze	B-cell malignancies
	Assoc Professor	**Griffin,S**	Viral oncology
		Lorger	Cancer biology
		Mathew (Neurosurgical Lead, Leeds NIHR Surgical MIC)	Glioma and neurosurgical innovation
	Assoc Professor from UAF	**West**	Colorectal cancer
		Samson (*CRUK Clinician Scientist*)	Oncolytic-virus immunotherapy
		Salmond	T-cell mediated immunity
		Stead (*UKRI Future Leaders Fellow*)	Bioinformatics
		Riobo-Del Galdo (joint with Faculty of Biological Sciences)	Cancer biology
		Appelt (*Yorkshire Cancer Research Fellow*)	Radiotherapy
		Murray (*Yorkshire Cancer Research Fellow)*	Re-irradiation and radiotherapy
Cardiometabolic Research	Chair	**Philippou**	Anti-coagulation therapeutics
		Scott	Maternal diabetes
		Hardie	Nutrition and metabolism
		Ajjan	Diabetes and thrombosis
		Wheatcroft (*ERC Fellow – Starting Grant*)	Insulin resistance and vascular biology
	Associate Professor	**Saha**	Stroke, Biosensors
		Turner	Cardiac fibrosis
		Bon	Ion channels
		Forbes	Foetal growth restriction
	Assoc Professor from UAF	**Bailey** (*BHF Intermediate Clinical Research Fellow*)	Smooth muscle in aneurysms
		Cubbon (*BHF Intermediate Clinical Research Fellow*)	Angiogenesis in diabetes
		Dall'Armellina (*BHF Intermediate Clinical Research Fellow*)	Diffusion tensor MRI, myocardial infarction imaging
		Forde	Platform science

		McKeown	Endothelial stimulus-coupled secretion
		Roberts (Diabetes UK RD Lawrence Fellow)	Metabolism and obesity
		Sukumar	Ion channels in vascular biology
Musculoskeletal Research	Associate Professor	**Vital**	Connective diseases
		Kingsbury	Osteoarthritis
		Ponchel	Translational research
Independent research fellowship awards are indicated in italics.			

2.3. Our People Strategy

Having recruited and retained the best possible staff we aim to support their development through all stages of their careers through the following approaches:

2.3.1. Pump-priming and independent research fellowships

We actively encourage our staff to apply for prestigious and competitive personal research fellowships to enhance their development and the vitality of their research groups. Career progression to this stage is facilitated by internal pump priming funds, Wellcome ISSF, the LTHT charity (Leeds Cares), and Academy of Medical Sciences schemes such as Springboard to fund critical career transition points. Thirty-five academics in UoA1 held independent fellowship during the assessment period, including NIHR research professorship (**Jayne**); BHF Senior Research Fellowships (**Schneider**, **Plein**); NIHR Clinician Scientist Fellowships (**Mackie**, **Vital**, **Tan**); NIHR Career Development Fellowship (**Del Galdo**); NIHR Post-Doctoral Fellowship (**Gierula**); British Heart Foundation Intermediate Clinical Research Fellowships (**Cubbon**, **Dall'Armellina**, **Bailey**); British Heart Foundation Intermediate Basic Science Fellowship (**Shi**, **Meakin**); Sir Henry Wellcome Fellowships (**Hall,M**, **Macrae**); Diabetes UK RD Lawrence Fellowship (**Roberts**); CRUK Senior Clinical Fellowship (**Short)**; Cancer Research UK Clinical Trials Fellowship (**Seligman, Gilbert**); Cancer Research UK Clinician Scientist Fellowship (**Samson**); and UKRI Future Leaders Fellowship (**Stead**).

2.3.2. Appraisal and promotion

The UoL Staff Review and Development Scheme (SRDS) reviews each individual's progress against agreed objectives: training, personal development opportunities and pathways to promotion are emphasised. All reviewers must undertake EDI training and all promotion panellists unconscious bias training.

Annual Academic Meetings (AAM) were introduced in 2017. At the AAM academic staff meet with their Institute Director and Director of Research and Innovation to discuss their academic profiles and ambitions. The purpose of the AAM is to encourage a two-way conversation to support development of academic plans in the context of the School's strategy and to identify support needed to assist the staff achieving their goals.

Supporting junior academic staff through the promotions process is of critical importance. A Promotions Coaching Scheme to support high quality promotion applications was piloted in 2016 and rolled out in 2017. To date, 26 people (77% female) have received or are being actively coached for promotion, including clinical and basic science academic, technical and support staff. Eighteen staff have volunteered as coaches (44% female) on the scheme and 100% of these promotion applications were successful. The number of successful promotion applications has increased from 6 (33% female) over

the four years before inception of the scheme to 19 (74% female) over the three years since the scheme started.

We recognise impact beyond academia as a key criterion for staff recruitment and promotion. We use AAMs to agree appropriate investment (e.g. workload and other resources) and targets (monitoring and evaluation) to sustain impact activity (all phases of the lifecycle) and delivery. We provide individually tailored support (e.g. through impact accelerator funds) so that academics at all career stages experience a healthy impact culture. This helps our staff to grow their research area and its impact.

2.3.3. Training and continuing professional development

Staff in UoA1 benefit from the University's excellent Organisational Development and Professional Learning Department (OD&PL), which provides a wide range of training and personal development courses, often tailored to the needs of specific staff groups/Schools/Faculties. In response to a review of leadership behaviours across the University, OD&PL have developed a Leadership Excellence Behaviours Framework in order to foster a positive and impactful working environment. The Framework is supported by leadership training programme, which are targeted towards different levels of leadership, including leading self, leading others and leading the university. Through these measures the school has delivered representative gender balance across its senior leadership though there is more to do on ethnicity balance.

2.3.4. Supporting our Leaders of the Future

Career development support for early career investigators is strongly prioritised. Mentorship is available both internally and externally. The University provides a central mentoring scheme, which was joined by 152 members of staff with the Faculty of Medicine and Health since 2016 (80% female). Clinical academic staff are signposted to external schemes including the Academy of Medical Sciences (AMS), onto which 5 male and 3 female clinical academics have enrolled.

A variety of initiatives support early career researchers in UoA1 (further support for clinical academics is described in 2.6):

- *Post-Doc Research Academy* - an initiative to support the career development of our post-doctoral researchers which consists of a website, seminar series, and fellowship application support sessions;
- *NIHR@Leeds Early Career Research Network* - a UoL/LTHT initiative to develop clinical academic researchers supported by the BRC. The remit of this group is to promote academic careers and provide support in developing fellowship applications;
- *Joint UoL-LTHT Clinical Academic Office* – to support clinical academic careers across the partnership, with a key aim of facilitating women in clinical academic careers;
- *School of Medicine Early Careers Group* – a School group which focuses on the needs of early academic researchers, particularly translational;
- *Academic Development Fund* - to allow researchers to maintain career development following an extended period of leave. We have made 20 awards in UoA1 (£247,066) since 2015, largely to female staff returning from maternity leave and have strategically deployed this funding to help with COVID-19 mitigation.

2.4. Equality, Diversity and Inclusion

Since 2014 we have made significant steps to develop a school culture that will maximise the potential of all our staff to deliver excellent research. We have developed processes to capture and monitor our

EDI progress: in the SoM, 13% of academic staff and 25% of our PGRs are known to be from a Black, Asian or Minority Ethnic group. Fifty-nine percent of our academic and research staff identify as female.

The School has invested significantly in promoting equality. In 2020 we appointed the first School Associate Dean for Equality, Diversity, and Inclusion in the University (Bryant UoA2). We have committed to the BMAs Charter for Medical Schools to prevent and tackle racial harassment, recruiting to three new roles: a Freedom to Speak Up Guardian, Race Equality Project Officer and EDI co-ordinator. Nationally we are the first medical school to achieve a Gold Athena SWAN Award, demonstrating a strong commitment to champion and promote gender equality and the impacts of intersectionality between gender and other characteristics. We have also invested in opportunities, including sponsorship of eight career development programmes such as Aurora (Leadership Foundation for Women), financial support of the Leeds Female Leaders Network and funding of externally delivered unconscious bias training for all staff.

We have a very active School EDI Committee comprising members from each Institute's EDI working group, the leads of which also sit on Institute Senior Management Teams. Our priorities and action plans for staff and students centre on improving mental health and well-being, ensuring inclusion and equality for those identifying as LGBTQ+, improving opportunities and access for those with a disability, and identifying barriers for career progression associated with ethnicity and religion. We are committed to research-informed EDI activities and have published on gender equality interventions in medical schools and mentoring as a complex intervention to address gender inequality.

We demonstrate leadership on national issues, for example, initiating a reciprocal agreement with the local NHS to honour terms and conditions for clinical staff on the Integrated Training Pathway to support clinical academics taking maternity/adoption leave: this is now national practice and recognised as good practice externally. Other initiatives include:

- Enhanced flexible working provision, including guarantees to staff who reduce their hours that they can return to their original hours on request within 5 years;
- Extension of fixed-term contracts to the end of a period of maternity leave to ensure access to redeployment and other support;
- Raising awareness in staff and students of what is considered unacceptable behaviour, including sexual harassment, and how to report it. SoM led on the University's new staff Code of Conduct and mandatory staff training which addresses these issues;
- Career coaching for staff seeking promotion to improve the number of women at senior levels. Since 2014 there have been an equal number of female and male applications to Professor and an equal success rate;
- With LTHT, we developed the Leeds Female Leaders Network (800 members) to support our female leaders across the organisations.

Our EDI plan for the next five years focuses on the following priority areas in promoting equality, inclusion and diversity in our research culture:

i. Increasing the proportion of female and BAME academics in senior roles and appointing **Ajjan** to provide leadership to this initiative;
ii. Creating parity of career development for staff on fixed-term contracts and a move towards a more sustainable career path for researchers;
iii. Identifying and tackling intersectionality issues of gender, race and disability, to understand the impact on research career development and progression.

Our goals for EDI align with the University's EDI Framework (2020–2025). Our Equality Policy Unit (EPU) used an Equality Impact Assessment to develop our REF mitigating circumstances policy. The EPU will interrogate our REF data by gender and other protected characteristics, to enable comparisons to previous returns and identify further priority areas for our attention.

2.5. Post-graduate Research Students

We recognise doctoral training as an essential contributor to the vitality and sustainability in clinical medicine. During the assessment period, 434 doctorates were awarded to PGRs supervised by UoA1 academics.

2.5.1. UoL Doctoral College

The UoL is committed to promote a vibrant PhD and postdoctoral community and has invested in several initiatives to embed a culture in which our PGRs can thrive (REF5a). PhD supervisory teams in UoA1 all have strong research orientated programmes, with each team having at least one highly experienced academic with a proven track-record of postgraduate degree completion. We provide a structured environment within stimulating and active research settings where PGRs are encouraged to mix with other trainees as well as post-doctoral researchers and clinicians. Our academics do more than academic supervision: they instill a strong ethical approach and understanding of governance, relying on all to take responsibility to cultivate the research mind-set, to produce highly trained individuals of a quality that will make them strongly competitive in the employment market.

2.5.2. PhD Programmes and Doctoral Training Platforms

UoA1 academics lead or contribute to a range of PhD programmes, key examples over the assessment period including:

- Cancer research is underpinned by an extensive training platform, including the YCR Academic Fellowship Platform which supported 8 PhD students affiliated with 9 UAFs (£4M);
- *BHF 4-year PhD in Cardiovascular Disease & Diabetes* – launched in 2017 following an internally funded pilot and subsequently supported by a £2.4M award from the BHF, this programme was renewed for a further four years in December 2020. The scheme has attracted 16 students, all from Russell Group universities (or international equivalents), 14 with 1st class honours in their undergraduate degree;
- *4-year International PhD academy: Cardiovascular & Metabolic Disease* – launched in 2018, this programme provides orientation and research skills training in the first year to overseas graduates wishing to undertake Cardiometabolic research at the University of Leeds, followed by a three-year PhD. To date 13 students have been recruited from Saudi Arabia (9), Kuwait (2), Botswana (1) and Malaysia (1) with four students holding offers for 2021;
- *4-year International PhD academy: Medical Research* – this programme, started in 2020, includes taught modules in Research Methods and Paper Criticism during year 1 followed by a research project;
- *Medtronic Clinical PhD training programme* in Cardiovascular Research (£450k industry funding);
- *UKRI Centre for Doctoral Training* in Artificial Intelligence for Medical Diagnosis and Care (£5.9M);
- *MRC DiMEN Doctoral Training Partnership* – 24 studentships are awarded per year across Leeds, Liverpool, Newcastle & Sheffield;

- *4ward North Wellcome Trust Doctoral Training Platform* – 25 clinical PhD studentships are awarded across Leeds, Manchester, Newcastle and Sheffield (£5M);
- NIHR Leeds BRC - 21 musculoskeletal researchers have been supported to undertake PhD and MDs.

2.5.3. Externally Funded PhD Fellowships

UoA1 researchers secured **122 externally** funded PhD fellowships over the REF period, including 20 NIHR, 8 Research Council, 33 Medical Charities and 2 ESRC/White Rose Fellowships. They also secured 52 overseas and 16 hospital funded fellowships.

Basic research-clinical collaboration and supporting our early career researchers in the new field of "clinical genomics" has been underpinned by clinical training fellowships from BHF and Wellcome Trust; bioinformatics of genomic-level datasets is a crosscutting theme.

- *CRUK Leeds-Manchester Clinical Research Training Fellowships* (£0.8M investment by SoM) - launched in 2019, this scheme delivers Clinical Research Training Fellowships in Academic Pathology and Clinical Trials (6 clinical fellows);
- *Erdheim Clinical PhD Fellowships in Cardiovascular Research* – supported by strategic re-alignment of endowment funding by SoM, this scheme was launched in 2020;
- *UoL 110 Anniversary Research Scholarship Scheme* funded by a £100M investment in 2014 and supporting 110 PGRs, 8 of whom were supervised by UoA1 academics.

2.5.4. Destination of postgraduate researchers:

During the assessment period, 434 PGRs supervised by UoA1 academics were awarded a higher degree. Of survey responders, 79% of postgraduate researchers awarded a PhD continued in an academic role and 21% were clinical researchers who secured an NHS post.

2.6. Clinical academic training in Leeds

Funded by the NIHR, and in partnership with Health Education Yorkshire and Humber and our regional NHS Trusts, the SoM's Integrated Academic Training (IAT) programme allows our medical and dental trainees to undertake research alongside their clinical training. The IAT programme at Leeds has one dental and five medical research strands, each overseen by a Deputy Academic Training Programme Director (dATPD). The Programme spans 23 clinical (led by **Quirke**) and five dental sub-specialties and has also posts in five NIHR Research Priority themes: Platform Science & Bioinformatics, Therapeutics/Clinical Pharmacology, Acute Care, Older People & Complex Health Needs and Mental Health. The Leeds IAT programme has supported 94 Academic Clinical Fellows (ACF) and 44 Clinical Lecturers (CL). Of these, 61% of ACFs moved into externally funded PhD/MD fellowships or directly into CL posts. For CLs, 25% were awarded Clinician Scientist/Intermediate fellowships and a further 18% of CLs moved to Clinical Academic or University-funded Associate Professor tenure track posts. In 2020 we integrated this platform with our nursing and allied health professional training programme (NIHR Dean and UoL lead Keenan UoA3) to foster interprofessional training.

2.7. Research active NHS clinicians

Strategic and collaborative working across the UoL/LTHT partnership provides an environment in which NHS-based clinical academics thrive. NHS consultants with active research portfolios are encouraged to apply competitively for the title of Honorary Clinical Associate Professor at the University of Leeds (currently 55 holders in Clinical Medicine). At a higher level, six full honorary Professorships were

awarded to research active LTHT NHS consultants during the REF period (*Callister*, *Duffy, Sagar, Scarsbrook, Toogood, Kay, Treanor*). Key highlights:

- *Callister* leads the Yorkshire Lung Screening Trial, the largest lung cancer screening trial in the UK;
- *Duffy* is Clinical Lead for West Yorkshire and Harrogate Cancer Alliance and Strategic Clinical Lead for the Leeds Cancer Programme. He was the National Clinical Director for Cancer;
- *Marzo-Ortega* is internationally known for her research in spondylarthritis and has been awarded over £1M in competitive grant funding over the REF period;
- *Sagar* conducts research in surgery for advanced colorectal cancer, inflammatory bowel disease and laparoscopic surgery;
- *Scarsbrook* is the local lead for the National Centre for Innovative Medical Imaging (NCIMI), a £15M programme of work funded by Innovate UK and led by Oxford University to develop AI tools for use in Radiology applications;
- *Toogood* is the Chief Investigator for the Sunflower study, a £2.8m NIHR-funded randomised controlled trial to establish the clinical and cost effectiveness of expectant management versus pre-operative imaging with MRCP in patients with symptomatic gallstones undergoing laparoscopic cholecystectomy;
- *Treanor* has pioneered virtual histology and digital pathology [ICS#UOA1-7], leads the *Centre for Digital Pathology Innovation* at Leeds and directs the *National Pathology Imaging Co-operative* enabling Artificial Intelligence technologies within UK histopathology departments.

Section 3. Income, infrastructure and facilities

3.1. Research income

Over the period 2014-2020 staff in UoA1 generated £213M in research income. Research funding awards to UoA1 researchers totalled £269.6M during the assessment period, with major contributions from UK charities, UKRI and NIHR (Table 3). Examples of our major funding awards are listed in Section 1 for each of our disease-specific research themes.

Table 3: Research funding awards to University of Leeds during assessment period with UoA1 academics as principal or co-investigator

Funding source	Value (£ million)
UK research councils	66.1
UK charities	108.6
UK Central Government / Local Health and Hospital Authorities	46.8
UK Industry / Public Corporations	19.4
UK Other Sources	0.5
EU Government	9.5
EU Other	6.7
Non-EU	11.9
TOTAL AWARDS	**269.6**

3.2. Infrastructure and Facilities

UoL has invested over £520M in infrastructure development (REF5a) to the benefit of UoA1 staff, who are participants in the following activities: Priestly International Centre for Climate, LIDA, Astbury Centre for Structural Molecular Biology, Bragg Centre for Materials Research, and the Global Food and Environment Institute. Investments supporting UoA1 intrastructure and facilities include a £41M refurbishment of the Worsley Building, housing the School of Medicine, a state-of-the-art pre-clinical imaging centre (ePiC) and the Advanced Imaging Centre (below).

3.2.1. UoA1-Led Research Centres

Three centres specifically underpin Cancer research:

- The *Cancer Research UK Centre of Excellence for Radiotherapy Research* (**Sebag-Montefiore** £3.5M 2019-2024) focuses on personalised, adaptive and novel strategies for brain, liver and pelvic radiotherapy for primary and recurrent cancer with a focus on patients with brain, liver and anorectal cancers;
- The *Cancer Research UK Clinical Trials Unit* (Brown,J UoA2, **Sebag-Montefiore, Cook,GP** £1.9M 2016-2022) focuses on haematology and radiotherapy clinical trials. It specialises in the methodology, design, delivery and analysis of innovative early phase and late phase platform clinical trials. that provide access to novel and innovative treatments;
- The *Leeds Cancer Research Centre* (**Sebag-Montefiore**, Ladbury UoA5) established in 2020 combines research excellence and state-of-the-art infrastructure in discovery biology, physical sciences, engineering, artificial intelligence and clinical research to unlock new insights in cancer biology and accelerate the translation of exciting new treatments and technologies to improve the prevention, diagnosis and treatment of cancer.

Three centres underpin the activities in the Cardiometabolic and Imaging Research Themes:

- *The Clinical MRI Centre* (led by **Greenwood**) was created in 1999 with funding from the British Heart Foundation. Since then, the centre has expanded to include a Philips 1.5T Ingenia and a Philips 3T Achieva MRI scanner. It supports a wide range of clinical research, playing a key role in delivery of cardiovascular clinical studies in UoA1, e.g. the 'Clinical Evaluation of 3T MAgnetic Resonance imaging for the management of patients with Coronary heart disease' (CE-MARC 2, **Greenwood**) which demonstrated that cardiac magnetic resonance (CMR) scanning could be used early in the diagnosis of coronary heart disease [ICS#UOA1-6];
- *The Advanced Imaging Centre* (directed by **Plein**) was created in 2017 through a £7.4M Clinical Research Infrastructure Initiative for a National Centre for Hyperpolarised MRI, led by the MRC with co-funding from Arthritis Research UK, the BHF, in collaboration with the University of York and Leeds Teaching Hospitals NHS Trust (£4.6M). The 500m^2 centre contains a Siemens Prisma 3T MRI scanner with multinuclear capability, laboratory space, offices and a modern seminar room;
- *Experimental and Preclinical Imaging Centre (ePiC)* - This state-of-the-art preclinical imaging centre (£1.9M BHF + £4M UoL) is led by **Schneider** (Wellcome Trust Investigator), who has published widely on non-invasive imaging of the rodent heart at ultra-high magnetic fields. ePiC provides the latest generation of multi-modality imaging platforms, including a 7T MR system, a PET/SPECT/CT scanner, µCT and optical imaging all from the same vendor (Bruker, Germany) alongside high frequency ultrasound from FujiFilm Visualsonics.

UoL/LTHT have been successful in attracting substantial NIHR infrastructure funding. Five centres forming NIHR@Leeds are applied across our major reseach themes:

- *The NIHR Leeds Biomedical Research Centre (BRC)* (**Emery** £6.7M 2017-2022) allows us to translate basic biomedical research in musculoskeletal diseases into innovative clinical practice and improved patient care. Established in the first cohort of NIHR Biomedical Research Units in 2008, the BRC brings together a vibrant cross-disciplinary team from the SoM and Faculty of Bioengineering, both of whom have the delivery of patient focused research driven by scientific evidence as the core of their activities. It underpins the Musculoskeletal and Imaging Research Themes;
- *The NIHR Leeds In Vitro Diagnostics Co-operative* (**Cook,G** £1.4M 2018-2022) supports the design and validation of new diagnostic tests. It hosts a portfolio of 68 projects, has engaged 156 companies (62 SMEs) and has leveraged £72M in research grant funding. Interdisciplinary expertise is focused in Oncology, Musculoskeletal Disease, Renal Medicine and Infection Diagnostics. In UoA1, **Emery** is evaluating biomarkers for musculoskeletal disease, **Seymour** is investigating novel diagnostics for myeloma and lymphoma and **Wilcox** is leading research on infection diagnosis and management (recent SAGE appointment on COVID diagnostics), infection control and antimicrobial resistance;
- *The Leeds NIHR surgical MedTech Co-operative* (**Jayne** £1.4M 2018-2022) develops new concepts, demonstrates proof of principle and devises research protocols for new health technologies that are applicable across the NHS. Its aim is to improve the quality of life and effectiveness of healthcare services for patients undergoing colorectal, hepatobiliary and vascular surgery. The Co-operative has secured >£13M in research awards during the assessment period. Examples of collaborative working with the Faculty of Engineering and Physical Sciences (Valdastri, UoA12) include a £583K Cancer Research UK funded first-in-human study for robotic flexible endoscopes in colorectal cancer screening and a £2.7M ERC award for novel lifesaving magnetic tentacles to assist surgeons;
- *Leeds NIHR Clinical Research Facility (CRF).* Led by **Twelves** (£0.75M 2017-2022) the CRF supports early phase, experimental medicine and translational clinical trials with principle investigators in the Cancer, Cardiometabolic and Musculoskeletal Research themes evaluating drugs, cell based therapies and devices. Infrastructure investment by LTHT includes the completion of a new £3M core CRF at St James's University Hospital in 2019. The CRF leveraged £51M research grant income during the assessment period;
- *Leeds NIHR Bioresource Centre*. An NIHR Bioresource in Leeds (£100k pa) was enacted in 2018 (lead **Savic**). We have successfully proposed and lead on three rare disease groups (Systemic Sclerosis, Giant Cell Arteritis and Systemic Autoinflammatory Disease) and jointly lead (with Manchester and Newcastle) on the common disease group immune-mediated inflammatory disease (£300k pa). Leeds is the top recruiter to the research tissue bank with >400 volunteers enrolled since October 2018.

Next Generation Sequencing Facility (**Carr**) performs a wide range of next generation sequencing methodologies on diverse samples of varying quality and, where necessary, develops novel sequencing and analysis techniques, such as *de novo* genome assembly, microbiome analysis, pathogenic variant detection and transcriptome profiling. The facility works with academic and commercial groups across Europe working on difficult samples not accepted by main commercial service providers. The facility is a core resource for the clinical genetics research undertaken in UoA1 [ICS#UOA1-9] and also processes several thousand patient samples per year, playing an important role in patient diagnosis across the Yorkshire regions.

Centre for Responsive HealthTech Innovation (**Jayne**, Frangi UoA11) brings together clinicians and industry partners to deliver world-leading, cross-disciplinary research, with value-based innovation at its heart. It responds rapidly to changing socio-economic needs, accelerating the transformation of innovation to deliver equitable, sustainable and responsible healthcare for all.

3.2.2. UoA1 Collaborative Facilities

Leeds Institute for Data Analytics is an interdisciplinary environment for over 150 data scientists and researchers from all seven faculties at UoL. Inaugurated in 2014 by bringing together the MRC Medical Bioinformatics Centre (described below) and ESRC Consumer Data Research Centre, LIDA supports £61M research across the University. LIDA provides a virtual research environment for each of the projects it hosts through its technology platform – the Integrated Research Campus. Research by UoA1 academics in LIDA is described in 1.7.3.

The £7M MRC Medical Bioinformatics Centre (formerly directed by **Markham,** now Gale, UoA2) supports ground-breaking bioinformatics research at the interface between the clinic, health records and high volume molecular and phenotypic data sets. Focus is on six areas: cancer genomics and malignant melanoma; genotype, phenotype and response to radiotherapy in rectal cancer; inherited rare diseases, proteomic biomarkers, patient similarity searches in lymphoma treatment; enhancing the value of the MRC-funded rheumatoid arthritis stratified medicine and RA-MAP consortia through linkage to complex data sets. The Centre has generated high impact academic outputs, including 340 publications and has leveraged £14.4M additional funding. The Centre collaborates with a wide range of partners including business organisations (e.g IBM, TPP Ltd), health care providers at a national level (e.g The Farr Institute, Cancer Research UK) and locally (e.g LTHT, NIHR@Leeds, Leeds City Council).

The Leeds Institute for Clinical Trials Research (LICTR; Director, Brown,J (UoA2) with **Sebag-Montefiore, Cook,G**) hosts the Leeds CRUK Clinical Trials Unit (**Sebag-Montefiore, Cook,G** £1.9M 2018 for 5 years). LICTR also hosted the Yorkshire Cancer Research Centre for Early Phase Clinical Trials (£1.4M, 2014-2020) and a Myeloma UK programme grant for the Concept and Access Research programme (CARP; **Cook,G**), the Leeds In Vitro Diagnostics Co-operative, the Leeds Surgical Technology MIC; and Concorde, the first early phase radiotherapy trials platform (£0.8M, CRUK & £770K Astra Zeneca).

The Leeds Centre for Immersive Technologies hosts *'Robotics at Leeds',* an interdisciplinary network driving innovation in robotics research. It has a wide range of application areas including robotics to improve surgery (£1M *da Vinci* robot, **Jayne**) [ICS#UOA1-2] and rehabilitation (**O'Connor**).

Other UoL Interdisciplinary Research Facilities (REF5a) utilised by researchers in UoA1 include the Astbury Centre for Structural Molecular Biology; The Leeds Institute for Fluid Dynamics; the Bragg Centre for Materials Research, including Bragg Centre PhD studentships starting October 2020 which encompass collaborative projects with researchers in UoA1 that involve deployment of materials research to medical applications.

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

4.1. Supporting Collaboration in Research

4.1.1. Interdisciplinary Research in Leeds

Interdisciplinary research (IDR) is one of the core commitments of the UoL and in 2016, a Dean of Interdisciplinary studies was appointed (Taberner, UoA26, REF5a). In UoA1 IDR is exemplified through strong links between academics in Medicine and other Faculties including Biological Sciences, Engineering (including Electronic & Electrical Engineering, Chemistry, Mathematics, Computing), and Environment (including Earth & Environment, Food Science & Nutrition). 88% of academics in UoA1 report undertaking IDR with researchers outside of their own field. During the assessment period, £289M of research grant income was awarded for collaborative projects including UoA1 academics and researchers returned in other UoAs. Section 1.6 highlights these collaborations.

4.1.2. Regional and National collaborations

92% of academics in UoA1 undertake collaborative work with other institutions in the UK. Our commitment to supporting collaboration in research nationally is demonstrated by leadership by UoA1 academics in several areas of strategic importance. **Stewart** chairs the *NIHR Clinical Research Network Co-ordinating Centre* hosted by UoL (**Markham** is board member). **Howell** was Director of NIHR Yorkshire & Humber Clinical Research Network 2014-17. **Stewart** is executive board member of *Leeds Academic Health Partnership (LAHP)*. As one of the biggest partnerships of its kind in the UK, LAHP harnesses world-class research and education, and cutting-edge clinical practice to transform great ideas into life-changing initiatives for the people of Leeds. **Stewart** was also board member of the Northern Health Science Alliance and is a member of the strategic advisory board to the Yorkshire and Humber AHSN. **Markham** is founding Non-Executive Director of *Health Data Research-UK* and Non-Executive Director of *UK Biobank*. **Sebag-Montefiore** chairs the National Cancer Research Institute (NCRI) CTRad, the clinical and translational radiotherapy working group with oversight of UK radiotherapy research.

We co-fund the £10.5M Cancer Research UK Manchester-Leeds Clinical Research Training Fellowship programme, which provides prestigious research training to clinicians with a specialist interest in academic pathology and clinical trials (supported by £1M from the School of Medicine) (Brown,J (UoA2), ***Selby***, **Quirke**).

Academics within UoA1 have a strong track record of collaborative working through academic consortia, including:

- the UK Inherited Retinal Disease Consortium (**Toomes** with Inglehearn UoA4);
- GLASS consortium (**Stead**);
- Cystic Fibrosis Trust Strategic Research Centre (**McDermott** – Director);
- CRUK Centre of Excellence fro Radiotherapy Research (**Sebag-Montefiore, Henry**);
- NIHR Devices for Dignity (D4D) MedTech Co-operative (**O'Connor** – Deputy Clinical Director).

Concordant with our rich data science portfolio, UoL is a partner of the Alan Turing Institute, the UK's national institute for data science and artificial intelligence. In UoA1 **Bishop** and **Morris**, along with Gilthorpe (UoA2) are Turing Fellows. **Hall,M** is Multimorbidity Lead for the Turing Health Programme Strategic Leadership Group. **Hall,G** is Clinical Lead and Deputy Director of *DATA-CAN*, the UK's health data research hub for cancer.

4.1.3. International collaborations

83% of UoA1 academics undertake International collaborative research and 51% of all our outputs have international co-authors. Exemplars include the £20M *CRUK Grand Challenge Award* (**Quirke**) - Manipulating the microbiome to beat bowel cancer - between UK, USA, Canada, Netherlands and Spain; the £2M NIHR Global Health Research Group in Surgical Technologies (GHRG-ST) (**Jayne**) which addresses unmet surgical needs in Arunachal Pradesh (North East India) and Sierra Leone.

4.1.4. Commercialisation and collaboration with industry

UoL has an excellent track record of successful research translation for patient benefit supported by specialist commercialisation expertise embedded in our Research & Innovation Service, based in our transformative hub for innovation (NEXUS) and wider *Leeds Academic Health Partnership*. Through investment in new initiatives by deployment of proof-of-concept funding (e.g. MRC CiC), our Specialist Research & Innovation Development Managers support academics to develop high-quality bids for follow on funding and support investigators with proposal development and planning, due diligence, market insights, patent identification and protection, as well as support for the generation of spin-out companies and/or licensing agreements as appropriate. Receiving the highest rank (MRC feedback score), our CiC portfolio has converted £2.1M of MRC CiC funding into £53.3M of follow-on funding (2014-), comprising £26.3M from other sources including UKRI (e.g. MRC & EPSRC), £13M from industry and £14.2M from Innovate UK. UOA1 academics hold 36 licencing deals with industry and filed 19 patents during the assessment period.

An exemplar of success in UoA1 is LUNAC Therapeutics (**Philippou**), spun out of UoL in 2018 following funding by Yorkshire Forward, MRC CiC, MRC DPFS, British Heart Foundation and Wellcome Trust Seeding Drug Discovery Initiative. Focusing on the development of new anticoagulants which prevent thrombosis without increasing bleeding risk, LUNAC Therapeutics has attracted £8.4M in follow-on funding, comprising £5M of Series A financing and £3.4M from Innovate UK (in partnership with UoL and the Medicines' Discovery Catapult).

4.2. Contribution to the research base, economy and society

4.2.1. Honours, Awards and Prizes

Emery was awarded an OBE in the 2018 Queen's Birthday Honours lists in recognition of his outstanding contribution to rheumatology.

The following academics in UoA1 received national or international awards or prizes in the reporting period:

Appelt: Young Physicist of the Year, Danish Society of Physics 2017; **Bailey**: Raymond Limet Prize International Meeting of Aortic Disease 2014; **Emery**: Master of American College of Rheumatology 2018; European League Against Rheumatism Meritorious Award for outstanding service to Rheumatology 2020; **Ford**: Rome Foundation-Aldo Torsoli Foundation award 2020; **Giannoudis**: BMA Medical Book Award 2015; **Gierula** National Healthcare Science Award for Research and Innovation 2019; **Helliwell**: Master of American College of Rheumatology 2017; GRAPPA presidential award 2018; Verna Wright prize, University of Naples 2018; Hon fellowship Royal College of Surgeons, University of Glasgow 2020; **Howell**: Royal College of Anaesthetists Macintosh Professorship 2016; **Jayne**: Bowel Cancer UK & RCS Eng Chair in Surgical Research; ***Knowles***: British Association of Urological Surgeons Gold Medal 2016; **Macrae**: Eberhard F. Mammen Young Investigator Award 2018; ISTH SSC Young investigator Award 2018; Milwaukee SSC President Award ISTH SSC 2018; British

Heart Foundation Reflections of Research image of the year 2014 and 2016; **Manoj**: European Academy of Rehabilitation Medicine Prize 2014; BSRM Philip Nichols Prize in 2014; **Mathew**: Flame of Hope Award for Research Engagement, Cancer Research UK 2017; **McGonagle**: Verna Wright international lecture Prize 2017; Philadelphia medical society Prize in Rheumatology 2018; Royal Academy of Med Ireland Bioengineering Prize 2019; **Newton-Bishop**: Society for Melanoma Research Lifetime Achievement Award 2017; **Quirke**: Fellowship Ad hominem Royal College of Surgeons of Edinburgh 2017; Honorary Fellowship of the Faculty of Pathology, Royal College of Physicians, Ireland 2019; Doctoris Honaris Causa. Grigore T. Popa University, Iasi, Romania 2019; **Rowe**: Andrew Burroughs Young Investigator Award for Research in Liver Transplantation, British Society for the Study of the Liver 2016; **Roberts**: Lilly Diabetes Basic Science Award Diabetes UK 2017; **Sebag-Montefiore**: Royal College of Radiologists Gold Medal 2019; **Scott**: Joseph Hoet Award for Research Excellence, European Association for the Study of Diabetes 2017; **Stewart**: Dale Medal Society of Endocrinology, International Laureate Medal – US Endocrine Society; **Vital**: Michael Mason Prize British Society for Rheumatology 2018; Emerging Leaders Award Medical Research Foundation 2018; **Wheatcroft**: British Atherosclerosis Society John French Lecturer 2015; British Cardiovascular Society Bernard & Joan Marshall Research Excellence Prize 2016.

4.2.2. Senior academic positions in UoA1

- NIHR Senior Investigators (8): **Jayne** (Surgery), **Quirke** (Pathology), **Hull** (Gastroenterology), **Pandit** (Orthopaedics); including the following Emeritus SIs: **Conaghan**, ***Selby***, **Emery**, **Stewart**
- British Heart Foundation Professors (2): **Kearney** (BHF Professor of Cardiovascular & Diabetes Research), **Plein** (BHF Professor of Cardiovascular Imaging)
- Wellcome Trust Investigators in Science (3): **Ariens, Beech, Schneider**
- Fellows of the Academy of Medical Sciences (9): **Beech** (Regional Champion for Yorkshire & Humberside)**, Bishop, Emery,** *Grant*, **Markham, Newton-Bishop, Quirke, *Selby*, Stewart** (Clinical Vice-President).

4.2.3. Scientific Leadership Roles

UoA1 academics hold a variety of scientific leadership roles. The following are selected examples of leadership positions held during the assessment period:

International scientific leadership: **Ariens**: President of the International Fibrinogen Research Society 2014-2018; **Conaghan**: Co-executive lead of the international outcomes group OMERACT; Treasurer, European Foundation for Research in Rheumatology (FOREUM); **Emery**: Chair of FOREUM, grant-giving body for European Rheumatology 2011-2019; *Grant*: chair of European Society of Cardiology 2019 Clinical Practice Guidelines on Diabetes, Pre-Diabetes and Cardiovascular Diseases. **Hopkins**: Chair of the European Malignant Hyperthermia Group; **Markham**: Chairman, the Lister Institute of Preventive Medicine; **Peckham**: Director of Education - European Cystic Fibrosis Society 2018; **Picton**: Coordinator of European Society of Human Reproduction and Embryology (ESHRE) Task Force on “Fertility preservation in severe diseases” 2010-2015; **Plein**: Vice President European Association of Cardiovascular Imaging (EACVI) of the European Society of Cardiology 2014-16; ***Selby***: President of the European Cancer Concord 2014-2017.

National scientific leadership: **Ariens**: President of the British Society for Haemostasis and Thrombosis 2016-2018; **Conaghan**: Chair of NICE Osteoarthritis Clinical Guidelines 2014; Chair of the Arthritis Research UK Osteoarthritis and Crystal Disorders Clinical Studies Group 2007-2017; **Cook,G**: Chair of the UK Myeloma Research Alliance and NCRI Myeloma sub-group; Chair of UK Myeloma Forum;

Greenwood: President Elect of the British Cardiovascular Society 2020; President of British Society of Cardiovascular Magnetic Resonance 2018-2020; Chair of the Society of Cardiovascular Magnetic Resonance clinical trials committee 2015-2017; **Hall,M**: Multimorbidity Lead, Health Programme Strategic Leadership Group, Alan Turing Institute, 2019-; **Helliwell**: President of the Group for Research and Assessment of Psoriasis and Psoriatic arthritis (GRAPPA) 2015-2018; **Hillmen**: Lead of the National Commissioning Group (NCG) Designated Centre for paroxysmal nocturnal haemoglobinuria (PNH); **Hull**: CRN National Speciality Lead – Gatroenterology; **Jayne**: Clinical Director for the NIHT Global Health Research Group; **Markham**: Chairman Northern and Yorkshire NHS England Genomic Laboratory Service Partnership Board, Department of Health (NIHR/MHRA) Clinical Practice Research Datalink (CPRD) Executive Board & Oxford CRUK Cancer Centre; Founding member of NHS National Genomics Board & NHS Digital, MRC/NIHR Research Advisory Group; **Mackie**: Co-chair British Society for Rheumatology Guideline on diagnosis and management of giant cell arteritis; **Morgan**: Chair UK GCA Consortium and the MRC TARGET Partnership; **Newton-Bishop**: Clinical Lead NICE Melanoma Clinical Guideline; **Philippou**: Scientific Secretary of the British Society of Haemostasis and Thrombosis 2016-; **Plein**: Treasurer Board of Trustees Society for Cardiovascular Magnetic Resonance 2020-; **Quirke**: Chair of the NHS Bowel Cancer Screening Programme Pathology Committee; President of the Pathological Society of Great Britain and Ireland 2015-2018; **Routledge**: Treasurer of UK Environmental Mutagen Society 2011-2018; **Sandoe**: Chair of the British Society for Antimicrobial Chemotherapy Endocarditis working party; **Sebag-Montefiore**: Chair of the NCRI Clinical and Translational Radiotherapy Research Group (CTRad) 2019-2022; Chair of the CTrad Proton Beam Clinical Trial Strategy Group 2018-2020; Vice Chair of the NIHR, Health Technology Assessment Prioritisation Panel for in hospital research 2018-2019; ***Selby***: Trustee of Cancer Research UK 2012-2016; President of the Association of Cancer Physicians 2007-2018. **Seymour**: National Lead of NIHR Clinical Research Network Cluster-Cancer, Surgery, Oral/Dental Health; Clinical Research Director, NCRI; **Simpson**:CRN National Speciality Lead, Reproductive Health & Childbirth; **Stewart**: Executive Board of the Leeds Academic Health Partnership and Lead for Centre for Personalised Medicine and Health; Northern Health Science Alliance board of Directors; **Wilcox**: UK SAGE - Scientific Advisory Group for Emergencies – COVID-19; Co-chair of SAGE Nosocomial Transmission COVID-19 subgroup; Lead on *C. difficile* infection for Public Health England; Medical Advisor to the National Infection Prevention & Control Lead at NHS Improvement.

4.2.4. Representation in national or international scientific peer review

Conaghan: Chair Versus Arthritis, Osteoarthritis and Crystal Diseases Clinical Studies Group, Versus Arthritis MedTech grant panel; **Dall'Armellina**: chair of the SCMR scientific committee and seed grant committee; **Markham**: Scientific Advisory Board Member, German Consortium for Translational Cancer Research of the Federal Ministry of Education and Research; Medicine Panel Member, Portuguese Government National Research Assessment Exercise; Panel member, Singapore National Medical Research Council, Translational and Clinical Research Flagship Programme; **Naseem**: Chair Heart Research UK Translation Research Panel; **Peckham**: Deputy chair, UK CF Trust Strategy Implementation Board; **Sebag-Montefiore**: Chair Cancer Research UK Clinical Trials Awards Committee; **Stewart**: Chair of British Heart Foundation Chairs and Programme Grants Committee; Chair of MRC Careers and Training Committee; Chief Scientific Adviser Scar Free Foundation.

4.2.5. Education and training

Training the next generation of researchers is a key priority for UoA1 and is covered in detail elsewhere in this statement. 40% of our academics hold dedicated roles in training of scientists or clinicians, in addition to their core academic role. Selected examples include PhD programme directors (**Beech**, **Cubbon**), clinical/academic training programme directors (**Scott, Quirke, Morgan**), chair of the

Interstellar programme for trainees (**Emery**), Director of Education – European Cystic Fibrosis Society (**Peckham**), and Lead for Marie Curie PhD Training programme (**Newton-Bishop**).

4.3. Public engagement and contributions to wider society

Patient and Public Involvement and Engagement (PPIE) is critical to our research activities. Patients are actively involved in our research in multiple ways, from early development of research ideas to dissemination activities. Patients and the public help to focus research aims addressing issues that matter to them, to ensure that studies are respectful of research participants needs, and to develop relevant, accessible recruitment approaches and materials. Patients and the public also help co-design new healthcare interventions, treatments and studies and co-produced the UoL-LTHT research strategy. Each research theme has developed PPIE Groups that are overseen by a joint PPIE NIHR@Leeds Strategy (Section 3.2.1), developed by the NIHR BRC and CRF (supported by 2.4FTE dedicated staff). This interdisciplinary approach promotes sharing of resources and best practice, including evidence of PPIE impact. Central to the strategy is "research for everyone": in 2019 we appointed an Outreach and Impact Manger to ensure under-represented and hard-to-reach communities are included in our PPIE activities. Our PPIE Group was pivotal in developing "Covid and Us" videos to promote greater uptake of Covid Treatment and Vaccine research in the Black and South Asian community.

The University has ten members of staff who support and facilitate PPIE work, with over 770 patients, carers and service users involved in research every year. These staff provide advice and guidance enabling our academics to consider PPIE in their work. The PPIE team organise and facilitate PPI meetings, advertise for and invite members of the public to specific PPI activities, and collect information to monitor and assess the impact of PPIE activities.

Promoting our research to wider community is undertaken through several mechanisms. Informal *Café Scientifique* meetings allow us to showcase our studies to the public; "Ask the Researcher" events open to the pubic are hosted through the BRC every 6-8 weeks; UoA1 academics participate in the UoL annual 'Be Curious' event to engage the local community in research; and widening participation initiatives to increase diversity within the SoM UG programmes. Within UoA1, 63% of our researchers have organised or participated in public engagement events whilst 50% of our academics have been interviewed about their research for the print or broadcast media. Communications are co-ordinated through Faculty and University based infrastructure.

Policy Leeds is the connecting hub for research-policy engagement at the University of Leeds. It strengthens the influence and impact of University of Leeds research on policy design, delivery and impact at the local, national and internationals levels. Policy Leeds works with the SoM to connect research and policy communities, communicate policy-relevant research (via policy briefing and blog series), coordinate policy engagement with similar work across the University, and support researchers so they become confident and competent policy engagers.

4.4. Contribution to the scientific community by Leeds NHS staff

Our NHS clinicians play a critical role in the national or international clinical research community. Fifteen NHS consultants hold Honorary Professor status within the SoM (+ 18 Emeritus Professors) and 61 are Honorary Clinical Associate Professor. Examples of major scientific contributions by our NHS clinicians include: *Crellin* (awarded CBE in 2019 for services to radiotherapy including NHS England Clinical Lead for the National Proton Beam Therapy programme); *Kay* (awarded OBE in 2019 for services to complex reconstructive hand surgery); *Blackman* (Secretary to British Cardiovascular Intervention Society; First-in-human studies in cardiac valve implants); *Toogood* (President of Association of Upper

Gastrointestinal Surgeons of Great Britain and Ireland); *J Scott* (President of the Vascular Society of Great Britain and Ireland); *Marzo-Ortega* (Chair of the British Society for Spondyloarthritis, Past President of the International Spondyloarthritis Congress).