

Institution: University of Nottingham
Unit of Assessment: UoA1 – Clinical Medicine
1. Unit context and structure, research and impact strategy

1A. Overview

UoA1 comprises eight Divisions and Research Units based in The School of Medicine. This return includes 146 researchers (138.6FTE) working collaboratively to deliver innovative, globally impactful health research. The creation of a world-class research environment has enabled our researchers to attract £139.3M in research awards into the University and another £32.7M into partner NHS Trusts during this REF period. Critical to our success is the development of future research leaders with 516 doctoral graduates. Our clinical academic trainees have increased by approximately 40% during this REF, with 79% of our clinical lecturers appointed to senior academic posts. We have published 4826 papers, 44% with named international collaborators. We have three new Fellows of the Academy of Medical Sciences and five NIHR senior investigator/professorship awards.

Following an in-depth, independent external research review in 2018, our research strategy continues to evolve, targeting the big health questions facing us today and the global challenges of tomorrow. Our world-class research strengths include: applied health research with practice-changing large pragmatic randomised controlled trials delivered through our expanding NIHR-accredited Nottingham Clinical Trials Unit; leading the international development of core outcome sets (for example dermatology, child health and musculoskeletal); advancing diagnosis and treatment of liver disease; and establishing global research hubs such as the Nottingham China Health Institute. Our patient and public involvement and engagement activities are at the core of our research strategy and have resulted in more Priority Setting Partnerships than any other institution. We value equality and diversity, hold an Athena SWAN Silver Award, and are working towards a Gold Award.

We have enhanced our vibrant research environment with world-leading areas of research excellence including one of the largest NIHR Biomedical Research Centres in England, incorporating interdisciplinary strengths in biomedical imaging (Sir Peter Mansfield Imaging Centre) and pathology (Nottingham Molecular Pathology Node). We embrace multidisciplinary team science and our researchers have benefitted from strategic investments in a new flagship Bio-Discovery Institute to facilitate and host multidisciplinary research groups in state-of-the-art shared facilities, including a forward-looking strategic increase in critical mass and expertise in cancer and stem cells, dermatology, and clinical trials.

We have translated our ground-breaking discovery and clinical science into impactful research that is improving the global health and well-being of individuals, patients, and society. Our thriving research environment has allowed us to impact national and global health with earlier diagnosis of lung, breast and brain cancers, better care of those with liver and skin disease, reducing NHS healthcare costs on a public health scale (vaccinations), and agile research teams tackling the COVID-19 pandemic. Our innovations have supported UK-plc through the formation of multiple spin-out companies, medical device adoption, commercial investment and income, as well as job creation. Our evolving Research Strategy will ensure our researchers continue to lead and deliver impact as part of the international research community, partnering with patients, healthcare providers and industry to continue our upward trajectory through the next REF and beyond.

1B. Structure

The Unit sits within the University of Nottingham (UoN) School of Medicine (SoM). SoM was formed in 2013 and is administratively organised into 12 Divisions/Units, eight in UoA1, and includes 146 researchers (138.6FTE) returned in REF2021 (**Figure 1**).

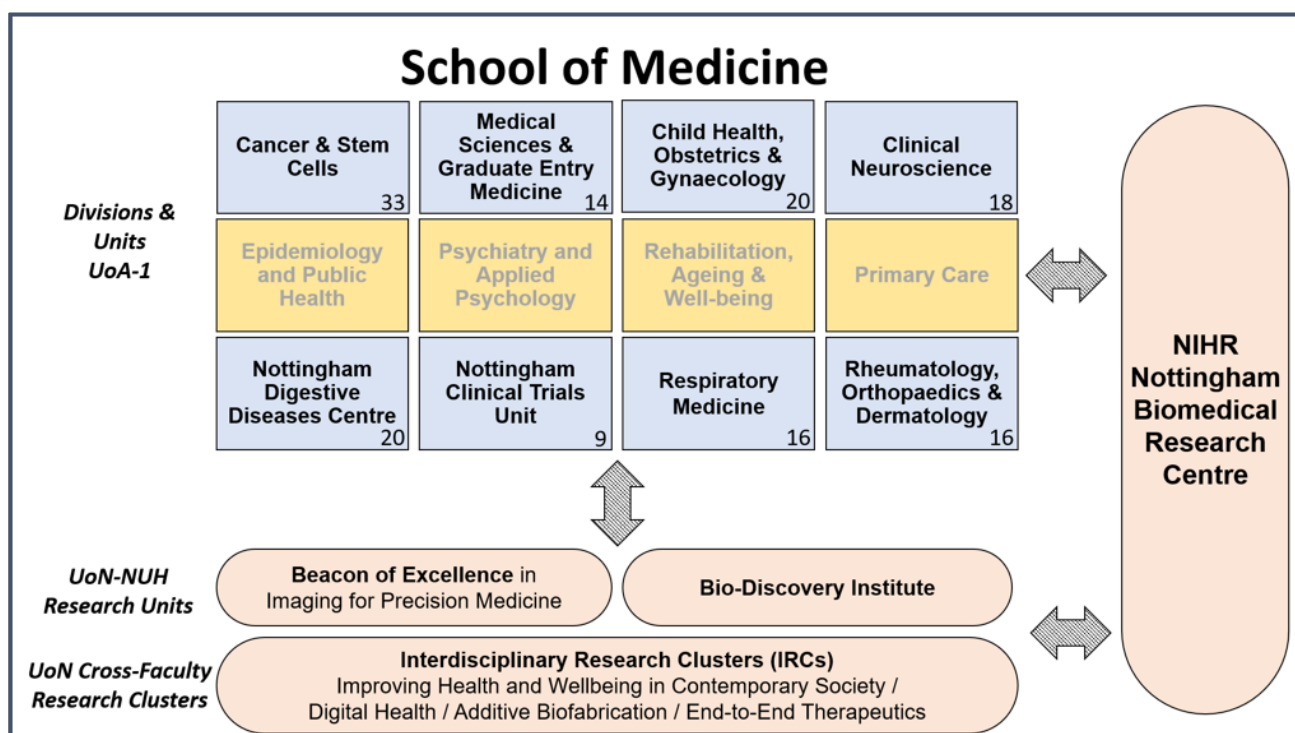


Figure 1: Structure of SoM, highlighting UoA1 returned Divisions/Units (blue) and numbers of REF-eligible researchers. Divisions returned in other UoAs (yellow).

Responsibility for our Research Strategy lies with the Head of School and Co-Directors of Research. Along with a Head of Research Operations, they sit on the School's Management Board and Executive, ensuring School strategy and operations align with research. They lead a Research Executive, which includes three academic Deputy Directors of Research and a lead for Equality, Diversity and Inclusion (EDI).

Clinical-facing research and teaching are fundamental to our School. Our research is strategically aligned with key NHS partners, primarily:

- Nottingham University Hospitals NHS Trust (NUH)
- Nottinghamshire Healthcare NHS Foundation Trust
- University Hospitals of Derby and Burton NHS Foundation Trust (UHDB)
- United Lincolnshire Hospitals NHS Trust
- Local Clinical Commissioning Groups
- East Midlands Academic Health Science Network (EMAHSN)
- NIHR Applied Research Collaboration East Midlands

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- East Midlands Pathology Services
- East Midlands NIHR Research Design Service
- NIHR Clinical Research Network.

1C. Objectives and plans

1C-i. Review of the assessment period

We have built on our research strengths in REF2014, nurtured emerging areas, and made sustained progress in people, income and infrastructure. This has enabled us to deliver significant gains to the quantity and quality of our research activity, outputs and impact. Key outcomes for each of our overarching strategic aims, as specified in REF2014 (quoted text in italics), are highlighted below.

“Sustain existing and build new critical mass in specific areas, including building new facilities and making targeted new senior academic appointments” and ***“Further invest in and expand our key research support platforms and units”***. In 2017 we were awarded £23.6M for the NIHR Nottingham Biomedical Research Centre (BRC) in conjunction with NUH NHS Trust (including a £1M investment from our School). The BRC, under Director **Hall**, is driving translational medicine into patient benefit. It is a world-class hub for health research in five key areas: Digestive Diseases, Hearing, Mental Health, Musculoskeletal Diseases and Respiratory Medicine with MRI imaging a cross-cutting theme. Four of the six theme leads are returned in UoA1. The BRC facilitates cross-theme events including sandpits and an annual scientific conference to allow further cross-fertilisation of ideas between patients, scientists and clinicians. This prestigious award has accelerated our research ambitions and provided hospital-based facilities in one of the UK’s largest NHS Trusts to translate our discovery science into better clinical care. Since its creation, our BRC partnership has formed 285 research projects with industry, managed 62 patents (including 6 new), agreed 16 commercial licenses and facilitated £16.6M of industry funding.

We successfully attracted significant investment from the University’s Strategic Development Fund (£9.4M) for programmes in Cancer, Dermatology and Stem Cell Biology, building on these areas of research excellence. This led to new academic appointments in Rheumatology, Orthopaedics and Dermatology (**Leighton/Boyle/Gran/Chalmers**); in Cancer and Stem Cells at Professorial (**Gaston**) and Assistant/Associate Professor levels (**McIntyre/Hannan/Thomson/Benest/Arkill/Ordonez-Moran** and **Merry** now Professor). We have expanded our NIHR-accredited Nottingham Clinical Trials Unit (NCTU); we secured dedicated space in accordance with our five-year plan, following £1M of University Strategic Development Funding, and appointed six new academic and three administrative posts; this has already significantly increased our national/international clinical trial portfolio.

The impact of these investments is demonstrated, for example, by our Dermatology researchers who have led six clinical trials across multiple skin diseases providing world-class research evidence. This has transformed clinical care throughout the NHS and around the world, informing 7 national and 34 international guidelines and changed clinical practice in 22 countries across 5 continents. Most importantly, this has improved the quality of life for people with skin disease, reduced deaths and serious side-effects, and reduced spending on ineffective treatments.

Enhancing our world-leading MRI research was a critical component of our research strategy entering REF2021. A partnership with the School of Physics led to strategic University investment in a “Beacon of Excellence” in Precision Imaging (£8.5M). This is delivering an ambitious, challenged interdisciplinary research programme focused on next generation imaging to enable precision

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medicine. This investment, including Medical Research Council (MRC) capital funding, has supported new senior academic appointments and enhanced our state-of-the-art imaging facilities, including two new MRI scanners and major upgrades to existing scanners.

“Promote, fund and facilitate large-scale multidisciplinary research across Schools and Faculties”. Our flagship Bio-Discovery Institute is UoN’s second largest research capital investment (£23M) and co-locates our researchers with those from other Schools including Pharmacy, Veterinary Medicine and Science. The Bio-Discovery Institute (Director **Denning**) is the final phase of a £100M interdisciplinary complex of interconnected buildings co-locating 800 staff. It provides a purpose-built space to support and nurture interdisciplinary working and to promote productive collaboration. Its multi-disciplinary approach allows our underpinning discovery science to extend into other areas of research strength, including through our partnership with the NUH NHS Trust. The Beacon of Excellence in Precision Imaging described above is also a transdisciplinary initiative (REF5a-2.1a).

UoA1 researchers are key members of the new University **Interdisciplinary Research Clusters** (founded 2019 with UoN strategic investment) in End-to-End Therapeutics, Improving Health and Wellbeing in Contemporary Society, Digital Health, and Additive Biofabrication. The clusters evolved from a number of earlier **Research Priority Areas** (2014-2019) led by UoA1 researchers and help deliver the University’s **Global Research Theme** for Health and Wellbeing.

“Improve research training and career opportunities for young researchers”. We are committed to supporting Post Graduate Researchers (PGRs) and Early Career Researchers (ECRs) (Section 2). Our grant writing training scheme and Fellowship application programme are highly successful. Fellows enter our Fellowship support and mentoring programme focussed on transition to permanent research positions. Clinicians entering research careers are supported by our Clinical Academic Training Programme.

“Promote major industry collaboration and commercialisation”. We recruited a Translational Business Development Manager supporting applications for translation research and linking with the University’s Technology Transfer team. We are successful in translating research into spinout companies, providing further financial support for UoN research (Section 1C-iii). Our translational work is externally recognised; for example, **Madhusudan** was awarded The Lady Estelle Wolfson lectureship in Translational Medicine in recognition of translational DNA repair focussed breast cancer research. We have significant industry collaborations facilitating the training of our PGR students with numerous case awards via MRC IMPACT, BBSRC DTP schemes, and bespoke collaborations with a range of biotech and pharmaceutical companies e.g. AstraZeneca.

“Make our research truly international”. We have made substantial progress in international collaboration and impact, including the appointment of a Global Engagement Lead, high-profile international research collaborations and the launch of our Nottingham China Health Institute (Section 4.3). Our researchers lead international projects ranging from randomised controlled trials of microfinance to improve child nutrition in India through to large European industry/academic liver disease projects totalling €66M. 44% of our REF returned research outputs have named international collaborators.

1C-ii. Research strategy

In 2018, the SoM undertook a major research review exercise, led by an external panel of senior experts, aiming to identify strengths and areas for improvement in our research activity.

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The review highlighted improvement in our School's research over recent years and identified significant strengths such as:

- excellent partnerships between the University and NHS
- examples of nationally-leading success such as the BRC
- strong research training for PhD students
- excellent progress in internationalisation including of the Nottingham China Health initiative and the emerging collaboration with Fudan University, Shanghai, China
- strong and proactive approach to EDI.

The review proposed 45 recommendations to maximise research performance, implementation of these was completed in April 2020 including:

- progressing collaborative working with NUH NHS Trust, including establishment of a Joint Office (Section 3F)
- improved technician support for research, through a commissioned review of Technical Services (Section 3C)
- additional improvements to the leading PhD-student training programme ("N-trans"), including new courses on laboratories and research software (Section 2G).

Our key aim is to create a supportive environment for world-leading research that encourages a culture of ambition and generates impact beyond academia. Our new 5-year Research Strategy builds on the foundations of UoN's Research Vision (REF5a-2.5) and comprises five priorities plus two cross-cutting priorities on EDI and Impact (**Figure 2**). These priorities are summarised below and detailed throughout our statement.



Figure 2: School of Medicine 5-year Research Strategy (2019).

Encourage ambition and grow research income to address the most pressing research priorities of the day. This includes: all research staff having a documented, ambitious research plan that articulates its relevance to internal and external priority areas; delivering multiple cross-

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cutting sandpit events bringing together colleagues from different disciplines/institutions, especially in planning response to strategic calls or building around priority areas; and promoting leadership with global health challenges.

Create a supportive culture that promotes shared priorities and a collaborative ‘Team Science’ approach. Holding multidisciplinary, cross-School and inter-Faculty events to foster collaboration; complementing a culture of active encouragement and reward teams and individuals at all levels.

Support career growth at all levels and staff families. Building on our Athena Swan Silver award to secure Gold Award in 2023; increasing the number of externally funded fellowships at all levels and investing in successful individuals to deliver world-leading research; supporting workshops and mentorship for newly promoted Professors to broaden engagement in University and international opportunities; increasing the proportion of researchers and support staff undertaking leadership programmes across all job families.

Encourage partnerships and collaboration (particularly industry, NHS partners and internationally). Building on successes of the industrial partnership team, enhancing the strategy/support for industry funding and collaborative opportunities; solidified partnerships with our key NHS Trust partners; appointing a patient and public involvement and engagement (PPI/E) co-ordinator to increase PPI/E in research at all levels; increasing cross-Faculty working and external collaboration with need-driven Interdisciplinary Research Clusters and Beacons.

Create high quality infra-structure that supports world-leading research. Facilitating research growth by expanding our research support and business development team; optimising research space and ensure further investment in infrastructure, including co-location where appropriate; augmentation of data management infrastructure and policies around research (particularly clinical trials); we have increased strength in key methodological areas including health economics, statistics (NCTU detailed earlier) and information specialist support.

The first cross-cutting priority is to **enhance and embed equality, diversity and inclusion** across all activities. EDI is embedded throughout the activities outlined in this research strategy and is a standing agenda item on all committees. It is closely aligned to our Athena SWAN action plan and extends across protected characteristics. Specific actions include a focus on supporting career progression, especially that of ECRs.

The second cross-cutting priority is to **maximise research impact beyond academia** (Section 1C-iii).

1C-iii. Impact strategy

Embedding a culture of impact across our Unit, we have strengthened our impact leadership and responsibility, for example through our Knowledge Transfer and Outreach Champions Group. We have also consolidated our areas of research excellence into influential groups of critical mass as reflected in our impact case studies outlined below.

REF2014 highlighted our close links with the NHS and industry partners. We have consolidated this through collaborations with the East Midlands Academic Health Science Network (EMAHSN) and through creating and funding the Centre for Healthcare Technologies (CHT) in 2016. CHT is a unique collaboration between UoN and NUH, bringing together key stakeholders, capabilities, and expertise to produce a pipeline for the rapid translation of fundamental scientific discoveries into MedTech innovations and healthcare adoption. It has developed additional integral units, such as the Centre

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for Healthcare Equipment and Technology Adoption established through interdisciplinary collaboration with Clinical Engineering at NUH and EMAHSN. In 2018, CHT received the prestigious NHS England Chief Scientific Officer Award for Developing Partnerships to Improve Outcomes, in recognition of providing a thriving ecosystem for innovative scientific and clinical research.

Our researchers are delivering research impact and knowledge exchange through spin-out companies including Oncimmune (early detection of cancer), NuVision (regenerative medicine), FAHRAS (family history risk assessment software), SurePulse Medical (newborn monitoring), Scancell and Exonate (biopharmaceutical companies).

Impact Leadership. We formed our Impact Group in 2017 embedding the value of impact at all stages of research and for all staff with research involvement including PGR students. We have appointed **Impact Champions (Bayston/Guha/Chalmers)** who deliver impact training and mentorship through workshops including those targeted specifically at ECRs, thus engaging the next generation of research leaders. We launched an annual impact competition (three awards up to £1500) and a PhD student award focusing on the importance of ensuring research has impact beyond academia. These awards have allowed researchers to further increase impact from their research, such as funding engagement activities.

Impact engaging and empowering. Our researchers are challenged to consider impact in their annual performance review and promotion criteria. Development of impact within grant and research plans is included as an integral part of our six-session Grant Writing Training programme. Our researchers are encouraged and advised to apply for funding specifically to strengthen the impact of their work, including external (UKRI) impact accelerator funds and internally funded schemes (Nottingham Impact Accelerator; REF5a-2.2).

A **grant focus group** for translational healthcare research brings together professional services from our School, University and key stakeholders including PPI/E, NHS and industry links (e.g. Medilink). They review current and upcoming translational research opportunities and identify how best to support researchers jointly between UoN and NUH. The initiative has been commended by NIHR, who praised the vision and the value it brings to the translational pipeline; NIHR programme managers assisted in establishing the group and we have strong connections with their i4i team. An example resulting impact was through MAGIC (**Marciani**), a first in-child study of a new mini-capsule MRI medical device to measure gastrointestinal transit in children with constipation, the team subsequently securing an NIHR i4i Product Development Award which was featured by NIHR as a “Collaborating for Innovation” case study. Continued support from the group resulted in the award of a £1.2M i4i grant (MAGIC2) for a large multicentre study.

Impact through Research Strength. We recognise that impact occurs more readily in excellent research teams, with a critical mass of expertise. We have supported a number of initiatives which are expected to lead to significant impact within a 5-10-year period. A new Nottingham Translational Cancer Research Centre will focus on early detection and treatment stratification to promote better survival in cancer patients. This will be underpinned by the Ex-Vivo Cancer Pharmacology Centre of Excellence; our world-class research in pathology; the University spin-out companies Scancell and Oncimmune; and our extensive experience in antibody and drug development. This will build on our world-leading impacts in clinical cancer such as The Nottingham Histological Grading System (**Ellis/Rakha**). This has advanced the personalisation and sophistication of breast cancer care, becoming the mandated method for grading breast cancer worldwide.

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Our **Future Strategy** for impact is integrated within our current 5-year Research Strategy and aims to improve the quality, value and impact of our research as part of the University's overall vision for impact transformation. One of the five major themes of our research strategy is to build on our parent/carer, industry and NHS partnerships. To enhance these research strengths, we have four key areas of focus:

- Better integrate industry partnerships and focus strategy and support to exploit more funding opportunities. There is a specific opportunity to address UK Place Strategy and link with the Midlands Engine
- solidify our partnerships with key NHS partners at strategic and operational levels
- increase representation of external partners (e.g. Public, NHS, industry) on committees, working groups and training events
- expand PPI/E across all research.

Our Faculty has established a Knowledge Exchange (KE) Strategic Implementation Group to deliver the Faculty's KE plan, led by the Industrial Strategy and KE Lead and the Research and Business Development Manager.

The breadth of impacts arising from our submitted impact case studies demonstrates the scale and scope of our underpinning research. Our cases demonstrate impact in **health and wellbeing**. These include: improved care practices in breast cancer diagnosis, lung cancer detection, skin care and surgery recovery; reducing infection related deaths with novel antimicrobial devices such as neurosurgical shunts; advancing liver disease prevention and markers of health; a clinically important reduction in time to diagnosis for children with brain tumours; and demonstrating rapid, life-saving clinical trials with dexamethasone treatment for COVID-19. Our Unit's case studies also demonstrate how our research contributes to **commerce and the economy**. This includes: changes in guidelines and care practices in the treatment of skin disease which have reduced costs of healthcare treatments resulting in savings across the NHS estimated at £15M; a significant change in UK adult vaccine policy which resulted in a projected saving of £233M to the NHS; several successful spin-outs including one specialising in early lung cancer detection tests, with an income from sales of over £2.5M and £15M of investment. We have had nominations of impact cases from every Division. Shortlisting, development and final selection were managed by the Unit's impact champions, based principally on quality of evidence for the impact and the strength of the link to the underpinning work in UoA1.

1D. Interdisciplinary research

We benefit significantly from Institutional strategies for Interdisciplinary Research, such as the Bio-Discovery Institute detailed earlier. Additional key examples include the founding of **Beacons of Excellence** and **Interdisciplinary Research Clusters (IRCs)** (REF5a-2.1b). Our ambition is to grow our reputation as one of the UK's leading centres for Applied Health Research and increase success with large-scale programme grants and externally funded Centres/Institutes.

The **Precision Imaging Beacon** (£8.5M), led by UoA1 **Auer**, spans multiple faculties including Physics, Maths, Psychology, Computer Science and Life Sciences. Our researchers receive investment, infrastructure, facilities and support for new interdisciplinary collaborations in emerging fields. Examples include: £160K to develop artificial intelligence diagnostic imaging for patients with occult scaphoid wrist fractures; next generation imaging including the world's first wearable brain

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scanner (optically-pumped magnetoencephalography); and interdisciplinary centres of excellence in areas such as physiological imaging, imaging-guided neuromodulation and ultrahigh field imaging. MRC Confidence in Concept pump-priming funding resulted in an NIHR/MRC EME Programme grant (£1.9M), with NHS partners at UHDB, for novel MRI methods for chronic kidney disease.

Our researchers have key leadership roles with four cross-University IRCs: Digital Health, End to End Therapeutics and Technological Innovations in Health and Wellbeing. The fourth IRC in Health and Wellbeing in Contemporary Society brings together researchers across the University with external organisations to catalyse change and tackle the most important challenges in this domain. It benefits from cross-faculty methodological expertise in systematic reviews, epidemiology, clinical trials, analysis of linked databases, health economics, qualitative methods, behavioural science, implementation science, and policy impact. It draws on key aspects of contemporary society, which include increased human interconnection, technological innovation, and anthropological/ecological transformation.

Our Research and Impact Highlights Programme facilitates interdisciplinary research and impact sharing. Divisions share their world-leading, impactful research, providing networking opportunities for all staff and PGRs, and identifying new areas for collaboration. Regular Divisional research seminars are held, many with external speakers supported by Faculty funding.

1E. Open Research

UoN has introduced a Data Management Policy requiring that research data deposited for archive is discoverable, via a publicly available metadata record (REF5a-2.3). Owners ensure research data deposited for archive are made available for sharing with as few restrictions as possible whilst maintaining funder and regulatory requirements, through assignment of a clear and accessible data usage licence.

We are represented on UoN's "Plan S" working group to proactively support our Institution in transitioning towards its principles of open access publication in advance of implementation. In 2017, UoN invested in a new Research Information System (REF5a-2.3) to support researchers in making their research outcomes Open Access, and UOA1 researchers have since deposited over 3500 outputs in this repository. Of the 4826 outputs produced by UOA1 2014-2020, 72% are classed open access, increasing to 76% since 2017. UoN Libraries teams support deposits and offer a Mediated Deposits Service. Between 2014-2020, over 500 theses from our School have been deposited with 102,160 downloads.

Access to funding to cover Article Processing Charges (APCs) or other paid Open Access arrangements (where preferred by our funders/stakeholders over Green Open Access) are provided by our block grants (covering work funded by RCUK and NC3Rs or a member of the Charity Open Access Fund), managed by the Libraries Research Team. Additional funds are made available with School approval where a case is established, and the University negotiates with publishers for reduced APCs. UoN financially supports open access initiatives including the Directory of Open Access Journals, and open science ePrint servers extensively used by our researchers.

In line with University objectives (REF5a-2.4), UoA1 is compliant with the Concordat on Open Research Data at a local level. UoN invested in a new archiving service providing a managed data repository, archiving service with functionality for surfacing data deposits and related metadata. Deposits are assigned identifiers for citing (DOI). Examples include: over 750 in vivo systematic genetic analyses of tumour progression (**Lourdusamy/Rahman**) which have been accessed

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globally; open data on novel polymers for human pluripotent stem cell expansion and multi-lineage differentiation (**Denning**); and open data on multifunctional 3D scaffolds for cardiomyocyte development (**Denning**). We have also developed and released multi-modal neuroimaging pipelines for data pre-processing, part of the BRC (**Auer**).

Our researchers have contributed to the wider research environment with open access software and tools for clinicians (e.g. algorithm for treatment of refractory constipation, **Corsetti**); patients and the public (e.g. free-to-download app for people to track their eczema using our validated outcome measures, **Chalmers/Thomas**); and for other researchers (e.g. NeuRoi, software for processing MRI images, **Tench**). **Hall** is PI for the MRC Strategic award for collaborative project delivering a genotyping pilot for UK Biobank (first 50,000 individuals). **Morgan** serves on the Sample and Data access committee for Brains for Dementia Research to ensure responsible, efficient and appropriate use of tissue and data in the brain bank network.

1F. Use of metrics and implementation of Code of Practice

The University is committed to responsible use of indicators in research and is a signatory of the Declaration of Research Assessment (DORA). In 2019, we extensively reviewed use of metrics in all aspects of research operations, development and research-related staffing processes such as recruitment and promotions (use of H-indices in promotions proforma has been abolished). We explicitly assess work on its content rather than its place of publication or journal metrics, a principle incorporated into our review and selection of outputs for REF.

Selection of outputs for REF2021 was led by **Thornton** who coordinated the review of outputs from every member of our Unit, with a panel of internal peer-reviewers representing varied research subdisciplines. Outputs were chosen for the Unit's pool principally based on the panel's scores and to be within the maxima for attributions to each author.

In respect to People, we are submitting 100% of Category A staff. For colleagues on research-only contracts, decisions on whether they meet the definitions of an "independent researcher" were made in line with our institutional Code of Practice. This was guided by objective indicators such as research income as PI, considered holistically alongside qualitative statements from the individual's Head of Division and other appropriate personnel. Final decisions based on this collated evidence were made by a panel of three (2F/1M; 1BAME): our two Co-Directors of Research, and the Research Executive's lead for EDI.

1G. Research Integrity

All our research is subject to rigorous standards aligning with UoN's endorsement and promotion of The Concordat to Support Research Integrity (REF5a-2.4). Training is provided in Research Integrity (mandatory for PGRs), codes of conduct, UK Concordat implementation and mentoring, as well as dealing with procedures for investigating misconduct and whistle blowing. The University, a member of the UK Research Integrity Office (UKRIO), has access to UKRIO training provision on research integrity.

Research Integrity is central to staff and PhD programme induction processes and development programmes delivered in parallel with UoN's Researcher Academy. Specifically, research governance is built into our Doctoral Training Programmes through our bespoke N-Trans programme for clinical-translational research and includes modules on the use of humans and animals in biomedical research, embedding the 3Rs in research, exploring ethics in research, Good Clinical Practice, PPI/E and data management. Data Protection training, including GDPR legislation, is

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compulsory for all University staff. The Libraries teams support Research Data Management standards.

Studies are either approved through NHS ethics or (for healthy volunteer studies) by our Faculty Ethics Committee, whose membership includes research, teaching and clinical staff, including honorary members from NHS partners.

Staff conducting in vivo studies aim to Reduce, Refine and Replace (3Rs) the use of animals as far as possible and their published results conform to the ARRIVE Guidelines and all relevant regulations. **Denning** is Chair of the NC3Rs Knowledge Transfer Panel (2017-20).

The University has a Code of Practice on Handling Allegations of Research Misconduct in line with UKRIO and UUK recommended processes. Relevant policies and procedures include Regulations of Academic Misconduct, Staff Disciplinary Procedure, Code of Discipline for Students and Fraud Policy. We have published tailored Authorship Guidelines to assist all staff and students (including staff on non-research contracts) in conferring accountability and credit appropriately.

2. People

2A. Staffing strategy

Our mission, vision and values cultivate a culture of curiosity, ambition and inclusion in everything we do in an environment that enables every individual to thrive. Our staff development strategies focus on the individual, providing personalised training and development. They are however, delivered in diverse groups to encourage interaction, understanding and contribution to our 'Team Science' ethos.

This is underpinned by our People and EDI strategies in addition to UoN's initiatives (REF5a-3). Our Transformation and People Strategic Committee and EDI Committee include senior School staff, Head of School and EDI Lead. Divisional and student EDI representatives sit on these committees, embedding EDI across our School. Our strategies and resulting actions have arisen through communicating with our staff/students via surveys, focus groups and regular open meetings/communications. Our action plans commit us to diversity and equality of opportunity for existing and future staff and students, in our thinking, our policies and our practices.

Our People strategy focuses on developing staff and students to be ambitious and achieve research excellence in a culture that promotes collaboration and diversity, supported with high quality infrastructure and resources. Our recruitment strategy aims to attract diverse, high calibre staff into areas of research excellence and is strategic, ensuring that appointments align with our global research strategy.

Each Division's Team Research Plan includes horizon scanning and succession planning to ensure sustainability of current and future areas of research excellence. "Retire and return" policies enable retirees to train and mentor existing staff to succeed them and become top future academic leaders. This is supported by a suite of institutional Leadership Training Programmes. **Walker** is a prime example of the success of this strategy: under the mentorship of **Thornton** (Professor of Obstetric clinical trials), she has progressed from clinical lecturer to associate professor with an £8.2M portfolio of obstetric clinical studies as chief or co-investigator.

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In UoA1, 20.4% of our staff are Black and minority ethnic (BAME), above the 17% BAME Higher Education Statistics Agency figures in HE employment (2018/19). Our EDI strategy/action plan has driven forward our actions to increase the diversity of our staff. When advertising we use a gender-decoder on our role profiles and adverts to avoid bias and we overtly welcome applicants from diverse backgrounds. All staff complete mandated EDI and unconscious bias (UB) training, and shortlisting and interview panels are gender balanced and diverse where possible. Our Vacancy Manager system structures application questions to avoid UB and shortlisting is undertaken without knowledge of some protected characteristics. Our current pilot of “Diversity by Design” goes further by removing biographical data prior to shortlisting. All vacancies are open to working part-time/job-share for flexibility and job adverts highlight wellbeing information and family friendly policies such as flexible working and shared parental leave. As a disability confident employer, applicants with a disability who meet the essential criteria are shortlisted for interview.

In UoA1, over 85% of our contracts are permanent (no gender difference) and 97% of our BAME staff have permanent contracts. Of REF-eligible staff, 19 are on fixed term contracts (5 Female; 14 Male) while 129 are on permanent contracts (35 Female; 89 Male). We do not use zero-hours contracts.

Leaver's data is scrutinised quarterly to identify any trends and implement any course of action. Exit interviews are offered with senior School members.

To facilitate collaborations between industry and public partners, we have a highly developed recruitment process for the attraction and recognition of “Honorary Appointments”. These prestigious titles, aimed at fostering long-term research collaborations nationally and internationally, enable appointees to hold grants and jointly supervise PhD students. We have more than 150 appointments at Assistant, Associate and Professor level. They are included as part of the Units academic and research community, with access to IT, libraries and School training.

2B. Career development, Equality of Opportunity, Performance Review & Conduct

As a signatory to the Concordat to Support the Career Development of Researchers, we strongly support our ECRs towards excelling in research. ECRs undergo formal induction and annual Appraisal and Development Conversations on personal ambition, improving employability and CPD. We offer grant-writing workshops (124 researchers trained 2015-18, delegates: 57% female, 28% part-time and 41% ECRs); mentorship schemes; careers optimisation workshops; shadowing opportunities; CPD in teaching, research and leadership. Our Research Committee hosts a programme of developmental events (Contract Researchers Forum, including some female only workshops in support of ensuring opportunity for researcher career development, team science and horizon scanning), and ‘Focus on Fellowship’ workshops. ECR representatives serve on key School committees.

Our Researcher Experience and Development Working Group supports ECR development through formal recognition of teaching and research supervision, developing examiner skills and establishing networking opportunities. Our ECRs are supported through personal fellowship applications. Since 2017, UoN has invested significantly in UoA1 with five Nottingham Research Fellowships and six Anne McLaren (Female STEM ECRs) Fellowships. Each includes three years’ salary, research expenses up to £75K, £5K/year childcare costs and a link to a permanent academic post on successful completion (REF5a-3.2). Our success with NIHR has provided ongoing support for the Silver Scholars (now Pre-Doctoral and the Post-Doctoral Bridging Programmes) in developing clinical researchers. Our Athena SWAN initiatives have tackled gender-specific issues through

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actions aimed at supporting ECR career progression to more senior roles, parental leave and access to a Conference and Training fund.

Appraisal Development Conversations (ADCs) and joint University/NHS appraisals, as required by GMC and Health Education England, are held annually. Our specific ADC forms map to the University's career pathway framework supporting the conduct of consistent ADC discussions. Decoupling of financial rewards from ADCs has enabled conversations to focus on career development. Bespoke ADC training for appraisers and appraisees is supported by an ADC checklist, developed as part of our Athena SWAN Silver Award. Our 2018 staff survey reports good compliance with its goals of feedback against personal development plans (Females 93%, Males 91%, BAME 93%, Disability 95%); agreeing objectives (Females 92%, Males 94%, BAME 100%, Disability 96%); and increased satisfaction amongst clinical staff (Females 75% vs 40% (2015), Males 94% vs 71% (2015), BAME 90%).

The Nottingham Rewards Scheme financially recognises and rewards staff for their research and impact. School panels consider the rewards, moderated by a diverse group across all staff families, to review rating consistency and track inclusivity/demographic trends. All members have EDI/UB training. Since 2014, the School "Above and Beyond awards" publicly recognise individuals and teams who have gone furthest to enhance our research activities and progress EDI.

Promotion is available annually and overt criteria are published. Proportionate adjustments are made for career-breaks and part-time working. Our Athena SWAN annual Careers Optimisation Workshop aids academic staff to plan their career and supports those intending to apply for promotion, increasing success rates. Success during this REF has resulted in 30 promotions in 2017-20 (16 to professor) compared with 18 in 2014-17 (10 to professor), far exceeding REF2014 numbers (22 in total and 12 to professor).

Career development programmes include:

- mentoring - approximately £20K investment in our mentor and mentee training programme. Mentees report benefits to career progression and as a transformative factor in seeking promotion. This is a national example of good practice as recognised by the Academy of Medical Sciences
- research leaders programme - offers researchers, at crucial transition points, opportunities to learn new skills, network and transition into high-level strategic research leadership roles
- leadership roles - help develop a wide range of skills and increase promotion prospects. To enable inclusivity, roles are openly advertised and time limited, typically 3-4 years, to support career development/succession planning
- committee membership – allowing researchers to develop and engage in the School's strategic planning and decision making. Active monitoring of committee membership enables us to promote inclusion. For example, the proportion of females on our Executive Committee in 2013 was 0%, whereas in 2020 it is 67%.

Post-fellowship progression and support:

- Supporting career growth is a core component of our Research Strategy and this is demonstrated with the transition of ECRs. In REF2014 we reported three HEFCE fellowships (**Sharkey, Harrison, Evangelou**) who have since transitioned to substantive posts in UoA1 (two Associate Professors and one Professor).

- **Rahman** is an outstanding example of our ECR development programme. After receiving the Nottingham Advanced Research Fellowship in 2011 he was appointed Assistant Professor in 2013 and promoted to Associate Professor in August 2020 following outstanding achievements including: British Neuro-Oncology Society Young Investigator of the Year (2014), a grant portfolio of £3.7M since 2013, international collaborations including Johns Hopkins University, Uppsala University, Mayo Clinic, membership on the Evaluation Committee for the French National Institute of Health and Medical Research (INSERM) (2019-present), editorial board member for Scientific Reports, Deputy Chair for the 'Children with Cancer UK' funded Children's Brain Tumour Drug Delivery Consortium across leading European and North American institutions (2016-2021).

Wellcome Prime scheme. This Institutional Strategic Support Fund (£500K, 2016-21) with matched funding from UoN (£500K), supports ECRs who aspire to become future research leaders. Seventeen scholars funded to date have used the awards to buy-out teaching to allow time and space, to make significant research progress, and to provide research continuity helping overcome the hurdle of moving from an applicant's first significant research grant to their second. In the most recent funding round, we introduced a Fellowship Support Award, alongside the Scholarships, for our ECRs to develop their own independent lines of research in preparation for applications to major fellowship schemes. We made two awards in January 2020.

2C. Staff engagement

In addition to the University's Staff Engagement Survey, we conduct biennial surveys of our staff including researchers. These are combined with staff and student focus groups including specific sessions for parental leave, ECRs and Clinical Academics. Most staff report that they enjoy working in our School and feel part of a team (Females 87%, Males 85%, BAME 91%, Disability 83%). As part of our commitment to creating an inclusive culture we undertook a 2020 Culture Values Assessment Survey and are now in action-planning phase to embed these values in our decision-making processes.

Our Wellbeing, Engagement and Sustainability sub-committee delivers popular activities that supplement those offered by the University e.g. Nordic walking, Yoga, time-management, blood pressure checks, resilience, negotiation and influencing. Our UoA1 Wellbeing Lead reports into the Faculty Wellbeing Executive Group.

2D. Staff training and development

Training and development courses are offered by the University's Professional Development Unit, Leadership and Management Academy (LMA) and the Researcher Academy to support researchers throughout each stage of their career. We have a high uptake for University central training courses, for example with the EDI course (Males 93%, Females 88%).

Promoting research excellence through People, we strongly encourage staff to engage with the LMA. Since 2016, 69 of our staff have participated in leadership and management courses (58 were research staff). Our researchers are also encouraged to develop leadership roles with external bodies and panels, national and international organisations, as well as industry (Sections 4B-D).

We supplement central University training with bespoke training/workshops, designed and delivered in-house to develop independent research careers and deliver research impact. This is supported by a £75K strategic budget. Examples include:

Unit-level environment template (REF5b)

- Grant Writing and Fellowship courses
- a tailored digital “PI Toolkit” as part of a suite of resources for staff development and support
- regular PGR supervisor training is supported with our intranet hosted “Supervisor Toolkit” developed as a resource to support and train our staff
- online and face-to-face statistics training available for all researchers including PGRs. Since 2014, we have employed a medical statistician to run free, weekly drop-in statistics clinics (>1000 consultations have been delivered)
- peer-review of grants before submission to improve quality and success
- to support equality of opportunity to attend training, a protected Conference/Training fund reimburses PGRs and staff for caring costs incurred when attending work-related training, events and courses e.g. £1000 for a carer to accompany parent and baby to an overseas conference.

2E. Equality and diversity

We have committed to promoting equality of opportunity. Our commitment to gender equality is evidenced by our sustained success in Athena SWAN applications since the School’s formation (Bronze 2014; Silver 2015; Silver renewal 2019). Our Transformation and People Strategic Committee champions equality across all staff groups at all levels and includes intersectionality in their work, reporting to the School Management Board via our EDI lead. In addition to an EDI lead, we have invested in a part-time paid position for Head of Athena SWAN, a full-time EDI administrator and a full-time data analyst to facilitate informed decisions on EDI strategy through staff and student data. An annual budget of £25-35K is available to support EDI projects and events. The very positive feedback from Athena SWAN on our progress and commitment towards equality means we are now working towards a Gold award (2023).

EDI is a standing item on every School Committee and a rolling policy review programme ensures new/existing policies have an Equality Impact Assessment completed. Diverse representation on key decision-making committees is important for the School and for individuals.

Flexible working is offered to staff and a high proportion take up this opportunity, reflecting an embedded respect for life outside work (**Table 1**). Our meeting times guidance, subsequently adopted by the wider University, require meetings to take place between 9.30-4pm with days rotated enabling inclusivity for those working part-time or with caring responsibilities.

Table 1: Numbers of staff working flexibly across SoM (unit-level data not available, source Athena SWAN 2019)

	Female	Male
Non-clinical academics	88%	93%
Clinical academics	87%	71%

Our Maternity/Adoption/Parental leave planner, developed from parents’ and line managers’ own experience and subsequently adopted by the wider University, supports discussions between individuals and their line manager before, during and on return from leave. We have dedicated breastfeeding/parenting rooms across campuses and reserved late-starter car parking spaces aimed at parents arriving after dropping children at school.

Unit-level environment template (REF5b)

We are highly supportive of institutional initiatives for BAME staff including the 'Stellar HE' Leadership programme. The University hosted the "BecoME BAME Leaders in Healthcare Conference 2019" to highlight the journeys of Black and minority ethnicity leaders in healthcare, and to inspire future healthcare leaders from all professions.

Other key EDI initiatives we have developed over the current REF period include:

- reverse mentoring by junior staff with protected characteristics
- development of Action Learning Sets for ECRs, providing peer support in navigating the challenges of career progression (funded sub-project within STEMM CHANGE, a UoN programme funded by EPSRC to drive a positive change in culture and practices in EDI)
- Equality Impact Assessment training and completion for all new and updated policies, meetings with roles and responsibilities identified to complete training and working practices e.g. post-COVID changes. Our Women in Medicine and Science group ran training events, including events on imposter syndrome and media training
- focusing on future clinical researchers with the establishment of a BAME undergraduate education committee and an action plan to address the BMA Charter for Medical Schools to prevent racial harassment
- Establishing Disability and Carer champion and Mental Health First Aider roles.

2F. Clinical Academic Training Programme (CATP)

We have received annual funding for clinical academic training posts since 2006, integrating clinical and academic training, managed by the School's CATP, and hosted in partnership with local NHS Trusts and Health Education England. Our CATP supports Academic Clinical Fellows (ACFs), Lecturers (CLs) and other clinical trainees undertaking higher research degrees. Our ACFs/CLs are embedded within our Divisions, NIHR-Nottingham BRC and MRC hubs.

The CATP team comprise a Director and two Deputy Directors with administrative support and senior mentors. CATP members have full access to our research infrastructure and are provided with office space co-located with the group hosting their research, IT facilities, technician-staffed laboratories (where relevant) and one-to-one research-costing support for their fellowship applications. CATP recruitment processes highlight matching of flexible NHS parental leave policies, maintaining the numbers of women and increasing the proportion of women taking up these posts.

The CATP has significantly increased clinical academic training posts (2014-20: ACFs +38%; CLs +43% compared with REF2014). We are attracting more women into clinical academic training, reflecting CATP recruitment processes, in-post personalised support and flexible parental leave policies (Females: 2015-17:50%; 2018-20:59%). This compares well nationally (MSC: Overall:44%; Same specialties:38%).

Since our CATP recruited its first trainees, 105 of our ACFs have completed their posts. During this REF period, 50% have continued to competitive external doctoral research training fellowships such as MRC, Wellcome, NIHR and Cancer Research UK.

All our CLs have attained competitive external funding during their posts, facilitating their successful appointment into research roles post completion of training. Of the 14 CLs who have completed their Clinical Academic Training since 2014, 11 (79%) have gone onto senior academic posts (Clinical Associate Professor/Senior Lecturer) compared to 58% of CLs completing their posts prior to 2014.

Unit-level environment template (REF5b)

Attendance at national/international conferences and networking events are financially supported through our CATP and Research/PGR Programmes. Examples include £1200 childcare during a student's partner's prolonged hospital admission.

2G. Research Students

Research careers are encouraged at an early stage with engaging programmes to increase undergraduate involvement. For example, five years of Wellcome Trust/Academy of Medical Sciences funding during this REF period has allowed us to deliver the INSPIRE programme enabling medical students to undertake research, to deliver a national research conference (UoN hosted in 2017 with matched funding from our School), to hold a research lecture programme and in 2019 to attract additional funding for two scholarships from Health Education England. Students can attend workshops on NIHR Academic training and mock interviews with our graduates going on to secure academic training posts (for example four were appointed within our region in 2018/19).

Educating and training future research leaders is at the heart of our PGR development programmes. All PGR students attend tailored, diverse training programmes as an integral part of their development. Our PGR students can choose one of two compulsory programmes: The Faculty Training Programme or the Nottingham Translational Research Training Programme (N-Trans). N-Trans is specifically tailored for a career in clinical translational research, providing multidisciplinary sandpit events, clinically focused research skills and the importance of clinical impact. PGR students also have opportunities to teach at both undergraduate and postgraduate levels.

PGR students hold important positions on our committees including the Doctoral Programmes Committee and the Doctoral Programmes Executive Committee, giving them unique opportunities to develop leadership skills and influence School policy. Each Division has student representatives providing feedback to these committees via this student network.

We have a team of Postgraduate Student Advisors led by a senior tutor, who help students with any concerns about their research studies and supervision. Final year PhD students are encouraged to join the School mentoring scheme, following the same process as our staff. Our Doctoral Programmes Committee holds a budget to support the development and activity of all PGR students.

Our supportive PGR environment has flourished with an increase of 34% in the annual number of doctoral degrees awarded from an average of 43.6/year in REF2014 to 58.8/year during this REF period. This corresponds with a headcount of 516 (411FTE) students graduating, the discrepancy reflecting our approach of assigning supervisors from different disciplines to support doctoral training. Effectiveness of our EDI policies at an institutional (REF5a-3.3) and Unit level during this REF period are demonstrated with graduating PGRs identifying their ethnicity (White 41%, BAME 57%) and gender (Female 48%, Male 52%), with 6.7% having a disability. We have supported our doctoral students with extensions in response to COVID-19, including automatically offering zero-fee time extensions of six months.

3. Income, infrastructure and facilities

3A. Income

Income in the REF2021 period averaged £14.7M per annum, an increase since the REF2014 period at £13.5M per annum. Reflecting our strategy of close collaboration with our NHS partner trusts and the clinical relevance of our research, we continue to attract significant funding from NIHR, accounting for 35% of the Unit's income in the period; over £35.3M in income from £55.2M in awards. The most significant award was the Nottingham NIHR BRC (**Hall**), a £23.6M partnership involving NUH, UoN and Nottinghamshire Healthcare NHS Trust, of which £13.7M was income to our School. In addition to the BRC, we have secured £31.6M of direct funding from NIHR (e.g. I4i, PGfAR and HSD&R). In-kind contributions through NIHR of £20.2M have supported the Unit's research. The success of the Nottingham BRC is reflected in the £127.7M of additional funding generated since its formation across the research themes (including areas outside UoA1).

Our researchers have also captured an additional £32.7M of funding where the lead contractor is through one of our local NHS partners.

We have secured funding for Doctoral Training Partnerships (DTPs) / Doctoral Training Centres (DTCs):

- MRC Impact DTP (2016-21, £4.5M total, £1.5M to UoN) a tri-University collaboration with Birmingham and Leicester with regular studentships and iCase awards. Our students enjoy shared supervision across disciplines, Universities and through the MRC Harwell Institute where they can access state-of-the-art facilities and equipment. To-date, 92 students have enrolled across institutions, cross-fertilising research ideas, increasing collaborations and networks
- Nottingham-Rothamsted DTP (2015-23, £12.3M) across UoN including UoA1
- EPSRC and MRC Centre for Doctoral Training in Biomedical Imaging (2014-2022, £3.9M)

Our research includes a substantial portfolio of work with charities representing 24% of our research income (£24.6M), from 109 separate UK and international charitable organisations. In the qualifying period, we secured £7.7M from 210 commercial partners, the largest single award being £1.2M from AstraZeneca.

The Unit has also secured significant UoN strategic investment since the previous review period, including £1.9M for Cancer Sciences, £1M to extend the NCTU, £2.4M for stem cell research, £4.1M for Arthritis and £8.5M for Beacon activity in Precision Imaging. In addition, our researchers were awarded £665K of internal funding to support cross-disciplinary research priority areas.

3A-i. Strategies for generating research income

In addition to UoN strategies (REF5a-4.1), we utilise various approaches to support research growth and ambition including:

- our Grants Training Programme (started 2015). Evaluation shows that more than half of attendees have improved application success rates, established new collaborations and enhanced PPI/E in applications. The University's Researcher Academy also provides a range of grant writing courses for researchers at all stages of their career
- applications undergo internal review from two or more experts allowing authors to revise and strengthen their proposal. We hold a list of internal experts with funding panel membership where applicants can seek support depending on the field and funder

Unit-level environment template (REF5b)

- each Division/Unit has its own Operations Manager to manage finances and support income generation
- close integration with the NIHR Research Design Service East Midlands, hosted by our School, providing high quality funding advice and methodological support to our applied health researchers
- close links with the East Midlands Academic Health Sciences Network, who provide support, expertise and networking opportunities for researchers wishing to embed research innovation into the health and social care sector.
- As a leading partner of the Midlands Engine, our membership of the Midlands Health Alliance and Midlands Innovation Health allows us to access the commercial funding pipeline for research, MedTech infrastructure and partners to take our discovery science into healthcare.

3B. Cross-HEI shared or collaborative use of research infrastructure

Nottingham Clinical Trials Unit (NCTU): works with hospital and University-based clinicians and researchers across the UK and in collaboration with international partners (e.g. Canada, Nigeria, Sweden). NCTU's expertise includes experienced trialists, trial management, data processing and management, statistics, health economics, systematic reviews and meta-analysis, and methodological research. The NCTU hosts the **UK Trial Managers' Network**, chaired by **Mitchell**, with over 1000 professionals working in UK clinical trial management.

The Versus Arthritis Centre for Sport, Exercise and Osteoarthritis Research: awarded to NUH, with Deputy Director **Kluzek**. The Centre includes a network of six universities: Nottingham, Oxford, Southampton, Bath, Loughborough and Leeds. Six UoA1 leads along with academics from UoA3 and UoA24 form UoN membership.

The Nottingham Molecular Pathology Node (NMPN, lead Knox): one of only six national nodes funded by MRC/EPSRC to develop molecular pathology tests delivering better targeted, more effective treatments i.e. stratified medicine. This partnership with NUH works alongside the Pathological Society of Great Britain and Ireland, and the University of Vienna to deliver the Molecular Diagnostics Training School. The NMPN also works with 11 business partners including Gilead Sciences Inc., Merck and Biogen.

Newborn and children's research has been significantly enhanced with the **Children's mock MRI Simulator** helping prepare children for both research and NHS clinical MRI scans; and the UK's only dedicated **Neonatal Critical Care Research Ambulance** delivering real-world newborn transport research in collaboration with industry partners (ParAid, Jaguar Land Rover) and linked with £1.2M of funding (including £872K NIHR i4i).

MRC Versus Arthritis Centre for Musculoskeletal Ageing Research: building an internationally recognised and globally networked research platform, generating novel and clinically testable approaches to reduce musculoskeletal ageing and disease. We are integrating and expanding complementary research and postgraduate training activity at the Universities of Birmingham and Nottingham, together with their associated NHS hospital trusts.

We are one of four core centres comprising the **National Breast Cancer Biobank** and we are the first large scale user of the UK National Biobank (for asthma genetics, MRC £3.4M).

3C. Technician support for research

Our Unit benefits from UoN's sector-leading technical services strategy (REF5a-3.4), and our researchers work alongside ~60FTE Technical staff (**Figure 3**). A recent review of local Technical resource strengthened how technicians are led (now by a senior technician) and deployed across our School. All technical colleagues are encouraged to take 10 days CPD/annum (pro rata).

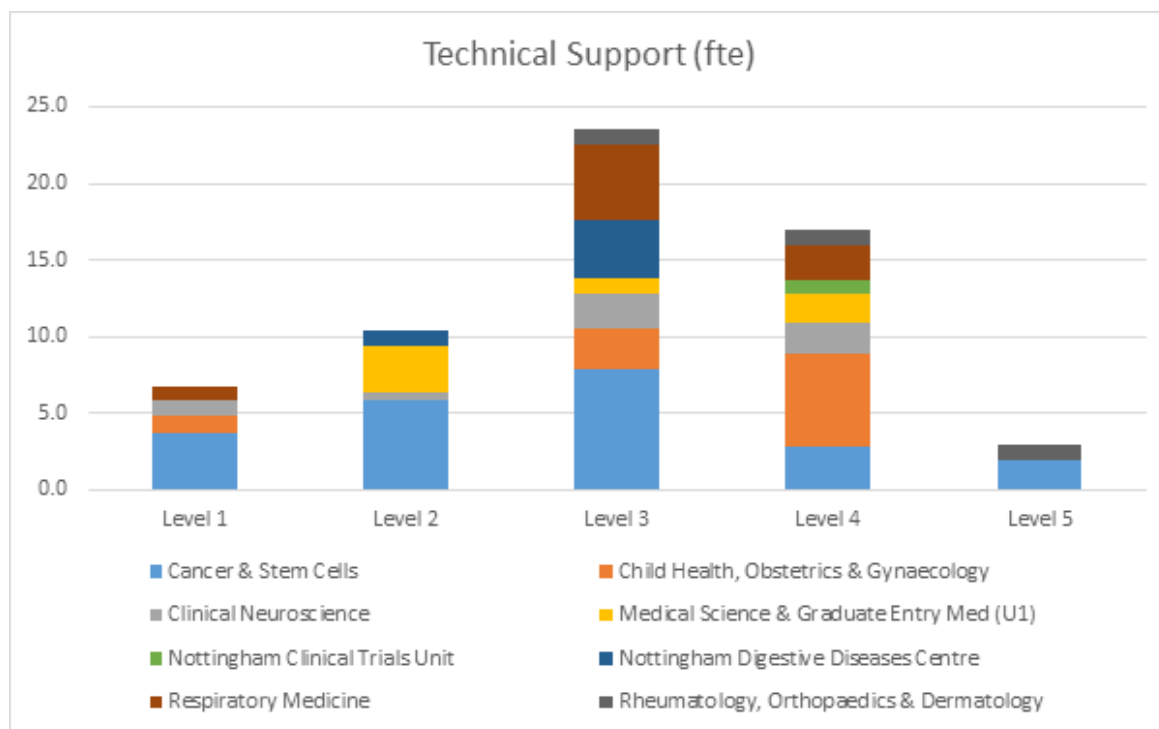


Figure 3: School of Medicine 5-year Research Strategy (2019).

3D. Infrastructure

Our Unit is located across the East Midlands and in many instances co-locates with critical NHS partners.

In 2019, a number of our Divisions/research groups, including Cancer and Stem Cells, Respiratory Medicine and Paediatric Oncology, moved into a new, purpose-built Bio-Discovery Institute (BDI) building on the University Campus (£23M) with a linked bridge to NUH NHS Trust. The BDI was built to co-locate researchers from multiple, distant sites into purpose-built space and included £1.5M of new capital equipment. Home to almost 1000 staff and PGRs, this supports and nurtures interdisciplinary working and promotes productive collaboration through shared, task-based working spaces. At the heart of the BDI is the promotion of sharing of best practice, bringing diverse groups together to succeed with joint funding bids to develop new research areas and bring in state-of-the-art equipment. The building has specialist cell culture suites, vented work areas, biomaterials formulation areas, histology, cell phenotyping, microscopy and glycobiology. It has large scale automated cell storage, multiple cold rooms, and centralised mycoplasma testing. The BDI was built with inclusivity in mind, with high levels of accessibility not only to the building and its facilities but also to specialist research equipment, for example through purchasing height adjustable MSC Class II biological safety cabinets.

Unit-level environment template (REF5b)

In March 2020 following a call from the Government, SoM coordinated (led by **Denning**) transportation of 16 Q-PCR machines (estimated value £1M including three from Nottingham Trent University) for the COVID-19 screening facility in Milton Keynes; these machines alone increased screening capacity by 20,000 tests/day, previously 5,000/day, and made up almost half of the 35 provided by ten UK universities in the first wave. This demonstrates the benefit of bringing our research together within the BDI, enabling large-scale coordination of infrastructure.

Nottingham has enhanced its historically strong position with the very latest imaging facilities in the 1500m² Sir Peter Mansfield Imaging Centre (SPMIC) which accommodates one of the few UK 7T MRI scanners. SPMIC, formed in this REF period, brings together interdisciplinary research groups from Medicine and other disciplines in a shared facility and, along with our hospital-based scanners, fosters innovative imaging research including a cross-cutting theme in our BRC across multiple specialties and diseases.

In 2014, a £7.7M award from the UK's Clinical Research Infrastructure initiative funded new medical imaging equipment including a multi-transmit upgrade on the 7T MRI scanner, new 3T MRI scanner, 0.5T upright MRI scanner, real-time magnetoencephalography upgrade, fNIRS system and an Auditory Brain Stem EEG system. This was enhanced by £1.3M of University funding for space refurbishment. A £700K award from the EPSRC Quantum Technologies Hub in Sensors and Metrology has funded the construction of a new high-performance magnetically shielded room at the SPMIC, to accelerate state-of-the-art, optically-pumped magnetoencephalography systems. In 2015, SPMIC installed the first UK dynamic nuclear polarization magic-angle spinning nuclear magnetic resonance facility, a collaboration with Chemistry and Life Sciences and funded through the Strategic Equipment Initiative of the EPSRC.

Strategic equipment purchases underpin research in the Unit. Examples include:

- £100K of equipment and antibodies for screening and early detection of Breast Cancer, an extension of the research related to Early CDT Lung and Liver (**Robertson**)
- £22K stoppering, tray, freeze fryer for research investigating a novel patented drying technique for human donor tissues in collaborative projects with our spin-out NuVision Biotherapies; the equipment enabled the researchers to identify new intellectual property and secure Innovate UK and EPSRC IKC grant funding
- £65K Finapres machine used extensively by the Kidney Research and Innovation group (**Selby/Taal**) in acute and chronic kidney disease studies directly related to patient-centred research. A Health Foundation award in 2014 allowed study of complex interventions on patient outcomes and funded the first multicentre randomised trial in this field (>20,000 patients). Demonstrating significant improvements in standards of acute kidney injury detection, care, duration, and length of stay in hospital.

3E. Digital Infrastructure

Digital Infrastructure is critical to the University (REF5a-2.1c&4.1d) and School strategic aims to enable and enhance the capabilities and achievements of our researchers, thus we have invested heavily in digital infrastructure during the REF period.

We have a dedicated Faculty Digital Research Specialist as part of the University's digital research team, bridging requirements between Information Services and research staff needs in terms of software, data collection and management, equipment, and access to High-Performance Computing (HPC) services. We have appointed two academic digital leads representing the digital needs of

Unit-level environment template (REF5b)

researchers in our Unit. The Digital Research Service also houses the Advanced Data Analysis Centre (ADAC), providing expertise and support across the fields of health data analysis and bioinformatics. ADAC manages the UKCRC Tissue Directory and Coordination Centre (TDCC) which has developed a FAIR database of samples and datasets. The lessons and approaches developed in TDCC formed the recent foundations in the Health Data Research UK (HDRUK) Innovation Gateway, resulting in an invitation from Sir Patrick Vallance to deliver the CO-CONNECT project to allow federated discovery and analysis of COVID datasets across the UK.

In 2017/18, the University invested >£600K in a new archiving service providing a managed data repository and related metadata. Supporting safe and legal storage of data we have utilised Cyber Essentials, delivering access to a government-backed accreditation to certify the highest levels of online data security and prevention against cyber-attacks, and GDPR data handling policies.

UoN invested £1.8M in 2017/18 in new HPC to expand data processing, simulation and computation across hundreds of cores, critical for the cross-cutting imaging research conducted in the Nottingham BRC. The Precision Imaging Beacon has used research grant funding to further expand the service and has a dedicated allocation of HPC use. We have invested heavily in Graphic Processing Units (GPUs) to support artificial intelligence and big data research, and to accelerate computational diffusion MRI.

We are investing in cloud bursting with Azure, enabling on-premises workloads to be cloud processed, boosting our capabilities without an increase in local hardware requirements. We have an ambitious programme for a windows-based launch of HPC services to reduce barriers of use for researchers.

We introduced the Clinical Database Support Service in 2019. This robust platform for researchers actively promotes regulatory compliance and provides specialist assistance in database design and management, and access/training for REDCAP database software.

We have future-proofed essential systems such as the roll-out of Microsoft OneDrive and Teams Cloud storage for data, supported by our Digital Research Team training. For example, the Tumour and Vascular Biology Laboratories (**McIntyre**) piloted digital notebooks, capturing all research data electronically and sharing securely. Following this highly successful pilot, the Digital Notebook scheme is now part of the University's Digital Futures scheme. Partnering with HDRUK and Microsoft, we have piloted a new clinical data exchange between NUH and UoN leading to streamlined research data handling.

3F. Future Plans

Our priorities include:

- Launching the Nottingham Joint Research Office in early 2021 between our School and NUH Research and Innovation to establish a common mechanism for developing our research strategy and prioritising joint strategic developments. This marks a pivotal step in increasing both commercial and non-commercial clinical research and trials
- aligning our infrastructure strategy with the NUH 2025-30 major infrastructure project Hospital Infrastructure Programme 2 (HIP-2 ~£1.2Billion investment), to ensure our research is at the forefront of joint plans

Unit-level environment template (REF5b)

- as the joint lead academic partner with Loughborough University, working with NUH as the NHS lead on the National Rehabilitation Centre (planned opening 2024, close to the University's Sutton Bonington campus and the new Armed Forces Rehabilitation Centre)
- diversifying our funding portfolio ensuring preparedness to respond rapidly to major funding priorities including a review of School structure (2021) to optimise cross-disciplinary research
- continuing to ensure our research infrastructure is accessible and fully inclusive
- expanding and renewing the BRC, aligning strategic priorities with industry and NHS partners
- increasing successes and leadership with 'Grand Challenges', developing ground-breaking programmes of research across multiple disciplines and stakeholders, growing collaboration with Midlands Innovation Health partners. Our response to the Coronavirus pandemic has demonstrated these capabilities
- further enhancing our world-class imaging capabilities, e.g. establishing a platform for large-scale, multi-centre clinical research in 7T MRI and spectroscopy, and investing in the enabling infrastructure (particularly HPC), taking forward the proposal as the National facility for the only UK 11.7T MRI (in advanced stage discussions with UKRI).

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

4A. Patient and Public Involvement in research

Patient and Public Involvement and Engagement (PPI/E) is at the heart of our research strategy and is proactively led by our PPI/E working group. The diverse range of active, high-quality PPI/E work across UoA1 has increased further since REF2014 ensuring our research is clinically relevant, beneficial for PPI/E members and supports buy-in from patient groups.

PPI/E partners provide input throughout our research including prioritisation of research questions, systematic reviews, management and steering committees for clinical studies, co-applicants on grants and contributing study development, design of study literature and international outcome measure initiatives. They also contribute to research training such as co-leading sessions on our Grant Writing Training programme.

We run innovative PPI/E focus groups and patient panels allowing researchers the opportunity to co-develop funding and research proposals so that they are informed by the lived experience of the health condition. On grant applications, public co-applicant partners share responsibility for the management and/or delivery of the study, and dissemination/communication. Budgeting guidance for PPI/E is provided on our PI Toolkit along with links to the Research Design Service, who also offer support and funding for PPI/E meetings during study design.

Exemplars of local engagement include:

- **Outreach activities** – working with the University and NHS partners, we believe in engaging and enthusing the local community as immediate beneficiaries of our research. Senior and early-career researchers act as role-models through PPI/E, the media, Festival of Science, Royal Society's Summer Science and through national societies; work in Widening Participation, science workshops in schools and academies and the Sutton Trust Programme; host open and taster days/work-experience for school and graduate students; participate in 'TAKE PART', community-based learning; foster and lead NHS research collaborations, mentoring NHS consultants in research; undertake undergraduate and postgraduate careers'

Unit-level environment template (REF5b)

fair “road shows”. Importantly, outreach is recognised in appraisal, workload planning and promotions.

- **Wonder** – a biannual University-wide Science one day event, with significant UoA1 presence, is open to all (typically 5000 attend) with a focus on family participation. Multiple demonstrations from our researchers including ‘How the Gut Works’ by the Nottingham Digestive Diseases Centre (NDDC).
- **Life Force Summer School** (2016) – an exciting collaboration with our NDDC (**Major**), the University Djanogly Gallery and Wellcome Trust funded artist Elpida Hadzi-Vasileva. It included an art/science exhibition of the gut with hands-on demonstrations and experiments for visitors (especially children) run by clinical scientists. It featured in The Guardian and exhibited in 2018 at the Grant Museum of Zoology at University College London.

Exemplars of local involvement include:

- **Nottingham Young Persons Advisory Group (YPAG)** – one of fifteen groups in the NIHR GenerationR Alliance national network, working across institutions with our co-located NHS partners at NUH. Examples of activity include significant YPAG input into paediatric NIHR i4i (**Marciani**) and MRC (**Sharkey**) projects.
- **East Midlands Sharebank** – innovative learning and development network for PPI in health and social care, arising from long-standing PPI initiatives in Clinical Neurosciences, and since forming the foundation of numerous NIHR programmes relating to PPI/E. It was adopted on the NIHR Involve website (2016) to share with other regions aiming to establish local Sharebanks
- **Centre of Evidence Based Dermatology’s Patient Panel and Nottingham Support Group for Carers of Children with Eczema** – longstanding partnership with carers, NHS and UoN researchers, running training events for patients/carers who would like to help with the design and conduct of skin research
- PPI/E groups enhancing our impact and dissemination include: **Nottingham Stroke Partnership group** (county wide public engagement group with national links to universities and industry); **Nottingham Respiratory Research Unit PPI/E** (established >10yrs for asthma, idiopathic pulmonary fibrosis and chronic obstructive pulmonary disease); **NDDC Patient advisory group** (longstanding >10yrs); **Dementia and Frail Older Persons PPI/E advisory panel**; **Pain Centre Versus Arthritis PPI/E group** (active part of ARUK Pain Centre and Nottingham BRC); **Nottingham Breast Cancer Research Centre** research and awareness days that attract patients, advocates, the public and media.

Exemplars of national/International PPI/E include:

- **Action for Pulmonary Fibrosis** – a patient-driven national charity established in 2013 by one of our academics (**Jenkins**), now employing 12 people and the leading UK funder in this field including two new fellowships in 2018
- **Centre for Evidence Based Dermatology** – works with national patient support groups including National Eczema Society, Eczema Outreach Support; Vitiligo Society, Psoriasis Association, The Hidradenitis Suppurativa Trust, and Pemfriends

Unit-level environment template (REF5b)

- **Centre for Evidence Based Hand Surgery** – a UoN, NUH and British Society for Surgery of the Hand partnership with a national Hand Fracture and Joint Injury Patient Advisory Group supporting development of research priorities and core outcomes, and designing clinical trials.

4B. Influencing and supporting the discipline

As early adopters of **James Lind Alliance (JLA) Priority Setting Partnerships (PSPs)**, we helped develop the JLA methodology and guidebook, ensuring our research priorities are grounded in the needs of patients and healthcare providers. We have conducted more PSPs than any other UK Institution, including dermatology (eczema, vitiligo, hidradenitis suppurativa, cellulitis, lichen sclerosis, hyperhidrosis, psoriasis, bullous disease); orthopaedics (hand surgery, foot and ankle surgery); respiratory (cystic fibrosis and COPD) and perinatal medicine (miscarriage and preterm birth). **Thomas** and **Smyth** sit on the national JLA Advisory Board.

Our PSPs have delivered significant impact resulting in commissioned funding calls from the NIHR HTA and EME as well as NIHR cross-programme calls in Cystic Fibrosis. They have guided the research agenda globally and resulted in several successes for our researchers with investigator-led proposals, for example studies/trials in dermatology and preterm birth. JLA priority setting is now embedded in Divisional Research Strategies aligning with our **Encouraging Partnerships** research strategy.

We lead international **core outcome sets**, ensuring global collaboration on what should be measured (and how) in clinical trials. These have improved research efficiency through international standardisation of clinical trials, enabling results to be synthesised in meta-analyses. Our core outcome sets include eczema, lichen sclerosis, vitiligo, cystic fibrosis, upper limb fractures, children's fractures, hand fractures/joint injuries, and rare diseases such as ataxia-telangiectasia. We have been influential in driving core outcome set methodology (**Thomas/Williams**), leading an initiative to provide methodological support for developers through the Cochrane Skin Core Outcome Set Initiative (CS-COUSIN), which currently supports 17 international core outcome sets.

Contributions to Science/Funding Leadership	
International	<p>Swedish Research Council (Thornton, Chair), Global Alliance for Medical Excellence (Atherton, Steering Group Member), Cochrane Skin (Boyle/Williams, Editorial Base), US Lymphangioliomyomatosis (LAM) Foundation (Chair) and National Centre for LAM (Director)(Johnson), Cochrane Cystic Fibrosis and Genetic Disorders (Smyth, Co-ordinating Editor), United European Gastroenterology (Atherton, Secretary-General and Scientific Committee Chair), European Commission Medical Devices and In-vitro Diagnostic Medical Devices (Marciani, Member), International Children's Brain Tumour Drug Delivery Consortium (Walker/Rahman, Chair/Deputy Chair).</p> <p>Numerous boards of the EU FP7, National Science Foundation (US), Research Councils in Norway, Finland, Hong Kong, Singapore, USA and Kuwait, and European charities.</p>

National	<p>HTA Commissioning Board (Williams, Chair), MRC Clinical Training Panel (Hall, Chair), UK Trial Managers Network (Mitchell, Chair), NC3Rs Knowledge Transfer Panel (Denning, Chair) and NC3Rs Board (Denning), HTA Programme (Williams, Director), Scottish Senior Clinical Fellowship Panel (Hall, Chair), COVID-19 Rapid Research Panel (Williams), Coeliac UK Research Board (Perkins, Chair), NIHR Strategy Board (Williams/Hall), Medical Schools Council UK (Atherton, Lead Chair), British Thoracic Society (Jenkins, Chair Science/Research Committee), UK Children's Cancer and Leukaemia Group (Grundy, Chair), Society of Academic and Research Surgery (Lobo, President-elect), British Renal Society (Taal, President), Royal College of Anaesthetists (Mahajan, President).</p> <p>Numerous boards/panels for the MRC, NIHR and HTA, for Charities including Wellcome Trust, Cancer Research UK, Asthma UK, Arthritis Research, British Heart Foundation, NC3Rs, Stroke Association, Wellbeing of Women and Action on Hearing Loss.</p>
Contribution to Science Engagement/Communication	
Journal Editorships	58 of our REF-eligible researchers have served on editorial boards and 12 as Editors/Editor-in-Chief including Thorax, British Journal of Anaesthesia and European Journal of Obstetrics and Gynaecology.
Other Research Excellence Indicators	
Learned Society Membership/ Senior Fellowships	<p>New Fellowship of the Academy of Medical Sciences include Williams (2014), Bath (2016) and Hall (2019).</p> <p>NIHR Senior Investigators appointments: Williams-reappointed (2012) and Emeritus Senior Investigators (2017); Bath-reappointed (2016) and Emeritus Senior Investigator (2020); Hall (2018); Knox (2019); Jenkins-NIHR Research Professorship (2018).</p>
Notable Award/Prizes/ Lectures	<p>During REF2021 period:</p> <p>CBE, Queens Birthday Honours (Dua); President's Award British Association of Stroke Physicians (Bath); Presidential citation American Academy of Dermatology (Williams); Association of Anaesthetists' Foundation Award and the RCoA Mackintosh Professorship (Moppett); British Society of Neuroradiologists du Boulay Professorship (Dineen); Dr Robert Grayson Award, British and Irish Hypertension Society (Appleton); Lady Estelle Wolfson Lectureship in Translational Medicine (Madhusudan); Brain Tumour Charity's Discovery Award (Walker); Sir Archibald Gray Medal, British Dermatology (Williams); William M Feinberg Award, American Stroke Association (Bath); Archibald Pitcairne Medal (Gordon); United European Gastroenterology Lifetime Achievement (Hawkey); European Respiratory Society Gold Medal (Jenkins); Oliver Wrong UK Prize Translational Nephrology (Glover); AXA PPP Health and Tech Award (Shaw); Sven Helleström Memorial Lecture Medal (Williams); F1000 Member of the Year Physiology and Outstanding member of the year (Symonds); Presidents Medal, British Division of the International Academy of Pathology (Ellis);</p>

	<p>Jacques Duparc Prize, European Federation of Orthopaedic Associations (Ollivere); Pathological Society of Great Britain and Ireland Ritchie Medal (Ellis); EM NHS Leadership Academy Innovator of the Year (Patel); EM AHSN Innovation in Healthcare Awards (Patel); LAM Foundation Scientific Advancement Award (Johnson); Rotary International, Global Alumni, Service to Humanity (Dua); Times Higher Education Award, Research Project of the Year (Dua); St. John's Dermatology Society Oration Medal (Williams); Kanski Gold Medal Lecture (Dua); National Representative of the Year, International Society of Geriatric Oncology (Cheung); British Neuro-Oncology Society YI (Rahman); Norman Williams Prize Winner (Acheson); NHS Innovation Challenge Prize Winner (Aithal); HSJ Value Award Winner (Aithal); British Society of Gastroenterology Service Prize (Aithal); Jan Waldenstrom Prize, Swedish Oncology Society (Durrant); Lifetime Achievement Award, European Society of Neurogastroenterology and Motility (Spiller); BCRF-Larry Norton Award, International Society of Breast Pathology (Ellis); Lifetime Contribution Award, Shine Charity (Bayston); Tony Mitchell Memorial Medal (Bayston); 50th Anniversary Heart Research UK award: Outstanding Researcher (Denning); National Programme Director of the Year (Ollivere)</p> <p>Team Awards:</p> <p>HeadSmart (Walker)-reducing diagnostic time of brain tumours in children, multiple awards including: National Lottery Awards Best Health Project 2017, AMRC Science Communications Award 2014 BMJ Highly Commended Dermatology Team of the Year Award; Shire Award in Gastrointestinal Excellence (SAGE) National Award; BMJ Gastroenterology Team of the Year Finalist 2015; NuVision Biotherapies Ltd (founder Hopkinson), Medilink EMs Business Awards Innovation Award (2015), Start-Up (2017) and 'One to Watch' (2019); SurePulse Medical Ltd (founder Sharkey), Medilink EMs Awards: Best Start-up (2018) and Innovation Award (2019), runner-up UK final, Innovation Award (2019)</p>
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Other notable fellowships:

Guha was one of the first cohort of 17 fellows under the NHS National Innovation Accelerator programme allowing development and adoption (NICE 2016) of his non-invasive liver fibrosis assay and care pathway. Now commissioned by the NHS, it is estimated it could save £406M per year in the UK if combined with current pathways; **Mistry** won a prestigious 4-year BHF intermediate basic science research fellowship (2015-19); **Watkins** won a BBSRC New Investigator Award (2017); our researchers also hold numerous NIHR, MRC, Wellcome Trust and Charity fellowships.

4C. International relationships

UoN is proud of its international reach and global connections (REF5a-4.1c), with campuses in Malaysia and China, and global offices and collaborations. To further enhance collaborations, we appointed a new role of **Global Engagement Lead** in 2015 to promote, monitor and increase international engagement. We are an active member of the Universitas21 Health Sciences group which facilitates research exchanges and collaborations for students and staff and of the Global

Unit-level environment template (REF5b)

Alliance of Medical Excellence which co-ordinates research and education across 9 leading global universities. For our research outputs, 49% of authors are international collaborators.

In 2016, UoN launched an initiative to address major public health challenges in China through research, education and training. Nottingham Health China facilitates interactions between UK and China-based researchers and clinicians, providing high-quality programmes tailored to China's healthcare sector, engaging with the government and Chinese private sector. Our new **Nottingham Health China Institute**, launched in 2018, enables cross-campus multi-disciplinary work in evidence-based healthcare both in China and the UK. We have launched the **Grading of Recommendations Assessment, Development and Evaluation (GRADE) Centre** in Ningbo to provide expertise on clinical guideline writing in China and internationally. This is only the 10th GRADE centre in the world and includes the Centre for Health Economics, the Computer Science/Big Data Centre, further health technologies and healthcare management and leadership.

Our researchers are well represented in the University's Asia Expertise Guide as part of the **Asia Research Institute**, which brings together our world-leading research and expertise concerning the major sustainable development challenges in Asia. Examples include exploring respiratory health (**Hall**) and household pollution (**Bolton**) in Nepal.

Established international collaborations: USA (Duke and Columbia Universities: **Aithal**, FDA: **Marciani**), Europe (Innovative Medicine Initiative: **Aithal**, Karolinska University and Denmark: **Humes, Thornton**), India (**Aithal, Monaghan, Smyth, Ojha, Mitchell**), Ethiopia (**Robinson**), Thailand (**Grabowska, Gaston**), USA/Canada/Spain (**Symonds**). The Nottingham Stroke Trials Unit lead and participate on international trials - Australia (**Anderson**), USA (**Saver**), Global (**ENOS trial, Bath**), Europe/Australia/NZ (TARDIS trial, **Bath**), Europe/Malaysia (TICH-2, **Sprigg**). The Cochrane Group (edited by **Smyth**) has editors in three continents.

Nottingham-Indonesia Collaboration for Clinical Research and Training: launched in 2019 (**Ilyas/Mukherjee**), fosters training and research collaborations with Indonesian institutions. Knowledge exchange is a key aspect of this collaboration, with our researchers training academics from institutions in Yogyakarta. The consortium advised authorities in Indonesia supporting their national management of COVID-19, focusing on increasing the capability of PCR-based diagnostic testing. The group has been highly successful, receiving seed funding from the Islamic Development Bank to establish a spin-off company, PathGen Diagnostik Teknologi, to implement low-cost molecular diagnostic platforms in Indonesia.

International Network of Chronic Kidney Disease Cohorts: **Taal** serves as a core team member, a committee of the International Society of Nephrology, which leads collaboration between 25 cohort studies of kidney disease in 19 countries. This has led to published outputs on blood pressure control and outcomes.

NCTU international project lead: for example POSNOC, axillary treatment in early-stage breast cancer (Australia/NZ); EXPONATE and STEPCARE, management of depression (Nigeria); AIMS, miscarriage management (Africa, Pakistan); Global Challenges Research Fund (Kenya, India); iCord (India, Pakistan, Uganda, Kenya).

Rheumatology, Orthopaedics and Dermatology: collaborations with large database studies (e.g. National Health Insurance Research Database includes the entire population of Taiwan, >23M); systematic reviews and meta-analyses, and large epidemiological studies of osteoarthritis (China).

Unit-level environment template (REF5b)

Cancer and Stem Cells: Cholangiocarcinoma, two Newton Grants (**Grabowska/Gaston**) and four research fellowships with Thailand.

Children's Brain Tumour Drug Delivery Consortium (CBTDDC): international Priority Setting project led by our researchers (**Walker/Rahman**) with collaborators in UK (King's College, Institute of Cancer Research, Bristol, Glasgow, Newcastle, UCL), USA (John Hopkins, Maryland, Boston), Netherlands and Pharma. They are leading the world accelerating the development and translation of drug delivery systems that target brain cancer and disease.

Collaborative Liver Networks: Our NDDC researchers' co-lead/partner on several large projects including European Cooperation in Science and Technology (**Aithal** vice-chair), Horizon 20/20 EU Liver Screen Project (**Guha** Co-PI, €6M 2020-25), TransBioLine (**Aithal** deputy project coordinator, €28M) and LITMUS (**Aithal** partner, €32M).

International Cochrane Groups: in **Cochrane Skin** and the **Cochrane Cystic Fibrosis and Genetic Disorders Group (CF&GD)**. Hosted by our Centre for Evidence-based Dermatology and with collaborators in all five continents, the editorial base for **Cochrane Skin** produces systematic reviews to improve the treatment of skin diseases with NIHR infrastructure funding (£700K over 5 years). Our researchers sit on Cochrane's Council Editorial Board (**Boyle**). Cochrane UK recently identified 52 guidelines published between 2017 and 2019 that cited Cochrane Skin reviews, including the National Institute for Health and Care Excellence (NICE), the Ministry of Health Malaysia, the American Academy of Dermatology, and the European Academy of Allergy and Clinical Immunology. The **CF&GD** Group is supported by a NIHR infrastructure grant (£800K over 5 years, **PI Smyth**) and has 192 current reviews on the Cochrane Library, 38 cited in recent NICE guidance.

4D. National collaborations and beneficiaries

We work in partnership with other Universities as lead and co-applicant to combine our areas of international excellence and collaboration. Key regional partners include Birmingham (formalised link between Universities), Leicester and Loughborough. Our musculoskeletal group has been particularly successful with these partners: MRC/ARUK Musculoskeletal Ageing Centre with Birmingham. Other examples of high level partnerships include: Imperial College London (UK Regenerative Medicine Platform MRC/BBSRC/EPSRC, £4.6M to Nottingham; BHF initiative on stem cell therapy in cardiac disease "Mending Broken Hearts", £7.5M); Exeter Control Engineering Department (MRC/EPSRC £1.5M for respiratory modelling); Birmingham CTU (several trials including FoxTRot - Fluoropyrimidine, Oxaliplatin and Targeted-Receptor pre-Operative Therapy for patients with high-risk, operable colon cancer); Leicester (UK BiLEVE study, MRC and SpiroMeta consortium for large-scale genome-wide association studies of lung function); and Loughborough and Keele (EPSRC Doctoral Training Centre for Regenerative Medicine, for training engineers and physical scientists to research regenerative medicine).

We lead on a number of national biobank initiatives including: one of four core centres comprising the National Breast Cancer Biobank; the first large scale user of the UK National Biobank (for asthma genetics, MRC £3.4M); and the first UK national biobank for kidney diseases in collaboration with Kidney Research UK.

We are partners in Midlands Innovation (Health), a collaborative network of Midlands Universities (Leicester, Birmingham, Loughborough, Warwick, Keele, Aston and Cranfield), sharing expertise

Unit-level environment template (REF5b)

and equipment. We are a central co-ordinator of Midlands Health Alliance which brings together the three Midlands NIHR BRCs – Nottingham, Birmingham and Leicester - and other NIHR bodies.

We are a lead academic partner on the National Rehabilitation Centre (with Nottingham University Hospitals as NHS lead) and proposed National facility for the UK's first 11.7T MRI scanner.

We have strong partnerships with the NHS and NIHR Clinical Research Network particularly through the Nottingham BRC. For example, Respiratory Medicine has excelled in this where investigators are key members of national/international groups for interstitial pulmonary fibrosis and COVID-19 (**Jenkins**), COPD and rehabilitation (**Bolton**), lymphangioliomyomatosis (LAM) and tuberous sclerosis (**Johnson**), pandemic flu (**Lim**) and hypertension (NICE, **Glover**). The Division's expertise and responsive team has allowed leading roles in National priorities such as Genomics England Clinical Interpretation Partnership (GeCIP) and the £8.4M NIHR/UKRI PHOSP-COVID study. Our researchers (**Lim/Juszczak**) were core members of the RECOVERY trial demonstrating dexamethasone treatment reduced death by one-third in COVID-19 saving an estimated 12,000 lives in the UK and 650,000 globally up to December 2020.

4E. Industrial collaborations

Through our School embedded Business Engagement and Innovation Services Executives, we have capitalised on opportunities created from our investments. Our thriving industrial collaborations include Innovate UK funded digital pathology networks, Google funded AI programs in pathology, and successful spin out companies (Scancell, Exonate, SurePulse Medical, NuVision, Platelet Solutions). Industrial partners include GE Healthcare and Merck (**Raine-Fenning**); Amgen (**Mistry/Kurlak**); Hamilton-Thorne Parallabs (**Maalouf**); Innovate and Renshaw (**Grundy**); Danone, Nutricia and Biotekna (**Symonds/Budge**); SurePulse, ParAid and Jaguar Land Rover (**Sharkey**); EryDel (**Whitehouse**); Vertex and Corbus (**Smyth**); River D (**Williams**) and Phagenesis (**Bath**). Our respiratory researchers have significant industry funding and collaboration based around specific projects in lung fibrosis (CRAFT consortium with GlaxoSmithKline (GSK)) and Galecto (**Jenkins**), asthma (AstraZeneca, **Harrison**) and translational genetics (GSK/Boehringer, **Hall/Sayers**). Four of the six BRC themes led by UoA1 have secured £11.7M of collaborative industrial funding since 2017.

As leading partners in the Midlands Health Alliance and Midlands Innovation Health we help connect the UK's largest cluster of MedTech companies (£1.6Bn into UK economy) with the medical research strengths of seven Midlands universities to drive world-class health research and skills development. The Midlands Engine (Health) links this with national partners (Department for Health and Social Care, the Office for Life Sciences, UKRI, including Innovate UK, NIHR, and the Department for International trade) to attract international collaboration and funding.

The University has an active Technology Transfer team who support industrial collaborations, knowledge transfer and intellectual property commercialisation. Dedicated internal and external funding streams accelerate these activities allowing commercialisation of discovery science into healthcare to improve patient care. The Division of Child Health, Obstetrics and Gynaecology have helped deliver clinical impact through collaboration on medical devices. The Monica fetal ECG monitor, based on collaboration between the Faculty of Engineering and our obstetric researchers, grew from a University spin-out company and is now used throughout the world, and was recently acquired (2017) by GE Healthcare. The team won the prestigious Colin Campbell Mitchell Award from the Royal Academy of Engineering (2019). Working with the same UoN engineering team, our researchers have developed a patented newborn resuscitation device; formed a University spin-out

Unit-level environment template (REF5b)

company SurePulse Medical (2014); attracted over £2.5M of joint research funding (including £1.41M Innovate UK in 2015) and substantial private investment (including £615K UoN); won multiple awards; and is an SME with ten employees including four UoN doctoral graduates.

4F. Collaboration across the University

We have interdisciplinary collaborations across all faculties particularly with Life Sciences, Chemistry, Mathematics, Engineering and Physics. Specific initiatives include: two supervisor PhD model (encouraging one from outside the School); a leading role in the Precision Imaging interdisciplinary Beacon; and cross-disciplinary workshops and pump-priming sandpits. This strategy has allowed us to build on our strengths. For example, NDDC partnered with Physics to win MRC funding for non-invasive imaging of gastric function in functional dyspepsia; NDDC and virology were awarded a Chief Medical Officer priority funding call for a community-based study to detect early liver disease.

Collaborations with Physiology, Imaging and Clinical Psychology resulted in the ARUK National Osteoarthritis Pain Centre (£2.5M). The Centre for Healthcare Technology brings together engineers, scientists and healthcare professionals across the University, NHS, industry and the wider research community.

The UoN-based East Midlands Academic Health Science Network (EMAHSN), is a key collaborator bringing University driven innovation to the NHS, supporting our focus groups and grant workshops. EMAHSN also works with our innovative spin-out companies such as NuVision, delivering amniotic membrane derived dry matrices for wound care.

The NIHR East Midlands Collaborations for Leadership in Applied Health Research (CLAHRC), awarded £10M of funding from the Department of Health joint with the University of Leicester (2014-2019), has attracted a further £18M of matched funding from local NHS, academic and commercial partners to translate research findings into improved outcomes for patients. The CLAHRC has delivered world-class research and capacity building in the East Midlands with its 60 partners across the NHS, Universities, local government, industry and the voluntary sector. The NIHR approved funding for our Applied Research Collaboration (ARC, 2019-24, joint with Leicester) to follow on from the CLAHRC.

Our CLARHC has created several excellent networks and centres of research that support innovative research and researchers, including large-scale data science and the Ageing Network. Our CLAHRC Faculty has over 300 members including the East Midlands Clinical Academic Practitioner Network. Collaborative CLAHRC achievements include:

- 82 research projects with over 8,500 participants
- 150 PhD students and 150 other postgraduate programmes
- over 500 peer reviewed publications
- more than £22M in matched partner funding
- over £54.7M in external funding, including from industry partners
- delivered over 360 courses in research methodologies, evidence-based care, service evaluation and implementation methods
- hosted learning events for over 12,600 people

Unit-level environment template (REF5b)

- full/part-funded over 80 PhDs and 7 postdoctoral fellowships.

4G. Category C staff

We have an outstanding group of Category C staff of predominantly honorary members who foster long-term research collaborations and allow joint grants and PGR supervision. Our Category C staff can transition between UoN and NHS partners, e.g. **Gran** was a Clinical Associate Professor at UoN and returned to full-time clinical work in NUH, retaining Honorary Clinical Associate Professor status with 109 research outputs held in our UoN repository; **Major** was an NHS Honorary Clinical Associate Professor but in 2019 transferred to full-time employment in our Unit as part of the BRC. We support Category C staff pursuing research career paths, e.g. we have supported three colleagues achieve successful MRC Clinical Academic Research Partnerships awards in 2019, a further eight were submitted in 2020 (outcome pending).

Examples of contributions to our research are shown in two Impact case studies with **Lim**, a member of our BRC, through his work on UK vaccines and the ASAP pandemic-readiness work which has impacted on COVID-19 outcomes, and is on the national steering group for the RECOVERY trial with Nottingham one of the leading recruiters nationally. Honorary Professor **Moran** collaborated with UoA1 researchers **Ollivere** and **Moppett** on research which created a National Hip Fracture Database and Scoring system, changed national policy (including NICE guidelines and quality standards), the development of an integrated care pathway, and the introduction of a Best Practice Tariff for hip fracture patients implemented in every hospital in England, developed in 2019 to include all femur fractures.