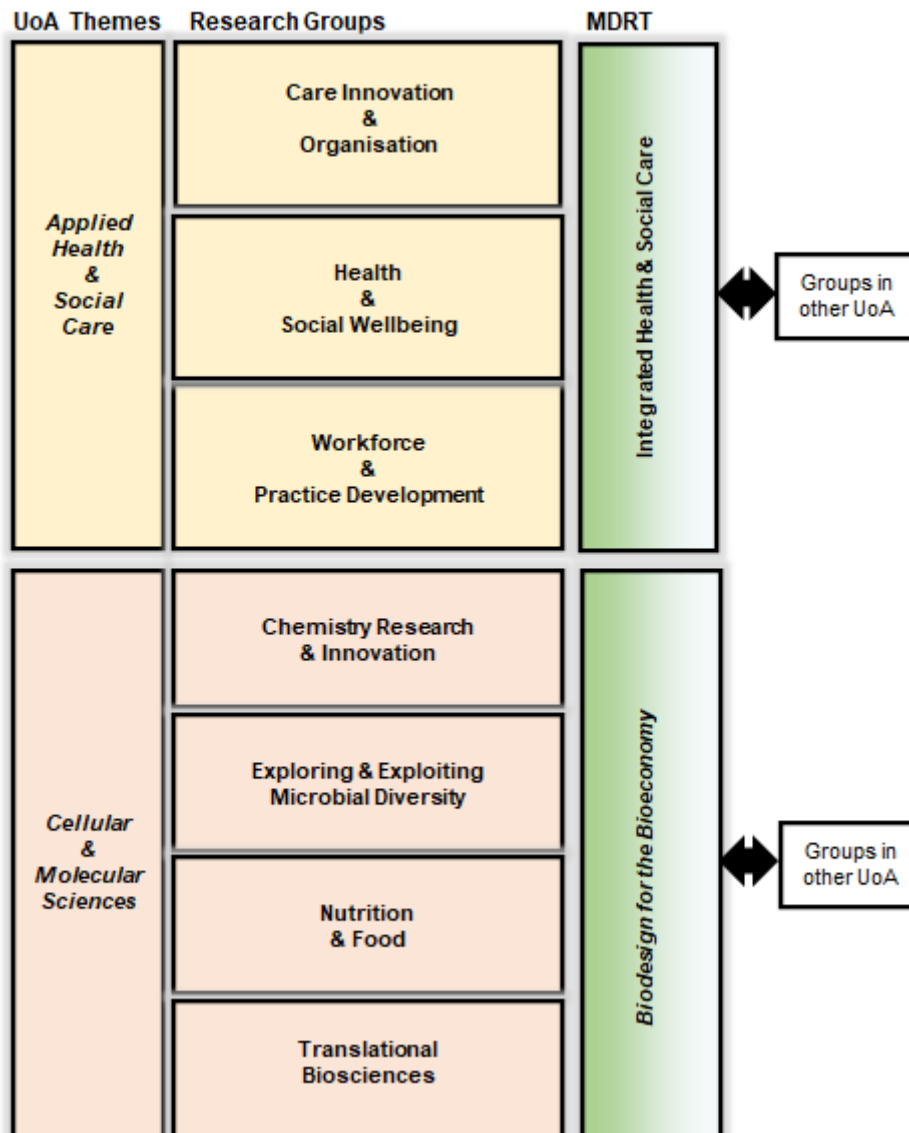


Institution: University of Northumbria at Newcastle
Unit of Assessment: UoA 3 Allied Health Professions, Dentistry, Nursing and Pharmacy
<p>1. Unit context and structure, research and impact strategy</p> <p><u>Organisation of Northumbria's UoA3 research</u></p> <p>Our REF2014 submission to UoA3 was significant in terms of both size (44.2 FTE) and quality (Grade Point Average 3.12), placing the submission in the top quartile by research power (21st of 94). This has since been matched by vigorous growth to 123.5 FTE (129 staff) and sustained success in the current REF period, as detailed below.</p> <p>As in REF2014, this submission is drawn from a wide discipline base, primarily in the Faculty of <i>Health & Life Sciences</i>, with a spectrum of activities ranging from laboratory-based sciences (at Northumbria's City campus) to nursing, health and social care research (at our Coach Lane campus). This is reflected in the organisation of our research into two over-arching areas: <i>Applied Health & Social Care (AH&SC)</i> and <i>Cellular & Molecular Sciences (C&MS)</i>. The following research groups sit within each of these, with significant cross-group collaboration and inter-disciplinary activity (Figure 1).</p> <p><i>Applied Health & Social Care (63.6 FTE)</i></p> <ul style="list-style-type: none"> • <i>Care Innovation & Organisation (18.8 FTE)</i> • <i>Health & Social Wellbeing (24.6 FTE)</i> • <i>Workforce & Practice Development (20.2 FTE)</i> <p><i>Cellular & Molecular Sciences (59.9 FTE)</i></p> <ul style="list-style-type: none"> • <i>Chemistry Research & Innovation Group (11.8 FTE)</i> • <i>Exploring & Exploiting Microbial Diversity (20 FTE)</i> • <i>Nutrition & Food (11 FTE)</i> • <i>Translational Biosciences (17.1 FTE)</i> <p>Two of the University multidisciplinary research themes (MDRT, REF5a) complement and underpin these two areas (Fig. 1): <i>AH&SC</i> staff contribute to the <i>Integrated Health & Social Care</i> MDRT (Lead: Lhussier) and <i>C&MS</i> staff to the <i>Biodesign for the Bioeconomy</i> MDRT (hereafter <i>Bioeconomy</i>; Lead: Black). The research groups provide focus, leadership and staff support, whilst the MDRTs serve a broader purpose in fostering collaboration between staff in different disciplines and providing infrastructure to deliver impactful work addressing key societal challenges.</p>

Figure 1. Relationships between organisational units supporting research in UoA3

The web of collaborations within and between research groups is not depicted. **AH&SC** is primarily based within the closely integrated Departments of Nursing, Midwifery & Health, and Social Work, Education & Community Wellbeing; **C&MS** is based in the Department of Applied Sciences.



AH&SC research represents substantial growth and intensification of the 'Health & Lifestyle' area from REF2014, having broadened into three interlinked collaborative research groups that reflect the reality of health and social care. Notably, the **63.6 FTE in AH&SC are a 6.8-fold expansion** on the *Nursing & Public Health* group returned in REF2014 (9.3 FTE), senior staff from which have led the development of the *Health & Social Wellbeing* and *Workforce & Practice Development* groups. Moreover, strategic staff appointments have allowed the establishment of the *Care Innovation & Organisation* research group, with 14.8 new FTE staff appointed since 2014. Staff

affiliated to other 'Health & Lifestyle' sub-groups in REF2014 are now returned to UoA4 and UoA24, reflecting the strategic development of research in these UoA.

C&MS has built upon the strengths in this area that were evident at REF2014, with **2.3-fold growth in staff to 59.9 FTE**. The cell biology, chemistry and microbiology groups returned in REF2014 have grown into mature research groupings, whilst targeted recruitment (8 FTE) has established critical mass in *Nutrition & Food* research, reflecting our REF2014 plan to focus on nutritional interventions and microbial ecology (microbiomes). Investment via our *Bioeconomy* MDRT has enhanced our 'multi-Omics' infrastructure (section 3), as planned at REF2014.

Achieving our strategic goals for 2014-2020

Overarching strategy

The expansion of research and impact in this UoA during the assessment period has been driven by both the **Northumbria 'Power with Quality' strategy** (REF5a 2.1) and the UoA3-specific aims and objectives defined at REF2014. Central to this was the aim to expand the research base and impact through "**investment in and development of our people, estates and external engagement**", which we achieved as follows:

1. An effective people strategy as detailed in Section 2. This submission is **2.8-fold larger** than that to REF2014, reflecting substantial growth in research intensity in both overarching areas, particularly **AH&SC**, demonstrating the success of our ambition to build an inclusive, broad-based high quality research community. This was achieved by combining:

- a) The *development and retention* of research active staff, including mentoring, training programmes; fair and effective reward and promotion schemes; and upskilling of staff through in-service doctoral study. 22 staff are returned here that were in post but not included at REF2014, reflecting the successful enhancement of their research activity, whilst all 30 staff who were submitted to UoA3 in REF2014 and remain at Northumbria are again submitted, nine of whom have been promoted since 2014.
- b) The recruitment of high calibre staff with strong strategic fits to the research groups (Fig. 1). **82 of 129** staff in the UoA have been appointed since 2014, thus **transforming our profile**, including **16** at Associate Professor and Professor to **strengthen leadership** and **15 Vice Chancellor's Fellows** (VCF, REF5a 2.2) and other ECR to **invest in potential**. Our ability to attract these strong researchers reflects the reputational growth of Northumbria since REF2014.

This strategy has been underpinned by a targeted average workload allocation of **40% of academic staff time dedicated to research**. Strengthened leadership within our research groups by increased numbers of senior appointments has improved staff mentoring and helped identify discipline-specific challenges and opportunities, including targeting external funding applications. The academic staff have supported a strong postdoctoral and postgraduate researcher (PGR) community, including in-service doctorates: **136 doctoral degrees** have been awarded in the assessment period, a **1.5-fold increase on REF2014** (19.4 versus 13.2 per annum [p.a.]), supported by university QR investment in studentships (REF5a 2.2; section 2 below).

Our increased vitality and productivity are further evidenced by steady growth in annual UoA3 scholarly outputs to ~250 p.a. (total >1600 2014-2020), with **40% in the top quartile of most-cited publications** (field-weighted; average annual **field weighted citation index 1.6**).

2. Estates and infrastructure investment as detailed in Section 3. Research group leads and senior research staff co-ordinate requests for faculty and university capital support, and other research investment (e.g., MDRT funding). Facilities development has been driven the need to house increased numbers of laboratory-based staff and by university commitments to matched support for major externally funded projects (Section 2). Overall, **>£3 million** have been invested strategically in infrastructure, particularly in our multi-Omics platform and the Clinical Skills Centre (section 3).

3. External Engagement as detailed in Sections 3 and 4. Staff returned in this UoA have attracted **>£21 million** in external research grant income. Research leads have supported staff to focus their funding applications via our **“4Ps approach”** outlined in Section 3. We have strengthened academic and administrative support to help staff prioritise their activities and enhance research grant application quality, value and volume for staff at all levels (section 2) and have improved mechanisms to develop and sustain extensive national and international partnerships with academic collaborators, health-related and pharmaceutical industries, services, practitioners and service users (section 4).

Specific Objectives and Achievements of the Research Groups

AH&SC

AH&SC research is inherently interdisciplinary and collaborative. Building on the REF2014 plan ‘to promote knowledge exchange...to advance the boundaries of methodology’, we have built critical mass in diverse methodological expertise and innovation, with significant development of leadership through a combination of promotion and **twelve senior appointments**.

- *Highlight:* staff from all three research groups were crucial to the successful collaborative application for £9 million (£438K to Northumbria) NIHR Applied Research Collaboration North East and North Cumbria funding (**ARC NENC**, <https://arc-nenc.nihr.ac.uk/>). Northumbria are a significant HEI partner, with our staff leading or co-leading programmes on *Implementation, Inequalities and Evaluation*.

To further enhance the delivery of our REF2014 aims we have explicitly invested in:

- Health Economics: senior (**McMeekin**) and early-career appointments (**Bate, McCarthy**) supporting development of priority-setting tools and cost-effectiveness research, complemented by growth in biostatistics research (**Lin, Ogundimu, Pakpahan**).
- Implementation science: senior (**Finch, Rapley**) and early-career appointments (**Potthoff**), internationally known for Normalisation Process Theory work (<http://www.normalizationprocess.org/>).

The *Health & Social Wellbeing* group (Leads: **Carr** and **Cook**) has achieved our REF2014 aim of extending established work in health improvement, transformation of health and social care services, alongside improving quality of life of the ageing population. Staff have expertise in Nursing, Health Services, Public Health, Realist research, Social & Environmental Gerontology and Sociology research to understand people's experiences of health, engagement with care services, welfare and wellbeing. We have broadened our activities to include exploring the experiences of older people, people with disabilities, long-term conditions and at end of life, delivering user-informed innovations and interventions. Staff also undertake a range of work in health inequalities including welfare and welfare advice, alcohol/substance use and marginalised groups, notably military veterans and Traveller communities.

- *Highlight:* Development of the *Northern Hub for Veterans and Military Families Research* (**Kiernan, Hill** and colleagues) with >£1.7 million funding from the Armed Forces Covenant Fund, Ministry of Defence, the Royal British Legion and others.

The *Workforce and Practice Development* group (Leads: **Clarke** and **Steven**) has evolved from our REF2014 ambition to address workforce issues and influence professional practice. The group draws together diverse disciplinary expertise, including Allied Health Professions, Education, Medical Education, Nursing, Midwifery and Sociology, to drive transformation in workforce education, training and practice development to enable health and social care staff to meet shifting societal needs and respond to the changing professional landscape. Studies undertaken range from scoping knowledge, skills and competencies for new roles, to developing knowledge and theory of learning processes and novel pedagogical approaches, promoting safe and effective

practice in regional, national and international contexts. The group also focuses on understanding and developing specific roles and services, including health visiting and midwifery, the mental health workforce, sexual health workers and palliative care.

- *Highlight:* Five country EU-funded *Shared Learning from Practice for Patient Safety* (SLIPPS) project (€435K total, **Steven**), a collaboration between health providers and HEIs, investigates student experiences and is developing tools and resources to support student learning about patient safety.

At REF2014 we planned to develop interventions for long-term conditions and have expanded this aim by creating a *Care Innovation & Organisation* group (Leads: **Finch** and **Rapley**) which focuses on understanding, innovating, evaluating and effecting change in care organisation and provision. Formation of this novel group has been driven by significant staff recruitment (14.8 FTE, including four Associate Professors and three Professors). Our approaches range from the development of novel ideas, to feasibility studies, pilot and full trials, and scaling up/out of evidence-based interventions. Staff have expertise in Biostatistics, Health Economics, Health Psychology, Medical Sociology, Nursing, Occupational Therapy and Physiotherapy. Research includes developing innovative, practical care and organisational solutions, with and for people with various health conditions, including long-term musculoskeletal and neurological conditions. The group is internationally recognised for leadership in implementation and improvement science.

- *Highlight:* EU-funded ImpleMentAll project, €6M total (<https://www.implementall.eu/>) for implementation of internet-based cognitive behavioural therapy across primary, secondary and community healthcare, in nine countries.

C&MS

As planned at REF2014, multidisciplinary research in this area has benefitted from significant investment in the **strategic development of a multi-Omics platform** integral to **C&MS** research, i.e., genomics/metagenomics (next generation sequencing), metabolomics and proteomics (mass spectrometry) technologies (section 3), supported by associated staff (**Scientific Officers**, section 2) who provide expert theoretical and practical support to users.

- *Highlight:* £8 million Research England 'Expanding Excellence in England' funding to develop a **Hub for Biotechnology in the Built Environment (HBBE, 2019-2022)**, a novel interdisciplinary 'bio-design' grouping led by **Black** and **D Smith**, with Zhang [UoA12] and Newcastle University (<http://bbe.ac.uk/>). The **HBBE** brings together staff with expertise in biotechnology, chemistry, microbiology and molecular biology to interact with architecture,

design and materials researchers to create a 'next generation built environment', including manipulating the *building microbiome*, in order to promote health, wellbeing and environmental stewardship.

The *Chemistry Research & Innovation Group* (Lead: **Perry**) has grown through the recruitment of five ECR (and five additional FTE returned in other UoA). As planned at REF2014, research in analytical chemistry has focussed on analysis of environmental hazards, forensics and mass spectrometry. Synthetic chemistry has focussed on diagnostic methods, medicinal chemistry and biotechnological applications. These include the development of enzyme substrates for microbiological diagnostics (more than two decades of collaboration with bioMérieux) and the synthesis of novel antimicrobial/medicinal compounds. This work is inherently collaborative, with strong links to other **C&MS** staff and externally.

- **Highlight:** UKRI Future Leaders Fellowship "Forens-OMICS" (£929K, 2019-2022) award to **Procopio** for an interdisciplinary biomolecular forensic study of ageing in biomaterials, enabled by our multi-Omics investment.

The *Exploring & Exploiting Microbial Diversity* research group (Lead: **Sutcliffe**) have used our outstanding multi-Omics facilities to deliver the expansion in microbiome studies and biotechnology planned at REF2014. We use sequencing to *explore* the diversity of the bacterial, fungal and viral communities in a range of clinical conditions, in collaboration with clinical colleagues notably at Newcastle's Royal Victoria Infirmary and Freeman Hospital (Visiting Professor **JD Perry**, Category C). This work is complemented by expertise in microbial systematics, diagnostics and studies of the population diversity of pathogens. We are *exploiting* microbial diversity through comparative genomics and functional metagenomics work to identify novel enzymes for green chemistry, biotechnological and 'bio-inspired' applications for systems biology, with commercialisation driven by our Nzomics Biocatalysis innovation unit (<http://www.nzomicsbiocatalysis.co.uk/>).

- **Highlight:** £148K Innovate UK and Northern Accelerator funding for **Moschos** to establish the PulmoBioMed Ltd. spin-out company (www.pulmobiomed.com) to produce and market the PBM-Hale™ exhaled breath condensate collection device for respiratory infection diagnosis and analytics, and environmental aerosol sampling.

Translational Biosciences (Lead: **Schwalbe**) has developed from the *Mammalian Cell Biology and Immunology* group submitted to REF2014, with 12 FTE appointments. The group has continued to advance understanding of a range of diseases and seeks to translate this work into the development of novel treatments, biomarkers and preventative strategies. Much of this work is

focussed on cancer and immunobiology, linked by interests in epithelial biology. Our cancer research has led to landmark studies in the diagnosis and patient stratification in a range of cancers such as leukaemia, medulloblastoma and melanoma. Immunobiology research is directed at understanding a range of inflammatory and/or autoimmune diseases such as arthritis, asthma, and lung diseases. New appointees (e.g., **Garner, Hilgen, Pal**) are establishing strengths in tissue physiology and imaging.

- *Highlight:* **Schwalbe** outputs in *Cancer Cell* and *Lancet Oncology*, improving diagnosis and redefining medulloblastoma treatments (see impact case study [ICS]).

As well as consolidating these three well-established groups, since REF2014 we have expanded significantly in *Nutrition & Food* research (Lead: **Lodge**). This group uses biochemical and molecular approaches to study responses to nutrients and dietary phytochemicals; and investigates dietary interventions that positively impact on outcomes including obesity, cardiovascular disease and markers of ageing. Gut microbiome studies are supported by collaborations with our microbiologists and Visiting Professor Glenn Gibson (Reading). These staff underpin the work of **NUTRAN**, an interdisciplinary nutrition-focussed clinical trials unit (<https://www.northumbria.ac.uk/business-services/engage-with-us/research/NUTRAN/>), which integrates our expertise in trial design and delivery (including researchers returned to UoA4 and UoA24) with biochemical, molecular, physiological and multi-Omics analyses.

- *Highlight:* EU-MRC funded 'Microbiota-Inflammation-Brain axis in heart failure: new diet, biomarker and AI approaches for managing undernutrition in older adults' (AMBROSIA), €370K to Northumbria of €1.2M total (**Brownlee, Lodge**).

Delivering Impact

Our researchers are encouraged to identify and pursue opportunities for co-production, knowledge exchange, business engagement and commercialisation. As set out at REF2014, our impact activities have focused on **health and social care industries** and **policy and practice in health and welfare**, with full integration of our impact and research strategies.

The **nine ICS** submitted are evidence of the multiple ways in which UoA staff interact with business and industry, health professionals, policy makers and the public to ensure that our work makes a strong economic and social contribution. The four key elements of our '**pathways to impact**' strategy are:

1. Maturation and growth of existing partnerships with non-academic users and beneficiaries. We have delivered commercial benefits to industry by diversifying our longstanding partnership with bioMérieux (section 4), whilst our expanding our decade-long biocatalysis collaboration with Prozomix (**Black ICS**), including BBSRC Network in Industrial Biotechnology & Bioenergy (NIBB) Proof-of-Concept funding to **Kelly**.

2. Development of novel partnerships such as the establishment of the *Northern Hub for Veterans and Military Families Research* project supporting the health and wellbeing of military veterans in partnership with the Armed Forces, Royal British Legion and other stakeholders (**Kiernan ICS**). Engagement with new SMEs is evidenced by the development of a novel medulloblastoma diagnostic assay with NewGene (**Schwalbe ICS**).

3. Public engagement. **AH&SC** researchers work extensively with the public, patients and 'Experts by Experience' (i.e., people with lived experience in an area such as mental ill health), highlighting the importance of co-production with key stakeholders. *Health & Life Sciences* faculty policy is to embed the involvement of Experts by Experience in all levels of research and innovation. Success in this is evidenced by **Bailey's** ICS on using co-produced and research-led theatre and film productions to improve public and professional understanding of ageing issues. Patient and public engagement is further promoted by our membership of **ARC NENC**, FUSE and the School for Public Health Research (Section 4).

4. Influencing policy and practice. The impact of our *Workforce & Practice Development* research group is manifest in several ICS, including those of **McNall/Noone** (developing the workforce to better support people with learning disability and/or autism), **Thompson** (developing workforce competency for the care of older people with complex needs) and clinical academic **Hand** (working with health and social care professionals to better support people with Parkinson's disease and their carers). **Cook's** ICS showcases the development of innovative and improved ways of supporting older people by integrating health, housing and care services, whilst influence on policy is evidenced by **PL Graham's** ICS on addressing holiday hunger.

Through this strategy we have built on our professional strengths, methodological innovations and engagement with external partners, research users and stakeholders (section 4) to achieve significant impacts beyond academia. We have appointed a UoA Academic Lead for Impact (**Lhussier**) to promote and expand impact activity, supported by departmental Directors of Research & Knowledge Exchange. Objectives for impact generation are reviewed at appraisal and reflected in staff workloads (Section 2). Delivering impact has been underpinned by university strategic investment in MDRTs, in Business Development Managers and in an Impact Support team, who provide training and related activities for staff at all career stages (Section 2).

Future strategic aims

The evident success of our current strategy of investing in **people, infrastructure** and **external engagement** means that we will continue to prioritise these through the successful mechanisms described above and in Sections 2-4.

People targets will include

- Raise the proportion of staff with significant responsibility for research to **100% of staff in scope**.
- Transition of VCF to lectureships and investment in the recruitment of new Fellows.
- Further collaborative partnerships with regional NHS Trusts via **joint NHS/University Clinical Academic appointments** and development of similar appointments with our social care partners, to increase our research scope, capacity and impact.
- Strengthening of our PGR community including application for **doctoral training partnerships** and continued staff development to allow those recruited from professional backgrounds to engage in doctoral research, with a target of 75% doctorally qualified staff across the wider staff base.

Infrastructure targets will include

- Relocation of our Coach Lane Campus to City Campus within five years, with attendant improvements in research facilities (e.g., co-production/participation spaces) and infrastructure, and enhanced 'melting pot' opportunities for interdisciplinary research involving **AH&SC, C&MS** and other Northumbria colleagues.
- Consolidate and extend our outstanding multi-Omics platform, including developing lipidomics, whilst further enhancing our infrastructure for cell biology, seeking capital investment for state-of-the-art microscopy, flow cytometry, digital image processing and live cell imaging.

External engagement targets will include

- Mentor staff through our **4Ps approach** (section 3) in order to increase RGCI with collaborative partners.
- Increased engagement with public and professional stakeholders, and external partners in the private and public sectors, including increased numbers of Knowledge Transfer Partnerships.
- Continuing to develop staff engagement in the impact agenda, building explicitly on our strong position in the health, industrial and social care economy, building from areas of continuing and nascent impact already identified (section 4).

- Further alignment of our strategy with the guiding principles of the Knowledge Exchange Concordat (<https://www.keconcordat.ac.uk/>).

Discipline specific targets over the next five years will include:

AH&SC will focus on continuing research to support the transformation of services and workforce to fulfil the Integrated Health and Social Care agenda, aligning with national policy initiatives and the proposed reorganisation of service provision. We will continue to consolidate our disciplinary and methodological expertise to sustain a collaborative interdisciplinary team delivering impactful research in this area. We will increase our focus on research that seeks to understand how to effectively change the organisation and delivery of care to improve health/wellbeing across health and social care boundaries. We will also extend and enhance our collaborations with health and social care professionals, and other stakeholder groups, to better enable the workforce to deliver care that is integrated, optimal and safe.

C&MS will continue to develop its strengths in fundamental research and extend these into novel translational research. The **HBBE** will provide a focus for research designing healthier living environments and forms the core of the *Bioeconomy* MDRT, which focuses on bio-based/bio-inspired technologies. Complementing this, biochemists and biotechnologists will use computational, molecular, protein engineering and synthetic biology approaches to drug design, diagnostics and other health technologies. Microbial population and dysbiosis analyses will also underpin nutritional neuroscience (gut-brain) studies and nutritional interventions being co-ordinated by **NUTRAN**. Recent *Translational Biosciences* staff appointments will allow us to develop strengths in computational/informatics research for diagnosis/prognosis, and in tissue physiology and imaging, including a focus on biomaterials and tissue matrix biofabrication. *Chemistry* will focus on the application of synthetic, analytical and polymer chemistry methods applied to the development of reagents and biohybrid materials suitable for medical and healthcare applications. Our state-of-the-art mass spectrometry capacity will be applied to the development of biomedical diagnostic methods and forensic analyses.

Academic Integrity and Open Science

We are committed to maintaining the highest standards of academic and ethical integrity. All staff are issued with a Code of Conduct and research is subject to full independent ethical review, overseen by the Faculty Ethics Committee and Director of Ethics. Our research is monitored for full compliance with appropriate external ethical standards (e.g., NHS ethical approval; NHS Research Passports), supported by an approval process for submissions to the Integrated Research Application System. All staff have access to extensive online resources to support effective Ethics & Governance processes (<https://www.northumbria.ac.uk/research/ethics-and->

[governance/](#)) and undergo mandatory training on GDPR, 'Information Security' and 'Research Ethics'. Technical support and Standard Operating Procedures are provided to ensure compliance with GMO regulations (directed by **Dover**) and the requirements of the Human Tissue Authority, with appropriate storage in our Human Tissue Bank, overseen by a Technical Support Manager as Designated Individual.

Our staff are committed to adopting an 'open research' ethos, with extensive data sharing via third party sites as well as peer-to-peer in accordance with FAIR guidelines that data should be findable, accessible, interoperable and reusable. In addition to provision of access to research outputs via our NRL repository (<http://nrl.northumbria.ac.uk/>), staff are able to store and share data via a dedicated institutional repository (<https://figshare.northumbria.ac.uk/>). Deposit of preprints in repositories such as *bioRxiv* is encouraged where permissible. Researchers that generate large scale genomic, metabolomics, proteomic and coding/imaging data sets are expected to share these through deposit in relevant public databases (e.g., NCBI, PDB, PRIDE etc.). Journal online supplementary material and bespoke repositories (e.g., Harvard Dataverse) are also used to provide access to underpinning datasets. Staff who are leading clinical trials and health interventions are encouraged to publish protocols and register their work with ClinicalTrials.gov or the ISRCTN registry. Staff producing systematic reviews are encouraged to register these via NIHR Prospero (<https://www.crd.york.ac.uk/PROSPERO/>) (e.g., **Cordier, Hackett, Lara**). The NoMAD study (**Finch, Rapley**) has developed a freely available Normalization Process Theory toolkit for implementation work (<http://www.normalizationprocess.org/nomad-study/>). Likewise all SLIPPs (**Steven**) outputs (i.e. data gathering tools in multiple languages, educational resources from analytic work, project information and presentations) are openly accessible via the SLIPPs learning centre (<https://www.slipps.eu/>).

2. People

Staffing strategy and staff development

Our staffing strategy has been tailored to support staff at various career stages (early and mid-career, established researchers), including upskilling of staff who have not previously been research engaged (e.g., by enrolment in doctoral study programmes). This approach has been complemented by our effective strategy of recruiting high calibre research staff with either established international reputations (as Associate Professor and Professor) or evident potential to establish such reputations (VCF and Lecturers). In addition to direct investment, notably MDRT and VCF appointments, the staff base has been strengthened by the university commitment to renewal, including use of voluntary severance (REF5a 3.1). This has driven an increase in

Unit-level environment template (REF5b)

appointments p.a. across this REF cycle, which will be sustainably managed in line with the university Vision 2030 strategy (REF5a 2.6; see turnover below).

82 of 129 (64%) staff have been recruited since 2014, with an overall equitable gender balance (**Tables 1 and 2**). We appointed **ten** Associate Professors (two since promoted) and **six** Professors (**Table 1**), greatly strengthening our research leadership across the UoA: the total number of Associate Professors/Professors has grown from 8/16 in 2014 to 20/23, with the proportion of female staff in these senior research roles rising from 42% in 2014 to 51% (22/43). **66** staff have been appointed as VCF/Lecturers, contributing significantly to growth through prioritising recruitment of active researchers.

Table 1 Gender balance of 82 new appointees since 2014.

VCF/Lecturer		Associate Professor		Professor	
Female	Male	Female	Male	Female	Male
33	33	5	5	3	3

Table 2 Gender balance of 129 UoA staff.

VCF/Lecturer (67%)		Associate Professor (16%)		Professor (17%)	
Female	Male	Female	Male	Female	Male
43 (33%)	43 (33%)	10 (8%)	10 (8%)	12 (9%)	11 (8%)

Recruitment has been used to bolster established research groups or areas targeted for growth (e.g., biostatistics, *Care Innovation & Organisation*). The recruitment panels also assess the potential of applicants to interact with research users, to identify appointees who will contribute to increasing knowledge exchange, public engagement and impact. HR Fair and Effective Recruitment policies are embedded into the process and all staff involved receive training on these. Faculty QR is used to support appropriate start-up packages negotiated with each appointee at discipline-appropriate levels.

Where appropriate, staff are recruited from relevant professional backgrounds, notably the NHS (e.g., **Hackett, Hand, Noone**). Recently, we have recruited staff (e.g., **V Smith**) on joint NHS/University appointments through an initiative of the NENC Clinical Research Network, in which Northumbria was the first HEI to participate. The *Health & Life Sciences* faculty five-year strategic plan is committed to further **Clinical Academic appointments** to support our **AH&SC** research, in partnership with NHS trusts, and we aspire to extend this scheme to social care professionals, in line with national policy direction. We are developing our legal and HR systems

in collaboration with our health and social care partners so that these posts will provide a defined career trajectory, with joint funding as appropriate, to improve recruitment and retention of high-quality clinical researchers who will deliver strong research impact. This is exemplified by **Hand**, who completed a Northumbria Professional Doctorate (2017) and was recruited as an Associate Professor, leading to an ICS on Parkinson's Disease care.

Each department actively manages natural turnover of staff and succession planning to ensure sustainability of our research groups and themes. Our age demographic (which is slightly older compared to the overall Northumbria profile) means we anticipate **~10% p.a.** natural staff turnover: replacement of staff without significant responsibility for research with active researchers will sustain further research growth in the next five years. Academic staff with teaching and research responsibilities are almost always appointed on open-ended contracts; only small numbers are recruited as fixed-term appointments (**2.4 FTE** submitted here, 2%), typically to bring specific professional or clinical expertise, or to replace staff relieved from teaching via grant funding. Fixed-term staff have full access to relevant staff development opportunities.

Staff development – new staff and ECR

All newly recruited staff have a probationary period (the duration of which reflects prior experience), which provides tailored support and workload for establishing research and innovation activities, with a research mentor assigned. The Faculty Executive (chaired by **Ford**) reviews all probation plans and final reports to ensure flexibility and career stage appropriate research objectives are set and delivered (e.g., planning for a first grant application). Specialised equipment requirements of new appointees are considered a priority in departmental capital equipment requests. For laboratory-based staff, research group leaders and senior researchers assist new appointees in addressing space and equipment requirements, as well as supporting induction into Health & Safety processes.

Our commitment to **ECR** is evident in the expansion of the University **VCF scheme**, which provides **significant strategic QR investment to recruit outstanding researchers** into three year 'tenure-track' fellowships (REF5a). These allow high potential researchers three years' intensive research time, with tapered teaching loads consistent with training to progress to lectureships, allowing innovation and expansion in our research portfolio. **15 VCF** have been appointed into this UoA in this REF cycle, all of which are expected to transition to lectureships. Similarly, two pre-2014 VCF (**Bridge, Sangal**) progressed to lectureships in 2016 and three tenure-track **Scientific Officers (Cheung, Nelson, Turnbull)**, funded through the *Bioeconomy* MDRT to strategically support multi-Omics infrastructure, progressed to lectureships in 2019.

30 of the 82 staff appointed since 2014 are ECR. An ECR Training Programme guides staff through our ethical approval processes, seeking external research funding (including Writing Retreats), producing research outputs and wider dissemination. All university workshops are mapped onto the Vitae Researcher Development Framework. ECRs are also encouraged to participate in both faculty and university ECR networks, which provide an informal mechanism to support staff in identifying their training and development needs and help foster interdisciplinary collaborations. The faculty ECR network organises regular seminars, discussion groups and an annual ECR conference. Staff who have recently completed doctorates are helped to gain PGR supervision experience by pairing with experienced staff in supervisory teams.

Post-doctoral researchers are supported by full access to ECR and other staff development opportunities. Post-doctoral researchers gain experience through mentoring in grant and publication writing, including as named or lead researchers on funding applications. In addition to participation in departmental planning meetings, direct interactions with research mentors, Directors of Research & Knowledge Exchange, research group and MDRT leads enables ECR and other junior research (including post-doctoral) staff to influence research planning and strategy.

Staff recruited in professionally facing disciplines who are not doctorally qualified are encouraged to register for PhD study during their probation. Four staff submitted here (e.g., **Carlin, Straughair**) have successfully completed in-service doctorates. Overall, 121 (94%) of the staff returned have doctorates.

Staff development and support – all staff

Northumbria is committed to the Concordat to Support the Career Development of Researchers (REF5a 3.4) and its implementation is overseen by a Researcher Development Strategy Group, on which the UoA is represented (currently by **Potthoff** and **Procopio**). All staff have access to a mentoring scheme whereby senior researchers help staff identify a career-stage appropriate mentor and/or coach. Where appropriate, staff are also encouraged to seek support from the **NENC NIHR Research Design Service** (<https://rds-nenc.nihr.ac.uk/>). **Howlett** and **V Smith** were selected to participate in the prestigious 2019 NIHR 70@70 Senior Nurse and Midwife Research Leader Programme (<https://www.nihr.ac.uk/documents/7070-nihr-senior-nurse-and-midwife-research-leader-programme/22750>).

Workload time for research, impact and knowledge exchange activities for all staff are reviewed through the twice-yearly Performance, Development & Appraisal process (REF5a 3.4), which is used to identify staff requirements for mentoring and/or collaborative support, training and other

development needs. **The 129 staff with significant responsibility for research** (as defined in our Code of Practice) **have an average workload time for research of ~45%**. Training (including Health & Safety for research) and CPD is supported by extensive online and workshop resources provided by HR and Research & Innovation Services.

QR disbursement to enable research (>£500K across the REF cycle) is overseen by appropriately representative departmental research management teams that consider prior commitments (e.g., reagents for university-funded PGR; start-up packages) and needs of ECR. Decisions on the use of QR are based on potential rewards/significance of proposals, ranging from initiating first research activity to leading large collaborative funding proposals or networks. Similarly, all staff have access to funding for travel for conferences, networking and engagement with external partners. Typically, an additional ~£35K p.a. is released from QR to this UoA for travel, with equitability of access monitored by departmental management teams.

All staff have an annual opportunity to apply for a one semester research/impact generation **sabbatical**. **18** UoA staff have benefited from sabbaticals in the REF2021 period. For example, **D Smith** used a sabbatical to establish PacBio sequencing within the NU-OMICs portfolio (below) and **Steven** was able to use a sabbatical to strengthen European collaborative links. Prospectively, departments will produce a rolling 5-year sabbatical plan to manage staff/areas for prioritisation, ensure equitability and encourage participation. Following a sabbatical, staff become eligible to reapply after six semesters. In addition, external grant funding can release staff from teaching (e.g., **Morey, Procopio**).

Research achievement is a key criterion for promotion to Associate Professor and Professor, administered through an **Annual Promotions and Progression** process, wherein Faculty and University Promotion Boards ensure equitability throughout. Staff seeking promotion are supported by departmental management teams and have an opportunity to participate in Action Learning Sets to develop their applications, facilitated by senior research staff. In this REF period, eight staff have been promoted to Associate Professor (six female, two male), including **Gray, McKay, Schwalbe** and **Thompson**, and eight staff to Professor (five female, three male) including **Haighton, Lhussier, McMeekin, Perry** and **Steven**.

Impact and knowledge exchange objectives are also embedded within the Performance, Development & Appraisal process, enabling the university to support staff to undertake engagement and impact activities. This allows workload models to be adjusted to recognise enterprise and/or impact activities and staff are eligible to apply for Impact and Knowledge Exchange sabbaticals.

Research & Innovation Services provide additional training and workshops on impact and related activities (e.g., 'Bringing Impact to Life', 'Evidencing Impact'), supplemented by online resources and one-to-one support for staff wishing to increase engagement with our external partners, including public engagement and media training. Informal lunchtime commercialisation seminars are delivered to introduce staff to key topics related to intellectual property and commercialisation. Overall, the Impact Support team have typically delivered ~five workshops and training events p.a., tailored for staff in this UoA. The impact team has thus created a university-wide impact 'community of practice' bringing researchers together across disciplines to collaborate and share good practice.

Research Students

PGR are integral to our research culture and the university has invested significantly (REF5a 2.2) in **Research Development Fund** studentships throughout the REF period (~9 p.a. in UoA3, typically prioritised to support newly appointed and ECR staff). Additional 'matched' university funding is made available to support **Collaborative PGR** studentships with external partners (REF5a 3.5), as detailed in Section 4. Overall, **136 PGR doctoral degrees** have been awarded (23% to PGR from outside the UK), compared to 66 in REF2014. In addition to Northumbria PGR, four staff (e.g., **Dalkin, Sanders**) are supervising PGR registered on the NIHR Clinical Doctoral Research Fellowship scheme.

The numbers of PGR recruited on these schemes are summarised in **Table 3** in comparison to UoA3 Research Training Support Grant Funding (RTSG). Additionally, QR is used to support in-service doctoral study and these staff make a strong contribution to the vigour of our PGR community. Academic staff enrolled for in-service doctorates are given a standard workload of 30% RSE to complete their research programme and are not yet considered to have significant responsibility for *independent* research (and so are not submitted, as defined by our Code of Practice), although they are expected to enhance the pool of staff with significant responsibility for research in the next REF period. Likewise, eight 'Graduate Tutors' (teaching staff on 'tenure track' for appointment as lecturers) are enrolled as part-time PGR and two members of the **C&MS** technical support team are undertaking part-time doctoral study.

Table 3 Investment in PGR 2014/15-2019/20

Research Development Fund	Collaborative	Staff	UoA3 RTSG funding
53 (mean 9 p.a.)	13 (mean 2 p.a.)	43 (mean 7 p.a.)*	£876K

* Doesn't include 'Graduate Tutors'

Additional PGR are recruited through external grant funding, including ESRC NINE DTP, EU and UKRI; **ARC NENC**; and four **HBBE**-funded students. High calibre candidates are recruited through supervisors' networks and advertisement, notably on *FindAPhD*. QR funding has also been used for open-ended *FindAPhD* advertisements, a cost-effective mechanism to recruit additional self-funded PGR. All PGR recruitment follows fair and effective recruitment practices implemented by the Graduate School.

Each student meets regularly (expected minimum monthly, typically more often) with their Principal Supervisor and has at least one other academic supervisor. Monthly meetings are documented to record progress and objectives using our e:Vision portal, which thereby monitors student engagement. Following an initial project approval (within 4 months of start), subsequent annual progression meetings (with written report and/or viva) are used to formally review progress, set objectives and to identify training and resource needs. Internal examiner(s) assess progress at each of these milestones. Faculty and departmental PGR Directors provide additional administrative assistance and pastoral care. Fast-track review of PGR project amendments and PGR drop-in forums have enabled alternative approaches to data collection (e.g., surveys, online interviews) for work with human participants disrupted by COVID-19. High levels of overall PGR satisfaction were reported in the 2019 Postgraduate Research Experience Survey (**89%** versus 82% sector average for this discipline area).

The Graduate School (REF5a 3.5) has faculty-aligned teams who manage PGR engagement, progression and examination. They also administer the PGR Professional Development and Research Training Programme, which includes a suite of more than 30 training courses which map to all four domains of Vitae's Researcher Development Framework. Examples include 'Doctorate Essentials', 'Managing Your Research Degree', 'Giving Your Research Impact' and 'Life After Your Doctorate'. Additionally, all PGR have access to advanced and specialist training delivered by the DTPs and CDTs in which Northumbria is a partner, such as the ESRC NINE social sciences DTP (<https://www.ninedtp.ac.uk/>). Indeed, the Unit's critical mass demonstrated at REF2014 was instrumental in securing our eligibility to participate in the latter.

In addition to formal training programmes, our PGR are encouraged to participate in seminar programmes (attending and presenting) and informal activities (e.g., journal clubs; disciplinary, methodological and topic-based discussion groups) at research group, departmental and MDRT levels. All PGR are invited to contribute to the annual faculty and university PGR conferences, whilst 2nd and 3rd year students are encouraged to take part in an annual Three Minute Thesis competition. Bursaries up to £300 are available to PGR groups wishing to organise discipline specific events (e.g., funding for the North East PGR biomedical conference 2016). PGR have access to a Conference Bursary Scheme providing £250 p.a. to support conference attendance

(often supplemented by supervisor contributions, e.g., from the Research & Enterprise Rewards Scheme [Section 3]). PGR are also encouraged to apply for travel awards from relevant learned societies.

In addition to our PGR community, our research is enhanced by the contribution of master's students who undertake a significant research project. Work from these projects has fed forward into funding applications and multiple publications with the students included as co-authors (e.g., **Hill, Lee, Sangal**).

Equality, Diversity and Inclusion (EDI)

Northumbria is a multicultural institution in which diversity is valued and encouraged, with faculty processes committed to the effective management of EDI across the UoA. Each department has a Director of EDI, who report via a faculty representative to the University EDI Committee (REF5a 3.6). Terms of Reference and membership of faculty committees relevant to research governance and staff management (e.g., Ethical Approval, Sabbaticals, Promotions Board) are actively reviewed to ensure full compliance with EDI policies; a designated Faculty HR Manager attends meetings where appropriate. We strive to ensure that no relevant group is under-represented or, conversely, over-represented (and thereby disproportionately overburdened) in this work.

All recruitment panels are assessed for appropriate gender balance and representation of staff from a range of backgrounds. All staff involved in recruitment panels are required to undertake an HR training programme in Fair and Effective Recruitment and Selection. Future initiatives will target improved delivery of our Unconscious Bias training (including the online Harvard University implicit bias test) because this is identified as a persistent challenge in STEMM.

Our diversity is reflected in the **international origins of ~25% of the UoA staff** (14% from Europe; 10% from non-European countries). Support was provided to reassure and guide EU staff throughout the Brexit process, including refunding of application fees for EU colleagues seeking permanent residence in the UK or British Citizenship. Northumbria also provides immigration costs for international colleagues (REF5a 3.3) and operates an Immigration Fees Short-Term Loan Scheme for those needing assistance with other costs. In 2020 the university signed up to the Race Equality Charter to further its commitment to understanding and combatting racial inequality, and has established a member-driven Black, Asian and Minority Ethnic Staff Network. 13% of staff submitted here are of ethnic groups Other than White.

As in REF2014, this submission has an ~50:50 gender balance of staff with significant responsibility for research (**Table 2**), although female staff are underrepresented when are

compared to the total UoA3 staff base (62% female), reflecting the sector overall in **AH&SC** discipline areas. We will address this through proactively locating and dismantling barriers to research engagement affecting our female staff and emphasise that good progress has been made in increasing the proportion of female staff in senior research roles (from ~40% to 51%). All staff who identify as female can join our Women's Network, a member-led forum for collaboration, networking and informal mentoring, which provides advocacy and raises issues that affect members. The university currently holds a bronze Athena SWAN institutional (STEMM) award (REF5a 3.6); of the three main departments underpinning this UoA, *Nursing, Midwifery & Health* was awarded Athena SWAN Bronze in October 2020; *Social Work, Education and Community Wellbeing* submitted in November 2020, and *Applied Sciences* is preparing to submit. The university is a Stonewall Diversity Champion. LGBTQ+ staff and PGR are supported by an LGBTQ* Network which raises LGBTQ+ visibility and ensures that inclusive policies are adopted and that inclusive spaces are available.

All staff undergo mandatory 'Equality and Diversity' training. HR provide all staff with guidelines, policies and support for our EDI initiatives, including materials relevant to each protected characteristic. Similarly, a Wellbeing Hub provides a range of materials supporting physical and mental wellbeing, including Gender Specific matters and Carer Support. Positive mental health is supported by training programmes available to all staff and >40 university Mental Health First Aiders.

Novel initiatives are supported by the Vice Chancellor's Diversity and Inclusion Fund (e.g., funding a *Health & Life Sciences* Autism Friendly initiative led by **Reynolds**, aimed at widening access and participation for autistic students and staff). We are a Level 2 member of the Disability Confident Scheme and staff with underlying conditions or declared disability are supported by reasonable adjustments to their workload/workspace where needed. One person with a declared disability is submitted here (consistent with the overall Northumbria profile).

Our line management structures support flexible working. Thirteen of 129 submitted staff are currently on fractional contracts, and six/seven have taken maternity/other family leave, respectively, in this REF period. Research leads work with Heads of Department to ensure mentoring and resources are made available to staff returning to work following career breaks including maternity/parental leave, medical leave and caring responsibilities; these staff can also access an HR-led Coaching Transition Programme supporting their return to work. A Parenting Network provides informal member-led support for staff. Research seminars and meetings are scheduled in core hours 10am-4pm to facilitate the attendance by staff with family responsibilities.

The University's Code of Practice used in preparing this submission was developed with an underpinning commitment to fairness and EDI. The UoA lead (**Sutcliffe**) and relevant staff have been given unconscious bias training provided by Advance HE. The UoA lead co-ordinated the internal peer review of outputs by 'colleges' of suitably experienced **C&MS** and **AH&SC** staff, with each constituted considering the need to maintain a gender balance appropriate to each area and for succession planning i.e., giving staff experience needed for future REF preparations. The output portfolio was selected by first attributing a primary output to each individual (typically their strongest output, although with management of co-authored outputs to maximise the expected Grade Point Average), followed by 'blinded' selection of the highest scored outputs needed to make up the requisite **268 outputs**. Where the option was available to select from equally graded outputs, equality assessment and the need to consider fair representation of all the discipline areas in this wide-ranging submission were taken into consideration.

3. Income, infrastructure and facilities

Income

As a result of our strategy to increase the critical mass of researchers in the UoA (section 2) and our drive to improve grant application volume and quality (below), we have **increased our overall RGCI to £10.2 million** in the current REF period, compared to £6.1 million in REF2014, and total awards of **£21.4 million**. Since 2014, we have been awarded 36 awards of ≥£100K and 33 awards of ≥£50K-£100K, with significant awards from RCUK, NIHR, EU and major charities.

Significant examples include:

Platforms

- **HBBE** (Research England) £8M total, £4M to Northumbria (**Black, D Smith**). Securing this Expanding Excellence in England funding, the largest of only 13 supported, was enabled by our institutional commitment to the linked staff, including PGR support and VCF retention, underpinned by our strategy of investing in multi-Omics infrastructure.
- **ARC NENC** (NIHR) £9M total, £438K to Northumbria (**Clarke, Finch, Lhussier, Rapley**), with 37 staff contributing at submission. The **ARC NENC** aims to improve health and social care outcomes in regional priority areas and on a national level working with other ARCs.

Innovation

- Map of Need (MoD, Armed Forces Covenant Fund) £1.1 million total, and Improving Access for Veterans £225K (Royal British Legion) (**Kiernan, Hill**).

- Forens-OMICS Future Leaders Fellowship (UKRI) £929K, integrating proteomic and genomic forensic/biomarker methodologies (**Procopio**).
- AMBROSIA (Microbiota-Inflammation-Brain axis in heart failure), €370K EU-MRC funding (**Brownlee, Lodge**).
- Developing a digital self-management tool to improve the quality of life of people with Sjögren's syndrome (Versus Arthritis) £274K (**Hackett**).
- Manufacturing Immortality project (EPSRC) £267K, designing and developing synthetic and bio-hybrid self-healing materials (**Perry**).
- Launch of **PulmoBioMed Ltd spin out company**, with £148K funding to Northumbria and £460K private equity/Innovate UK funding to the company (founder **Moschos**; Northumbria stake 49%).

Trials and Evaluations

- BATH-OUT-2, Bathing Adaptations in the Homes of Older Adults: A Randomised Controlled Trial, Economic Evaluation and Process Evaluation (NIHR School for Social Care Research), £962K, led by **Whitehead**.
- ImpleMentAll project (European Commission) €6M total, £556K to Northumbria (**Finch, Rapley**). European collaboration towards faster and more effective implementation of eHealth. Northumbria led the implementation toolkit development and trial process evaluation.
- **Carr** £207K (NIHR School for Public Health Research) evaluation of the impact of advice services on health and health inequalities.

Our strategy to achieve income growth was to target funding applications to major funders (UKRI, NIHR, EU etc.) as well as small and medium sized funders (such as charities) and industry (e.g., KTP and Innovate UK). Application numbers p.a. have increased steadily across the REF period, with an approximately 3-fold increase in total application values by 2019/20. To enhance success rates for funding applications, departmental Directors of Research & Knowledge Exchange, supported by MDRT and research group leaders, are implementing a “**4Ps** approach” to supporting staff, i.e. ensuring the right **Person** is applying to the most appropriate **Programme** (funder and level for their career stage), with the strongest possible **Project** proposal (supported by robust but constructive internal peer review) and appropriate external **Partnerships** (academic, business, clinical and third sector organisations). Senior research staff and mentors help prospective applicants map their funding plans onto these four cardinal pillars. Departmental and/or research group leads are alerted once prospective applications are logged in our Agresso management system so that internal peer review by an appropriate subject expert(s) can be arranged. Our emphasis on individualised career-stage appropriate support recognises the diversity of our staff base and ensures equitable access to support for funding applications.

Our *ECR Development, Next Generation of Large Grant Holder* and *Fellowship Ready* programmes provide career-stage appropriate training to help staff progress to more ambitious, larger scale research proposals. For funding schemes where numbers of applications are restricted, a university triage process, overseen by the Research and Knowledge Exchange Content Board, identifies those staff who will be given dedicated support with applications. Funding applications are further incentivised by the **Research & Enterprise Rewards Scheme** under which up to £5K p.a. is returned to successful applicants (even when overheads have not been awarded) to flexibly support further research and knowledge exchange activities.

Evidence for the effective targeting of applications from staff at the right career stage to the right funder can be seen not only in the award of a Future Leaders Fellowship to **Procopio** but also in important awards at different levels to ECR and new appointees such as **Bate** (£50K, Northern Cancer Alliance), **Hand** (£100K, Parkinson's UK), **Turnbull** (£170K, Innovate UK) and **Vijaykumar** (£59K, ESRC) and **Wilson** (£65K NHS Clinical Commission Group).

Successful applications for larger grants in **AH&SC** have been driven by the recruitment of senior staff who, aside from leading their own applications, help mentor, support and (where appropriate) collaborate with other on larger grants, as evidenced by awards to **Scott** (£210K Dunhill Medical Trust) and **Whitehead** (£199K, NIHR School for Social Care Research and £962K BATH-OUT2, above). A major driver of successful applications for larger grants in **C&MS** has been the substantial capital investment in our multi-Omics platform (detailed below), which provide multidisciplinary technologies to underpin the activities of all four research groups and increase the ambition and size of our applications, as evidenced by HBBE, Future Leaders and AMBROSIA funding (as above) and Action Medical Research (£176K, **D Smith, Bridge**), MRC (£134K **Dover**) and NIHR (£127K **Lanyon**) funding.

Research Development Managers in Research & Innovation Services work with individuals/teams to develop proposals in response to appropriate funding calls. They disseminate funding news, deliver briefings on funders and the funding landscape, deliver cohort-based development programmes and best practice resources, including a repository of successful applications to a range of funders. Legal support for applications and developing partnerships is provided by our dedicated legal team.

Centralised and faculty capital expenditure processes (REF5a 4.3) ensure co-ordinated and equitable access to investment in estate and facilities, including prioritisation of infrastructure needs of newly appointed staff. Expressions-of-Interest are reviewed based on alignment with UoA/faculty and university strategy. Improved infrastructure (both staffing and facilities) has also

driven overall staff ambition and awareness of expectations to deliver high quality research outputs, emphasised and mapped through specific Personal Development & Appraisal objectives. Improving the quality and ambition of our RGCI funding applications, often through multi- or interdisciplinary approaches and enhanced by internal peer review, has in turn created a 'virtuous circle' wherein funded projects have delivered higher quality research outputs.

Much of our most impactful research comes from engagement with external partners (section 4), funded via collaborative research, contract research, consultancy and knowledge transfer programmes (>£10 million funding awarded). Engagement with industry through UKRI Innovate UK/TSB, NIBB (**Black, Kelly, Koutsidis, D Smith**) and KTPs (e.g., **Moschos, Turnbull**) generates intrinsically impactful research. Examples range from multiple biocatalysis projects (e.g., **Black** with Prozomix) through to our bioMérieux collaboration (**Dean, Jones, Stanforth**; >£300K since 2014). Similarly, NIHR-funded research to inform health and care practice, and related contract and collaborative research projects (e.g., **Adams, Gray, Haighton, McParlin, Scott**) and workforce development activity (e.g., **Steven, Thompson**), leads to direct benefits for our external partners. In addition, funding from charitable sources (e.g., **Hodgson**, Equal Arts; **Henderson**, Association for Young People's Health) and newer social care collaborations (e.g., Home Group, **Cook**) supports research with direct benefits outside of academia. Such collaborative working with our external partners has led directly to the ICS submitted (section 1).

We will continue to build on this success, working towards a target of at least one career-stage appropriate grant application per academic p.a. over the next five years. This will be managed through our Personal Development & Appraisal process and supported via research group, MDRT and departmental leadership. The £9M **ARC NENC** funding will support **AH&SC** staff to access a new dedicated pump-priming funding stream over the next five years, which is further extended to £16m by in-kind partner funding agreements. Indeed, in the first **ARC NENC** open funding competition (2020), UoA3 staff won the most awards of applying partners (7/31, values £35-80K; e.g., **Thompson**, development of a standard evaluation method for evaluating the impact of frailty pathways and their outcomes). Our significant and growing critical mass in implementation sciences, health economics and expertise in working with marginalised groups will be consolidated to deliver distinctive and impactful research. In **C&MS**, we will seek RGCI to support impactful research through our *Bioeconomy* MDRT, which will also drive funding applications for other translational research in biofabrication and bio-inspired Chemistry, whilst the **NUTRAN** clinical trials unit will allow us to extend our industrial and healthcare partnerships.

Infrastructure and facilities

AH&SC research is founded on a combination of interdisciplinary desk and fieldwork, with most of fieldwork conducted within the community and/or health and social care organisations. Consequently, strategic investment has focused largely on 'soft' infrastructure, through recruiting staff with specific disciplinary and methodological expertise. Senior (**Finch, Rapley, Sanders**) and ECR (**Potthoff, Scott**) appointments have substantially improved access to methodological expertise in implementation and improvement science, as well as disciplinary knowledge around Health Psychology and Medical Sociology. The targeted recruitment of senior staff (**Cordier, Dickens, Hackett, Haighton, Hand, Henderson, Pollock, Whitehead**), biostatisticians (e.g., **Ogundimu, Pakpahan**) and Health Economics experts (e.g., **McMeekin**) has increased methodological expertise in quantitative work, notably clinical trials and systematic reviews, as well as disciplinary knowledge in Health Services Research and Occupational Health. This has enhanced the development of novel interventions, randomised controlled trials (including parallel process evaluations and cost-effectiveness studies) and the implementation of evidence-based interventions, as well as extending interdisciplinary capacity. We have established the Northern Realist Research hub to support researchers in this area (<https://www.northumbria.ac.uk/about-us/academic-departments/social-work-education-community-wellbeing/north-northern-realist-research-team-hub/>).

Equipment and facilities for **AH&SC** research at our Coach Lane Campus include our *Clinical Skills Centre* which provides state-of-the-art simulation facilities and environments for research. This facility will also support post-COVID research projects by NHS staff undertaking further study as part of our NHS Blood and Transplant CPD contract (awarded June 2019). Refurbished facilities with enhanced IT infrastructure have also been provided (£171K investment) to increase capacity to support the participatory research and knowledge exchange activities. Biostatistics and Health Economics staff, alongside others undertaking more quantitative work, have benefitted from QR investment in STATA, Triage, and Concept Systems Global MAX software and high specification hardware (PCs and laptops). Staff involved in qualitative research have been supported through QR investment in encrypted digital voice recorders (with a bank of unidirectional, stereo and conference microphones), transcription pedals and software, QSR International NVivo software, and laptops and tablets to support external fieldwork.

Additional infrastructure is provided via Information Scientists (within Library Services) and the Impact Support, as well as partnership in the North East and North Cumbria NIHR **Research Design Service** (**Clarke** is an Executive Team member; £170K funding to Northumbria over 5 years for provision of Health Economic and qualitative methodological support). Support from the Learning Technology team has been particularly used by the *Workforce and Practice*

Development group (**Kelleher**, simulation and virtual reality; **Morey**, General Nursing Council funded project; **Steven**, SLIPPs and Health Foundation-funded projects) to develop online data collection tools, for data analysis and to produce outputs such as simulation scenarios and e-learning materials for health professionals.

Our already strong laboratory infrastructure to support **C&MS** research has benefitted from substantial investment since REF2014. Our core biosciences research laboratories (262 m² across three co-located laboratories, with adjacent preparation room) were fully refurbished in 2017. This footprint has been expanded by the 2019 development of 130 m² laboratory dedicated to our HBBE project and the addition of new laboratories for tissue culture (107 m², capacity expanded from four to eight hoods; £168K), multi-Omics and associated preparation (33 and 45 m²), and a dedicated laboratory for radiochemistry (£94K, 29 m²). Senior academics coordinate the operation and development of these multi-user research spaces, supported by a 24-person technical team who ensure safe and effective day-to-day running and maintenance of facilities. This team includes two Grade Six *Experimental Officers*, dedicated to supporting our NU-OMICs facility (see below) and tissue culture/microscopy research respectively. A **C&MS** Technical Support Steering Group oversees quarterly calls, whereby staff can apply for access to technician time (0.4 FTE per quarter) to support specific research projects. Staff can also utilise the expertise of two former Scientific Officers (**Cheung, Nelson**; now lecturers) with ongoing roles (and workload) to facilitate use of our –OMICs facilities for genomics and mass spectrometry.

Substantial capital investment has developed our research capacity in these facilities, of which the jewel in the crown is our outstanding multi-Omics suite with new investment in DNA sequencing (£346K PacBio and £61K Illumina MiSeq; £99K Hamilton liquid handling robot) and metabolomics (£340K Q Exactive Plus mass spectrometer and £750K Thermo ID-X mass spectrometer) to complement our extant proteomics capability. HBBE funding has further improved our genomics infrastructure by allowing purchase of NextSeq (£165K) and Oxford Nanopore GridION (£64K) sequencing platforms. These have allowed our NU-OMICs sequencing facility (directed by **D Smith**; <https://www.northumbria.ac.uk/business-services/engage-with-us/research/nu-omics/>) to develop into an established service supporting both internal staff research, along with substantial external engagement (evidenced by a steady increase in contract income from £31K in 2014/15 to £191K in 2019/20, separate to the COVID-19 work detailed in section 4). Cell biology research has been supported by the extension of tissue culture facilities (detailed above) and our microscopy suite has benefitted from £177K invested in confocal and fluorescence microscopy, including Laser Capture Microdissection capacity, complemented by purchase of a 3-laser 8-colours FACS Canto II system (£95K).

Unit-level environment template (REF5b)

Analytical chemistry and nutrition research facilities (166 m² across five co-located laboratories) include multiple high-performance liquid and gas chromatographs linked to mass spectrometers with multiple detection systems (ion mobility and trap, time-of-flight, orbitrap and quadrupole; £367K investment). Elemental analysis facilities include atomic absorption, inductively coupled plasma-optical emission (£60K) and X-ray fluorescence (£86K) spectrometers. There is a dedicated lab for a multinuclear probe Jeol 400 MHz Eclipse NMR Spectrometer and full suite of UV-visible/fluorescence/Raman spectrometers complemented by a range of optical, Raman, FTIR and confocal microscopy. A suite of thermal methods instrumentation (£46K differential scanning calorimeter and thermal gravimetric analysis) supports our growing capacity in polymer characterization and additive manufacturing methods. A dedicated 118 m² fully equipped laboratory with nine fume hoods provides ample capacity for synthetic chemistry.

In addition to utilising the above biosciences and analytical chemistry facilities, the members of the NUTRAN trials unit conduct multi-disciplinary research utilising our Brain, Sleep, Sports and Vascular laboratories (managed by staff in UoA4 and UoA24).

Our 'wet' laboratory facilities are complemented by a High Performance Computing Cluster and IT support for increasing engagement of staff with informatics technologies (£102K BIOS hardware) for microbial genomics (e.g., **Nelson, Sangal**) and systems biology (led by two VCF, **K James** and **Kelly**). Additional IT support for researchers is provided by a centralised IT support team, including access to specialised software and applications for research whilst 'working from home'.

Our Library infrastructure includes both a 'Digital Commons' and a 'Research Commons', dedicated library spaces for digital scholarship, collaboration and networking. Facilities include a Research Reading Room and collaborative spaces for small groupwork, whilst all staff and PGR can access face-to-face expert librarian support. These spaces in the main City campus library are complemented by a similar 'Research Zone' within our Coach Lane campus library. Library investment (journals and books; databases) in UoA3 discipline-specific areas has grown considerably from £246K p.a. in 2014-15 to £313 in 2019-20 (total six-year expenditure £1.9 million). These resources are extended by investment in access to multidisciplinary databases, ebook and ejournal packages, which has grown from £788K to £1.2 million p.a. in the same period.

The University Accessibility Review Group promotes improvements to accessibility to all our buildings and services, including laboratories.

In-house infrastructure is extended by collaboration to use external facilities and data sources. *Chemistry* researchers have utilised the EPSRC National Mass Spectrometry Facility (**Stanforth**,

Tetard) and structural biology research has been supported by access to Synchrotron radiation sources at ESRF (Grenoble) and Diamond Light (Oxford) (e.g., **Dover, P James, van Loo**). **Simoos** UKRI-funded collaboration with Litron Lasers is supported by loan of their laser equipment (£12K in-kind).

In addition to use of the databases in which we deposit our data for sharing (e.g., NCBI; Section 1), genomics researchers also use platforms such as Galaxy, MRC CLIMB and Terra. UoA staff have been given access to specialised external databases and/or data including: the Avon Longitudinal Study of Parents and Children (**McKay**); the Australasian Maternity Outcomes Surveillance System (**Pollock**); the Cochrane database (**Lara, Reynolds**); data sharing agreements with all the main UK veterans charities (**Kiernan** and colleagues); the National Diet and Nutrition Survey database (**Lodge**); Sheffield Multiple Symptoms Study 3 trial data (**Sander**); and Consumer Data Research Centre funded research by **Vijaykumar** has used machine-learning approaches to analyse Twitter data to explore the conversation surrounding probiotics and their links with health. Work in collaboration with NHS researchers (e.g., **Adams, Hand, Scott**) is also typically supported by in-kind contributions of NHS staff time and data-sharing agreements.

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

Regional, national and international collaborations with a wide range of partners have been vital to strengthening our research since REF2014, fostering multi- and interdisciplinary research, and translation of our research into practice and impact, as exemplified by our **nine ICS** and further evidenced below. Much of this activity is focussed on addressing national and global challenges such as research relevant to ageing populations, diet and nutrition, and infectious diseases, including our response to COVID-19.

Overall staff in this UoA have **more than 300** national and international collaborations (as evidenced by co-authored publications and/or funded projects; **40% of the >1600 UoA outputs since 2014 include international co-authors**) with universities, research institutes, SMEs and industry, NHS and social care organisations, and other third sector organisations. Staff engaged in these external partnerships are stimulated by the two-way process of knowledge exchange and rewarded by seeing 'real world' benefits from their research; in turn, the research environment is further enriched by funding for PGR and research assistants, and by public participation (for example by involving Experts by Experience).

Promoting external engagement

Building collaborations with our external partners, research users and stakeholders has been a strong feature of our impact strategy and our four ‘**pathways to impact**’ (section 1), underpinned by university investment in impact support (Sections 1 & 2).

To facilitate the development of collaborations and partnerships, QR funding is made available at both faculty and departmental levels to support travel and networking events, with additional funding made available through our MDRT budgets and via the **Research & Enterprise Rewards Scheme**. This has allowed both outgoing staff travel to visit collaborators and networking events, as well as supporting incoming visitor travel. Staff have also been successful in obtaining external support for travel (e.g., **Newham** British Council ECR award, Brazil workshop; **Geddes** ERASMUS mobility grant, visit to Italian collaborators) and have participated in externally funded networking opportunities such as the BBSRC NIBB events and professional association events.

Four Business Development Managers support staff in finding external partners and developing sustainable relationships through a range of Knowledge Exchange activities, with additional support from our participation in the *Northern Accelerator* (e.g., £49K **Moschos**; <https://www.northernaccelerator.org/case-study/breath-diagnostic-device>). To further promote our activities to external partners, the university promotes wide access to our designs, expertise, research tools, software and technologies (<https://www.northumbria.ac.uk/business-services/engage-with-us/research/>).

The University **Collaborative PGR** studentship scheme (section 2) is further evidence of our investment in external engagement, with **thirteen Collaborative PGR** match-funded in this UoA. External partners who have co-funded studentships include AkzoNobel (**Perry**), bioMérieux (**Jones**), High Force Research (**Moschos**), Marlowe Foods (**Munoz**), NHS (**Steven, Wilson**), Prozomix (**Black**) and Rank Prize funding (**Lodge**).

Academic collaborations

In addition to **significant multi-partner projects** (e.g., AMBROSIA, ImpleMentAll and SLIPPS; see section 1), the UoA staff are typically working with multiple national and international HEIs and clinical researchers. Notable collaborations include:

- **Lanyon**: multi-centre international (Australia, UK, USA) cystic fibrosis microbiome consortium (*Microbiome* 8:45) and the NIHR *Efficacy and Mechanism Evaluation* MAGPIE trial on enteral feeding of preterm infants (£127K to Northumbria).

- **Lhussier**: School for Public Health Research-funded study (£562K total, £162K to Northumbria as lead) on how local authorities meet health inequalities targets with constrained budgets, in collaboration with 5 other UK Universities.
- **Simoës**: investigated osteopontin-mediated protection in allergic airway disease with Biomedical Research Foundation of the Academy of Athens (EU-funded; *PNAS* 111:E856).
- **Tetard**: design of novel Parkinson's disease interventions with collaborators in Konstanz and Strasbourg (patent WO2016079502A1 pending; *Archives Toxicol.* 94:3105).
- **Vijaykumar**: collaborating with the University of Georgia (USA) to study communication about infectious diseases via social media (\$50K funding from WhatsApp).
- **Zevallos**: collaboration on wheat-induced intestinal dysfunction with McMaster, Canada (*Gastroenterology* 156:2266).

Partnerships with non-academic users and beneficiaries

Our research has contributed to **economic growth** through partnerships with industry, SMEs and the health and social care sectors. We have *extended* our long-term relationships, such as with bioMérieux (led by **Stanforth** and **JD Perry**) and Prozomix (**Black, Kelly**), whilst **Lhussier** and colleagues have led on the 'Year of Care' approach to advancing care and support planning with Northumbria Healthcare NHS Foundation Trust. We have *expanded* our range of partnerships through novel projects such as:

- Six KTP projects, including **Moschos** with Hart Biologicals (2020, £196K) to develop a simpler, automated coagulometry instrument and **Perry** (co-I with Engineering colleagues, diagnostics, £137K) with QuantuMDx to develop a medical diagnostic product utilising smart material coatings.
- The **NUTRAN** interdisciplinary consultancy and clinical trials unit, which provides commercial clients with a full experimental pipeline from the laboratory through to physiological effect, e.g., collaborative PGR and additional PGR studentship funding (£51K) from Marlow Foods to investigate prebiotic benefits of Quorn β -glucans (**Commane, Munoz**).
- **Gray** is collaborating on an RCT funded by Stryker to assess improving knee replacement outcomes using robotic-assisted surgery.
- **Lodge** collaborating with A2 Milk to deliver an alternative casein diet for children with autism (£45K).
- **McMeekin's** work with Sarissa Biomedical Ltd (£37K) on developing point-of-care intravenous devices for paramedics dealing with stroke patients.

- **Pal's** National Centre for 3Rs studentship award (£90K) to explore using 3D bioprinted microtissues in patient-specific cancer drug development, in collaboration with Great Ormond Street Hospital, the Great North Children's Hospital and Alcyomics Ltd.
- **Perry** is a chemistry lead in the Transforming Foundation Industries Industrial Strategy Challenge Fund £5M **TransFIRE Hub** (£401K to Northumbria, 2021-2024) which aims to improve competitiveness and sustainability in materials manufacturing.
- **Todryk** is co-investigator with Engineering colleagues on £346K EPSRC-funded work with Epigem Ltd and OJ-Bio developing biosensors for medical diagnostics.

Working with health and social care organisations is at the heart of **AH&SC** research and our leadership and membership of the **ARC NENC** reflects our ongoing strategy to work with multiple organisations to consolidate and sustain research in national high priority areas of health and social care. Our partners include a wide range of NHS Trust and Clinical Commissioning Groups, charities and other third sector organisations. Examples include:

- **Bailey** and colleagues have worked with Newcastle and Northumbria Local Authorities and Elders Council Newcastle to devise home adaptations in improving later life (funded by Centre for Ageing Better, £40K).
- **Cook** has established an innovative partnership with the Home Group social enterprise (£52K funding) to develop technology-enabled homes to promote older persons independence (winner of the 2020 People's Choice Award at the 'Dynamites' North East IT and Technology awards).
- **Gray** is collaborating in the NIHR funded (£252K to Northumbria) Effective Treatments for Thoracic Aortic Aneurysm study across 25 NHS Trusts.
- **Hackett** was awarded the College of Occupational Therapists Innovation Award (2014) for work to address the needs of users within a specialist fatigue clinic.
- **Hand** is the Clinical lead for Nursing with Parkinson's UK Excellence Network (<https://www.parkinsons.org.uk/professionals/clinical-leadership-team-uk-parkinsons-excellence-network>).
- **Thompson & Tiplady** leading workforce development projects with NHS Health Education England (£149K funding over 2 years)
- **Whitehead** is leading the BATH-OUT-2 trial on bathing adaptations to improve the lives of older adults (NIHR funded, £962K), working with four Local Authorities.

Staff (e.g., **Carr, Finch, Lhussier, Steven**) contribute further as members of the Academic Health Science Network, regional NHS Trust and Research for Patient Benefit panels. **Carr** and **Lhussier** have been Associate Directors of FUSE, the Centre for Translational Research in Public Health (<http://www.fuse.ac.uk/>), which brings together the North East Universities and the public health

sector in collaborative research to improve health and wellbeing and tackle inequalities. Our partnership in the NE LEP Innovation Delivery Partnership for Healthy Ageing Product and Process Innovation, and **Cook**'s role as a strategic partner in the National Innovation Centre Ageing's Ageing Innovations hub, will ensure Northumbria expertise plays a key role in research-informed product and service development focussed on healthy ageing.

Our participatory and stakeholder-driven research has allowed engagement with diverse communities, for example through theatre and creative writing work (e.g., **Bailey**, with Skimstone Arts) and our extensive work with marginalised communities, including Gypsy, Roma and Traveller communities (**Dalkin, Forster, Lhussier**), and our *Northern Hub for Veterans and Military Families Research* (**Kiernan, Hill** and colleagues; <https://www.northumbria.ac.uk/business-services/engage-with-us/the-northern-hub-for-military-veterans-and-families-research/>). The latter is based on the fundamental principle of 'collaboration in research for the benefit of others' and has secured more than £1.7 million in funding to work with a range of partners and stakeholders such as MoD, the Royal British Legion, NHS Trusts and Sunderland Council and, importantly, with veterans and their families.

We also work with government and other agencies to influence policy and practice, as exemplified by our Holiday Hunger ICS (**PL Graham**, who has also led an evaluation of the StreetGames Fit and Fed pilot programme), whilst **Cheetham** is working with the Department of Work & Pensions, Gateshead Council (as an embedded researcher) and others to assess and address the impact of Universal Credit (Cheetham et al. *BMJ Open* 2019 was cited in the report of the UK visit by UN Special Rapporteur on Extreme Poverty and Human Rights). **Steer** has worked with Public Health England to improve social prescribing engagement and outcomes. **Hand**'s research was cited in an All-Party Parliamentary Group 'Mental Health Matters Too' report (2018). In **C&MS**, toxicologist **Jowsey** has collaborated with the Public Health England Centre for Radiation, Chemical & Environmental Hazards in multidisciplinary studies of adverse effects of medical radiation, and **E Graham** collaborated in an EU-funded 15-partner network of excellence to create the European Virtual Centre of Forensic Genetic Research (*Forensic Science International: Genetics* 10:40). **Fox** is a member of the Food Standards Agency 'Advisory Committee on the Microbiological Safety of Foods'.

Category C staff

Visiting Professor **JD Perry** is the only Category C staff. He is central to sustaining our partnership with bioMérieux and provides access to facilities and resources at Newcastle Freeman Hospital.

Translating collaboration into new impact

The success of our impact strategy is evidenced by the **nine ICS** submitted and the range of beneficiaries therein, from the public to pharma, and further evidenced by novel areas of growing impact that are expected to mature post-2021. These include:

- **Adams** has developed rehabilitation interventions for older people with co-morbid long-term conditions and worked with services and healthcare professionals to improve practice and patient outcomes in the UK and the USA.
- **Gray's** NIHR-funded research project 'Shifting the Gravity of Spending' has provided Public Health Commissioners within Local Authorities with tools and training to best allocate budgets for service delivery in ways that maximises health & wellbeing and value for money.
- **Jones** has developed novel culture media to improve detection on nontuberculous mycobacteria, in a promising diversification of our collaboration with bioMérieux and Freeman Hospital.
- **Moschos'** work with PulmoBioMed Ltd. to develop the PBM-Hale™ hand-held collection device for diagnostic respiratory and environmental aerosol sampling.
- **Steven's** Health Foundation-funded research on health professional's fatigue, is co-designing activities, interventions and a fatigue risk management strategy for midwifery services in an NHS trust.
- **Turnbull's** 2019 KTP with Sterling Pharma Solutions will improve the manufacturer's self-sufficiency in biocatalysis and has already expanded their customer base such that significant income is expected over the next three years.

Community and Public Engagement

In addition to our significant co-production activities, staff are encouraged to promote their research beyond academia through public engagement activities, including social and traditional media, and via channels such as The Conversation (e.g., **PL Graham**) and Globelynx (e.g., **Moschos**). For example, **Nelson** and **Turnbull** have used Facebook, LinkedIn and Twitter accounts to promote our *Bioeconomy* MDRT; the USP project (**Hand**), ImpleMentAll, ARC NENC, SLIPPS and our military veterans team have strong presences on Twitter.

Staff contribute to outreach events such as Soapbox Science (e.g., **Jones, Kelly**) and are encouraged to contribute to our NUSTEM outreach initiative (<https://nustem.uk/>), which works to increase the number and diversity of young people choosing STEM careers. **Potthoff** is Head Editor of the Practical Health Psychology blog (<https://practicalhealthpsychology.com/>). **Garner** is

the Public Engagement expert on the Biochemical Society Education committee, promoting their Art and Science Exchange outreach activities, and **Vijaykumar** has worked with the Cap-A-Pie theatre company in schools. **Dean** and **Turnbull** have been recognised by Royal Society of Chemistry 'Inspirational Member' awards for their roles in developing diverse and accessible outreach activities (2020 and 2018, respectively).

In 2014 the University entered into a Partnership Agreement with the International Centre for Life (<https://www.life.org.uk/>) to develop further our relationship, building on activities such as workforce development with geneticists from the genomics medicine service and informal 'Meet the Scientist' events (e.g., **Sangal, Jones**). **Bailey, Thompson** and **Tiplady** are working with Tyne & Wear Museums to improve health and wellbeing by engaging older people in arts and cultural activities. Publicising our research is supported by the University Marketing & Communications service.

Response to COVID-19

Our researchers are contributing directly to the COVID-19 response. Notably, the NU-OMICs sequencing team are members of the COVID-19 Genomics UK Consortium (<https://www.cogconsortium.uk/>; group authored papers in *Cell*, *Lancet Microbe* and *Science*), sequencing >6000 samples since March 2019 (UKRI funded, >£500K).

Our expertise has allowed rapid innovative multidisciplinary responses including:

- **Perry** (£100K DASA, Col) to develop superhydrophobic antiviral coatings.
- **Li** (£393K UKRI, Col) to establish an 'Observatory for Monitoring Data-Driven Approaches to COVID-19'.
- **Tetard** (£25K Innovate UK, with Ideal Manufacturing) investigating ozone nanobubbling effects on viral disinfection for laundry applications.

Novel projects to assess the healthcare impact and response to COVID have been developed including **Rapley** (£10K Elizabeth Casson Trust, to improve use of telehealth in children's therapy services), **Thompson** (£7K UKRI, to assess the healthcare needs progression of residents in sheltered accommodation) and **Pollock** (QR, research into the wellbeing of healthcare and hospital workers). **Houghton** and **Sanders** are members of the NIHR COVID Recovery and Learning Research College of Experts. **AH&SC** staff (e.g., **Kelleher, Pollock**) have also worked with NHS Health Education England to deliver workforce development COVID CPD for frontline staff. **Moschos** has provided extensive expert commentary to >100 regional, national and international (e.g., CNN) media outlets.

Internally, in response to limitations imposed by COVID-19, work with human participants has been adapted by prioritising distance data collection methods (e.g., documentary analysis; online interviews).

Contributions to our disciplines

Our staff are energetic and proactive in seeking to influence our diverse discipline areas (section 1) through participation in the work of learned societies, funding bodies and key committees. These contributions are recognised and supported through workload allowances. Activities include: membership of BBSRC and MRC research committees and review panels (**Black, Ford, Li**); various NIHR grant panels (**Carr, Finch, Houghton, Sanders, Whitehead**); Educational research committee of Association for the Study of Medical Education (**Steven**); Chair, International Committee on Systematics of Prokaryotes (**Sutcliffe**); Irish Health Research Board Post-Doctoral Fellowships panel (**Finch**); International Research Network on Transitions to Adulthood from Care Steering Group (**Cordier**); Convenor, National Ambulance Frequent Caller National Network (**Scott**); Professorial Advisory Group, Chartered Society of Physiotherapy (**Adams**); Royal College of Occupational Therapy Research and Development Board (**Whitehead**); and Royal Society of Chemistry committee memberships (**Carlin, Dean, Perry, Turnbull**). **Kelly** has been appointed to the EPSRC Early Career Forum (2021-2023).

In addition, staff have contributed regularly to the peer review of funding applications for more than 50 organisations, including:

- UKRI and government: BBSRC, EPSRC, ESRC, Health & Care Research Wales, MRC, NIHR (HTA, HS&DR, PGfAR, PHR and RfPB), UKRI Innovate UK and Future Leaders Fellowships.
- UK Charity: Alcohol Research UK, Alzheimer's UK, Daphne Jackson Trust, Dunhill Medical Trust, Nuffield Foundation, Parkinson's UK, Royal College of Nursing, Versus Arthritis, Wellcome Trust, World Cancer Research Fund UK.
- International: Australian National Health and Medical Research Council, Canada First Research Excellence Fund, Czech Science Foundation, EU Marie Curie Actions, French National Research Association, Health Research Council of New Zealand, Irish Health Research Board, Natural Sciences and Engineering Research Council of Canada, Netherlands Organisation for Scientific Research & Organisation for Health Research & Development, NIH USA, South Africa National Research Foundation.

Further disciplinary and scholarly contributions have also been made by our staff who participate as editors for scientific publications including the Editor-in-Chiefs of *Advances in Biological Chemistry* (**Black**), *Antonie van Leeuwenhoek* (2009-2019, **Sutcliffe**) and *Food Hydrocolloids in*

Unit-level environment template (REF5b)

Health (Brownlee). Staff also contribute as Associate Editors of >15 journals including: Ageing and Society (**Cook**), Bioactive Carbohydrates and Dietary Fibre (**Brownlee**), BMC Family Practice (**Sanders**), BMC Microbiology (**Sangal**), Frontiers in Genetics (**McKay**), Frontiers in Microbiology (**Sutcliffe**), International Journal of Systematic and Evolutionary Microbiology (**Jones**) and PLOS ONE (**Antoniou, Haighton, Todryk**). Others have served as Special Issue Guest Editors (e.g., **Bailey, Hodgson** and **Wilson** International Journal of Environmental Research and Public Health; **Ryan** British Journal of Pharmacology) and Editorial Board members of >15 journals, including British Journal of Neuroscience Nursing (**Hand**), Cells (**Soundararajan**), Frontiers in Immunology (**Bridge**), Implementation Science (**Rapley**), Nursing and Residential Care (**Cook**), Nutrients (**Lodge**) and Physical Therapy Reviews (**Adams**). Finally, staff in the UoA frequently contribute their expertise as peer reviewers, with most staff typically reviewing multiple manuscripts p.a. Overall our staff have peer reviewed for more than 150 different journals, including Ageing & Society, American Journal of Clinical Nutrition, BMC Medicine, BMJ, Dementia, Implementation Science, Journal of Advanced Nursing, Journal of Hepatology, Qualitative Health Research, Nature Human Behaviour, Nature Microbiology, Nurse Education Today, PNAS, Royal Society Open Science and Social Science and Medicine.

Members of the UoA have been externally recognised for their contributions to their disciplines through invitations as speakers at prestigious national and international conference or workshops, such as the Chronic Living Conference (Copenhagen 2020, **Sanders**), Dutch Implementation Science Conference (Utrecht 2019, **Rapley**), European League Against Rheumatism (Amsterdam 2018, **Hackett**), European Society for Swallowing Disorders conference (Barcelona 2015, **Cordier**), Industrial Genetics of Microorganisms (Pisa 2019, **Munoz**), International Genetics of Ankylosing Spondylitis (Versaille 2019, **Antoniou**), 6th International Workshop on the Causes of Childhood Leukemia (Munich 2019, **McKay**), 8th International Conference on the Tear Film and Ocular Surface (Montepelier 2016, **McDermott**), 4th Nordic conference on research in patient safety and quality in healthcare (Kuopio 2016, **Steven**), World Nursing & Health (Rome 2018, **Bailey**) and the 5th World Parkinson's Congress (Kyoto 2019, **Hand**).

Staff have also contributed to the organisation of multiple conferences, symposia of learned societies and workshops such as the Cornea and Ocular Surface Gordon Research Conference (2018 and 2020, **McDermott**), EMBO Viruses of Microbes conference, (2016, **D Smith**), Gordon Research Seminar in Synthetic Biology (Vermont 2017, **Kelly**), European Health Psychology (since 2015, **Potthoff**), International Conference for realist research, evaluation and synthesis (Brisbane 2017, **Dalkin**), International Society for Zinc Biology (Monterey 2014, **Ford**) and 15th International Symposium on Hyphenated Techniques in Chromatography and Hyphenated Chromatographic Analyzers (2018, **Dean**).

Unit-level environment template (REF5b)

As well as conference contributions, staff have also delivered ~100 invited research seminars at other institutions and have contributed as external examiners for more than 100 PhD examinations at national and international institutions such as Monash University Malaysia (**Jones**), Sorbonne Université (**Sutcliffe**), Stellenbosch University (**Steven**), Trinity College Dublin (**Haighton, Perry**), University Pompeu Fabra Barcelona (**Simoës**), University of Sao Paulo (**Gallibadino**) and University of Tasmania (**Carr**) and the University of Waterloo Canada (**Li**). We have also contributed to institutional review and appointment/promotion panels, for example for the European Implementation Collaborative (**Finch**), Institut Pasteur (**D Smith**), l'Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail (Montréal) (**Lhussier**), Universities of Ghent (Belgium) and Nevada (USA) (**Sutcliffe**).

Commitment to reproducible science

Colleagues experienced in advanced statistical analyses and methodological approaches support others in improving the rigour and robustness of both experimental design and data processing. Examples of best practice include methods sharing in microbiome studies and the development of realist research methods (**Dalkin**). Our commitment to Open Science (section 1), notably release of primary data via publicly accessible databases, also ensures our work is available for scrutiny and reanalysis. In addition, our researchers have contributed to >100 systematic reviews and meta-analyses that have validated and extended findings from earlier studies. Examples include **Cordier** (*Journal of Medical Internet Research*), **Crandall** (*Cochrane Database of Systematic Reviews*), **Dickens** (*International Journal of Nursing Studies*), **Lara** (*British Medical Journal; BMC Medicine*) and **Newham** (*Cochrane Database of Systematic Reviews*).