Institution: UNIVERSITY OF LEEDS

Unit of Assessment: UoA4

1. Unit context and structure, research and impact strategy

1.1 Context:

Our submission includes 54 staff (49.6 FTE) who conduct theory-driven, solution-focussed research, reflecting excellence within four grand challenges (**GCs: Figure 1**, **right**):

- Nervous system and its disorders (**GC1**)
- Lifespan development (**GC2**)
- Health and wellbeing (**GC3**)
- Behaviour change (**GC4**)

These GCs naturally overlap, building from the fundamental science of genetic, cellular and neural mechanisms of behaviour (GC1), through to changes in individuals over time (GC1&2), revealing the causes of ill-health across interacting populations (GC2&3), and ultimately understanding and changing human behaviour within large, complex, social and environmental systems (GC4). GCs align with a cross-Faculty University research strategy, optimising impact through interdisciplinary translational pipelines designed to benefit society.

1.2 Structure:

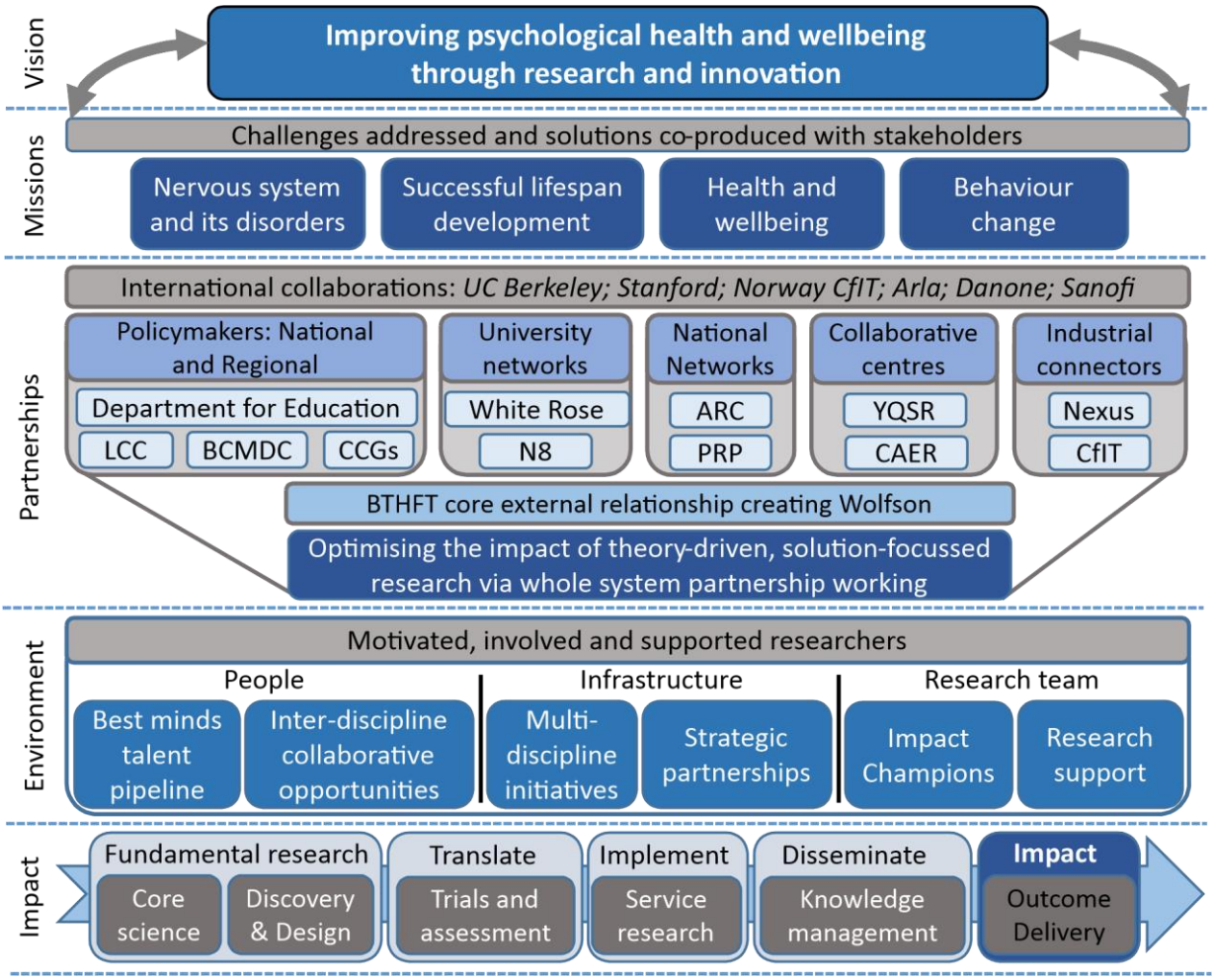
Operationally, UoA4 research is conducted across three Faculties: **Medicine and Health** (FMH - School of Psychology, School of Medicine), **Biological Sciences** (FBS - School of Biomedical Sciences) and **Engineering** (FEPS - School of Mechanical Engineering). The scale and complexity of our GCs demands interdisciplinary partnerships within Leeds, including researchers submitted in UoAs 1-5,7,11,12,14,19.

To achieve our vision, and meet the needs of ***regional*, *national*, *and global priority areas***, we conduct interdisciplinary, fundamental research investigating mechanisms of behaviour and developing innovative applications for our findings. This strategic approach was facilitated by significant investment by the **University of Leeds** (with co-funding) over the REF2021 period to create and support outstanding platforms for UoA4 research and impact, including:

- Wolfson Centre for Applied Health Research – based at our Bradford campus and focussing on patient safety and lifespan development (**Wolfson**)
- Yorkshire Quality and Safety Research group (**YQSR**)
- Centre for Applied Education Research (**CAER**)
- Centre for Immersive Technologies (**CfIT**)
- The eight research intensive Northern universities (N8) Programmes in Agrifood (**N8: Agrifood**) and the Child of the North (**N8: CoTN**)

Interdisciplinary approaches support longstanding, strategically important research infrastructure. Strategic partnerships with the NHS, Local Authorities, Central Government, and Industry have shaped impactful research into neuroscience, cognition, health, nutrition, child development, education, and data science (particularly 'immersive technologies').

1.3 Research and Impact (R&I) strategy:



Acronym Key: **L**eeds **C**ity **C**ouncil; **B**radford **C**ity **M**etropolitan **D**istrict **C**ouncil; **C**linical **C**ommission **G**roup; **N**orthern **8** (research intensive Universities); **A**pplied **R**esearch **C**ollaboration; **P**revention **R**esearch **P**artnership; **Y**orkshire **Q**uality **S**afety **R**esearch; **C**entre for **A**pplied **E**ducation **R**esearch; **C**entre for **I**mmersive **T**echnologies; **B**radford **T**eaching **H**ospitals **F**oundation **T**rust

Figure 2: Research and Innovation Strategy Map.

We foster a dynamic R&I environment by actively pursuing research as a mechanism for generating positive societal change through realising our vision of ***improving psychological health and wellbeing*** (Figure 2). Our missions address global priorities, achieved through outward facing GCs. A 'Push, Pull, Link, Exchange' approach lies at the heart of our GCs to ensure our research leads to societal impact. We hardwire the dissemination of knowledge into our research (push), stimulate a knowledge demand (pull), and promote the organisation of activities to unite our stakeholders (link and exchange).

Regular re-evaluation of the GCs with our interdisciplinary collaborators has reinforced the value of these structures, which underpin our future research plans (Figure 1). Following REF2014, we consolidated two GCs ('Successful Childhood Development' and 'Successful Ageing') into **Successful Lifespan Development**. This enabled a holistic approach within the GC, and facilitated the application of novel solutions across UoA4 disciplines (e.g. adapting children's handwriting assessment technology to measure cognitive decline in older adults), and cross-links to UoA2's Ageing health service research.

Our **refreshed GCs** provide:

- A flexible structure to foster interdisciplinary collaborations that address globally-relevant research priorities (all UoA4 staff map onto one or more GCs)
- A strategic framework for identifying and supporting our research strengths
- A principled approach to investing in infrastructure, shaping University priorities, and aligning our activity with major University investments (e.g. Nexus – connecting our researchers with business; and the Leeds Institute of Data Analytics, **REF5a**)
- A road map for fast-tracking fundamental science to societal impact
- Agility to adapt to societal priorities as needs arise (e.g. COVID-19)

UoA4 contains Research Groups delivering interdisciplinary research across the GCs. These Groups provide bottom-up organisational structures that foster our researchers. For example, 'neuroscience at Leeds' (**Neur@L**) is a cross-faculty group facilitating interdisciplinary collaborations to investigate mechanisms of neurological diseases. Research Groups develop and support PGRs, ECRs, and senior researchers through weekly meetings, journal clubs, and feedback on grants, papers and fellowship applications.

Applying our agile R&I strategy to COVID-19: We responded to the global coronavirus pandemic by mobilising our researchers and supporting policy, advisory and outreach roles. National and regional COVID-19 committees co-opted UoA4 staff (***Section 4***). Our researchers joined the District Gold Command scientific advisory group (**Mon-Williams**), evaluated impact on global health (**Kellar**), set psychology research priorities (**O'Connor**), and led a national task force addressing identification of vulnerable children (**Mon-Williams**). We received rapid response grants to determine the lockdown impact on educational, developmental and nutrition outcomes (e.g. **Fildes**, **L.Hill**, **Nash**, **A.Waterman**). Outreach initiatives included: publishing a special issue on dietary behaviour research (**Flint**, **Hetherington**) and outputs on psychological impacts (**O'Connor**)**;** hosting webinars (with Stanford University) to connect school leaders with health professionals (**Halford**, **A.Waterman**); briefing government (**L.Hill**, **Mushtaq**, **Mon-Williams**, **A.Waterman**); and establishing a counselling service for headteachers (**Mon-Williams**).

1.4 Delivery of R&I Strategy:
Our R&I strategy rests upon motivated, involved, and supported researchers. We operate a distributed leadership model involving Faculties, Schools, GC research leads, Professorial staff (with specific mentorship roles), and Impact Champions. Our research leaders identify research excellence and ensure investment in areas that have clear impact aims, and credible delivery plans with effective and pragmatic evaluation methods. We invest in attracting the best minds to Leeds (PGRs, ECRs and established researchers), facilitate collaborative opportunities (within the University and with external stakeholders), and provide leading edge research infrastructure.

Our researchers drive and deliver our strategy by creating Research Groups that reflect their interests, skills and interdisciplinary needs. Our structures allow us to support staff in developing sustainable plans for progress in impactful research (e.g. via the provision of competitive Impact Accelerator Accounts). We support staff to develop their leadership skills and lead research groups. Ten Faculty **Impact Champions** (IC) support our impact environment (e.g. **R.Lawton**). We created the IC role in the current REF cycle to support delivery of our vision, and these champions provide a systematic approach to delivering high quality research and impact, and engagement with stakeholders. The champions are impact experts and generate significant

impact through their own research. Their role is to ensure that impact is embedded into our research, and support researchers to include impact principles in their work. Our Case Studies demonstrate impact across all four GCs, with Impact delivered in partnership with stakeholders drawn from public (e.g. health authorities), government (local and central), and industry (e.g. food).

Our strategy recognises that a collaborative interdisciplinary ecosystem is required to deliver high quality impactful research. Our GCs support interdisciplinary team-driven investigations by researchers at all levels. Since 2014, we have expanded our regional, national and international academic partnerships (***Section 4***) as indexed by collaborative outputs published in the *Proceedings of the National Academy of Science* (**Billington**, Leverhulme Fellowship in collaboration with UoA5); *Current Biology* (**Mushtaq** with Princeton and UC Berkeley); *Psychological Science* (**L.Hill** with Stanford University); and *Journal of Clinical Investigation* (**Gamper** with Hebei Medical University, Shijiazhuang, China).

Our strategy has resulted in the creation of new centres over the REF2021 period (Wolfson, YQSR, CAER, CfIT). These centres provide our researchers with access to bespoke research space, leading edge technologies, patients, datasets and practitioners. Importantly, they embed our researchers within regional and national networks, and connect them to policy makers (allowing the acceleration of research into policy).

Our researchers have created research infrastructure of international significance. For example, researchers from across the world can access the **Born in Bradford** (BiB) dataset, with **A.Waterman** and **L.Hill** providing the cognitive and sensorimotor measures within the dataset (for over 17,000 children). Our researchers have helped establish the **Connected Yorkshire** database which has already linked routinely collected data from education, health and social care for 1.4M residents. Likewise, we support the UK-based birth cohort **Gemini** involving 2,402 families with twins (co-directed by **Fildes**). Our research infrastructure allows us to support the **Leeds City Council** (LCC) and **Bradford City Metropolitan District Council** (BCMDC) in evaluating policy implementations (e.g. BCMDC's *£0.65M* investment for tutoring disadvantaged children). We adhere routinely to a policy of Open Access (OA) publishing for all outputs, and the principles of the open science framework (OSF) are crucial to our strategy to increase openness, integrity, and reproducibility of research using pre-registration, data sharing and publishing OA preprints (e.g. Data@Leeds).

An Impact team led by a permanent full-time **Impact Officer** support our strategic plans to prioritise Impactful research. Our Impact team use 'roadshows' to raise awareness of the Impact strategy across our Schools, organise workshops to support our researchers, and create Impact Groups within Schools to provide peer-to-peer support.

1.5 The Grand Challenges:
The GCs align with regional, national, and international research needs. Thus, we match local capacity to globally relevant research priorities (including the UN sustainable development goals of Good Health and Well-being, Quality Education, and Reducing Inequality).

1.5.1 GC1 The nervous system and its disorders: GC1 research improves understanding of neurological disorders, chronic pain, ageing and healthy brain function (perception, action and cognition), then translates this knowledge to assessment, intervention and prevention strategies. We meet this challenge by having a breadth of expertise spanning all levels of biological

complexity: molecular genetics and imaging, modelling cells, animal models of neurological disease, laboratory studies of human behaviour, and clinical trials. The Neur@L team applies interdisciplinary approaches to investigate mechanisms of neurological diseases. The fundamental research investigates characteristics of the spinal cord connectome (**Chakrabarty**, **Deuchars**, **Kwok**), sensory processing (**Gamper**, **Johnston**), brain control of metabolism (**Filippi**, **Johnston**), and general mechanisms of neuronal excitability, synaptic transmission and plasticity (**Clapcote**, **Deuchars**, **Gamper**, **Johnston**, **Kwok**, **Wood**)**.** We examine disease states or pathologies, enabling identification of new therapeutic avenues for exploitation. We have specific expertise in spinal cord injury and repair (**Chakrabarty**, **Deuchars**, **Kwok**), where enhancing plasticity post-injury can lead to functional recovery. We focus on ageing (**Clapcote**, **Deuchars**, **Kwok**) where neuromodulation is used to target autonomic imbalance (**Deuchars**), and manipulation of plasticity can aid memory improvement (**Kwok**). Our researchers further the understanding of pain transmission and chronic pain mechanisms (**Gamper**, **Lloyd**, **Wood**). We undertake genetic studies of rare diseases and characterise functional effects of specific genetic variants using cellular and animal models. We investigate genetic influences on the onset of neurodevelopmental, neurodegenerative, and psychiatric disorders (**ICS#UOA4-1 Clapcote**, **Inglehearn**). For example, cilia defects identified using whole-genome siRNA-based functional screening have been linked to heterogeneous inherited developmental conditions affecting the central nervous system (**Inglehearn**). We have identified the role of molecular and epigenetic pathways (**Clapcote**, **Wood**) and the biochemical markers of diabetes (**Filippi**, **Wood**) to generate new therapeutic targets. We have advanced the understanding of molecular and neuro-physiological events associated with potential brain targeted therapies for obesity and diabetes (**Filippi**, **Johnston**).

Alongside GC1's discovery science, our research has identified pathways for improving outcomes for those with developmental disorders (**Billington**, **Mon-Williams**), cerebral palsy (**Holt**, **Mon-Williams**), stroke (**Chakrabarty**, **Wilkie**), and trigeminal neuralgia (**Coats**). Collaboration with Mechanical Engineering has delivered innovative methods to investigate motor control, e.g. measuring human visuomotor attention (**Coats**, **L.Hill**, **Holt**). Our research on human cognitive function: language and memory (**Allen**, **Brown**, **Delvenne**, **A.Waterman**); perception and action (**Billington**, **Burke**, **Coats**, **L**.**Hill**, **Lloyd**, **Mon-Williams**, **Mushtaq**, **Wilkie**) has led to impact in vehicle evaluation and design, informing the newly established 'Direct Vision Standard' developed by Transport for London, based on our measurements of human perceptual capabilities (**Wilkie**). From March 2021, this vision safety standard will affect all >12 tonnes gross vehicle weight lorry operators entering Greater London.

1.5.2 GC2 Lifespan Development: GC2 focusses on the psychological, social, nutritional, and neurological processes associated with childhood development and ageing. Using powerful patient datasets (including longitudinal birth cohort study **BiB**) we identify risk and protective factors amenable to intervention (**ICS#UOA4-2**)**.** Our interdisciplinary teams tackle critical issues affecting childhood development including: nutrition (**Bryant**, **Dye**, **Fildes**, **Hetherington**), sleep (**Nash**), the social, cultural and economic factors in children's home environments (**A.Hill**, **Nash**), and cognitive development (**Allen**, **Nash**, **A.Waterman**). Understanding how neurodevelopmental disorders affect outcomes (and early identification) is central to our research (**L.Hill**, **Mon-Williams**, **Nash**, **A.Waterman**), including risks to children's mental health (**L.Hill**, **Hugh-Jones**, **Mon-Williams**). Through these projects, we are building the evidence base for effective interventions (**Bryant**, **Dye**, **L.Hill**, **Hugh-Jones**, **Mon-Williams**, **A.Waterman**). For example, our nutrition research is leading to impact delivered through policy

and practice increasing vegetable intake amongst preschool children (**Fildes**, **Hetherington**) and promoting breakfast for school children (**ICS#UOA4-3**). It has informed development of UK national infant feeding guidelines and fast-growing single vegetable product lines to support vegetable-first strategies by food companies (**Birtill**, **Fildes**, **Hetherington**). We have conducted longitudinal studies of cognitive development beginning in the preschool years (**Nash**), and followed the development of cognitive and motor function after entry to school in 17,000+ children (**L.Hill**, **Mon-Williams**, **Mushtaq**, **A.Waterman**, **Wilkie**). Our research identifies the need for early screening of developmental dyslexia and detection of language difficulties with implications for education policy (**Nash**). Findings from BiB demonstrate that new service delivery models are needed to prevent further exacerbation of social inequality and this has driven policy change (**Mon-Williams**, **Mushtaq**). We have also developed and evaluated interventions to reduce health and social inequalities with this cohort (e.g. **Bryant**, **Mon-Williams**, **A.Waterman**), linking with the goals of GC3.

GC2 research investigates how healthy ageing affects cognition and decline and applies the research to detection of age-associated cognitive impairment and dementia (**Bunce**, **Burke**). We are part of the UK Dementia & Neurodegenerative Diseases Research Network (**Holt**). We have expertise in the early detection of age-related neural decline using neuroimaging methods (**Bunce**, **Burke**, **Delvenne**), as well as studying memory deficits in older adults (**Allen**). We characterise depression and cognition in older adults (**Bunce**) and age-related changes in quality of life due to nutrition status (**Dye**, **C.Lawton**). In collaboration with University of New South Wales and Australian National University we exploit large-scale population-based data to investigate associations between cognition and frailty, and neurocognitive predictors of falls (**Bunce**). We explore links between endocrine function, wellbeing and sexual health through the European Male Aging Study and the English Longitudinal Study of Aging (**O'Connor**).

1.5.3 GC3 Health and Wellbeing: GC3 works to maintain the health and psychological wellbeing of individuals, families and workforces through our well-established strengths in psychological health, nutrition and obesity research. Interdisciplinary teams apply diverse methods of investigation, from behavioural genetics to laboratory-based experiments, community-based RCTs, observational studies, qualitative approaches and systematic reviews. Our research has identified genetic markers of psychotic experiences in adolescents, identification of major risk alleles for schizophrenia in consanguineous families (**Cardno**), and obesity risk in early childhood (**Fildes**). We have conducted, with University of Cambridge, clinical trials of family therapy for young people who self-harm and investigated cause of death in adolescents after hospitalisation for self-inflicted, drug/alcohol or violent injury (**Cottrell**). Our research laboratories have identified psychological and physiological vulnerability predictors for people at risk of suicide (**O'Connor**), and we have undertaken trials of collaborative care for depression in older people (**A.Hill**, **Traviss-Turner**). We have applied qualitative enquiry to enhance understanding of specific physical and mental health challenges (**Guthrie**, **Madill**, **Hugh-Jones**); and investigated psychological harms associated with obesity stigma in children and adults (**Flint**, **A.Hill**, **Stubbs**). We have conducted influential systematic reviews and intervention studies into the health and wellbeing of healthcare professionals and, in collaboration with local NHS Clinical Commissioning Groups (CCGs), identified ways to reduce healthcare professional burnout and protect patient outcomes and safety (**Johnson**, **O'Connor**). We have provided 'Improving News Delivery in Ultrasound' workshops for public health and healthcare professionals, policymakers, and lay stakeholders (**Johnson**).

Interdisciplinary collaborations with the NHS (**Conner**, **R.Lawton**, **O'Connor**, **Prestwich**, **Kellar**) have led to a strategic focus on patient safety, and transforming practice (**ICS#UOA4-4**), underpinned by NIHR funding that is larger than that of any other UK Psychology department (see ***Section 3***, ***Table 1***). The obesity science research within GC3 captures our values of interdisciplinarity, discovery science, and translation (**Birtill**, **Blundell**, **Bryant**, **Dye**, **Fildes**, **Finlayson**, **Gibbons**, **Halford**, **Hetherington**, **A.Hill**, **C.Lawton**, **Stubbs**). Psychology is home to the UK's first human appetite research facility, established by **Blundell** in 1989 (noted in RAE2008 as having 'particular distinction in psychobiology'). Foresight in establishing this laboratory has led to sustained and expanding internationally renowned research in appetite, nutrition and infant feeding at a time when obesity has become a public health crisis. This facility has grown substantially and now supports the research activity of 6 professors, 3 associate professors, 1 University Academic Fellow (UAF), a dedicated research dietitian, and a team of PGR students and ECRs. It has been at the forefront of obesity science and impact for 30+ years. For example, robust methodologies for appetite studies (REF2014 ICS, **Blundell**) have contributed to patented satiety agents, 'energy balance' discovery science, and clinical trials of obesity treatments (**Blundell**, **Dye**, **Finlayson**, **Halford**, **Hetherington**, **Stubbs**). We have developed the first integrated computerised procedure for dissociating the conscious pleasure for food (**Finlayson**), which is currently used by the French and US militaries to track food preferences of soldiers during field training. This tool has already improved the awareness and understanding of soldiers' eating behaviour during missions and is informing changes in military ration policy.

1.5.4 GC4 Behaviour change: GC4 builds on research across GC1-3 to deliver improved societal health and wellbeing guided by the WHO's identification of *behavioural risk factors* as the leading causes of morbidity and mortality. Health-oriented behaviour change research at Leeds has more than 20 years of continuous funding. GC4 contributes to a better theoretical understanding of effective behaviour change techniques (**Conner**, **R.Lawton**, **O'Connor**, **Prestwich**), and examines specific mechanisms of action through large scale, complex interventions, systematic reviews, and meta-analyses of behaviour change interventions. Specifically, we use behaviour change to improve human health through the prevention and management of chronic stress (**O'Connor**), obesity, diabetes, depression, cancer, persisting and emerging infections, and maintaining medication adherence (**Kellar**). We focus on changing behaviours related to smoking (**Conner**), children's eating behaviour (**Birtill**, **Fildes**, **Hetherington**), breakfast consumption (**Dye**, **C.Lawton**), physical activity and weight loss management (**Blundell**, **Finlayson**, **Gibbons**, **Halford**, **Prestwich**, **Stubbs**), blood donation (**Conner**), cancer screening attendance and vaccination (**O'Connor**), and improving patient safety (**R.Lawton**).

NIHR has funded intervention development that NHS Trusts use to reduce 'never events' occurring when feeding tubes are accidentally placed in the lungs with potentially fatal consequences. This training has been disseminated to >1000 NHS staff (**ICS#UOA4-4**). The EU funded **NoHoW** project is an example of a large scale, multinational, interdisciplinary project that integrates expertise from GC3 and 4, developing digital technologies to objectively measure energy balance for long-term weight management (**Stubbs**). The MRC/NPRI funded smoking prevention projects involving 6,000 adolescents from Yorkshire and Staffordshire (**Conner**) shows the scale and significance of our research. This low-cost school-based intervention, that successfully reduces adolescent smoking initiation, is being licensed directly to Local Authorities to be implemented in secondary schools across the UK. Our collaboration with specialists in

medicine, public health, epidemiology, health economics, and trials to develop a novel tool (typology of interventions in proximal physical micro-environments: **TIPPME**) to improve systematic design, reporting and analysis of choice architecture and nudge interventions evidences our interdisciplinarity. **TIPPME** has been applied to the selection, purchase and consumption of food, alcohol, and tobacco (**Prestwich**).

1.6 Plans for the next five years:
We will drive forward our strategy to improve health and wellbeing, aligned with the FMH strategy, through our **GCs** (Figure 2).

We will continue to promote **interdisciplinary research** by leveraging the infrastructure and capacity of major investments, such as **N8**, **CfIT** and **Wolfson**, and strengthen our partnerships, e.g. working with the Leeds Institute for Data Analytics and partners in the Department for Education to develop a National Electronic Vulnerability Index to identify 'at risk' children; and with N8 NetZeroNorth initiatives to support resilient, sustainable food systems to combat food insecurity exacerbated by COVID-19.

We will further develop our thriving research environment through:

- Taking a strategic approach to **public and patient engagement**, by building sustainable partnerships with existing groups, increasing diversity, and developing novel methods of involvement using our **Impact Support Team** (see Collaborations)
- Building on our EDI strategy to promote a diverse, equitable and inclusive **research culture**
- Leveraging policy-maker, professional, public, industrial and academic **partnerships** to maximise the relevance and reach of our research
- Securing grants from major government, research council, charity and industry funders, and targeting longer and larger awards to ensure sustainable **research income**, and ensure our researchers maintain access to **leading-edge research infrastructure**
- Recruiting, identifying, and developing future **research leaders** by winning high quality doctoral, postdoctoral and senior training fellowships. In early 2021 Psychology will recruit three new outstanding Grade 8 Lecturers to align with existing peaks of research excellence.

2. People

2.1 Staffing strategy:
We recruit and develop high-calibre and highly motivated staff to deliver - sustainably - our R&I strategy. Our staffing strategy constitutes a progression framework that is fair and inclusive, recognising and rewarding effort and excellence, built on the following principles:

- Support and promote existing staff e.g. Reward and Recognition Scheme
- Nurture and develop our ECRs for future leadership (e.g. supporting **Billington**, **Kwok** with successful Leverhulme Trust Fellowships)
- Recruit and develop world leading researchers (e.g. **Morehead** from Harvard University)
- Ensure equality of opportunity across the career span for personal and professional development (e.g. **Mushtaq** appointed Alan Turing Institute Fellow at 5%FTE)
- Protect researchers needing to take a career break (e.g. caring or maternity duties) through the Faculty Academic Development Fund

The staffing strategy is underpinned by our commitment to Equality, Diversity and Inclusion (EDI). UoA4 staff comprise: 35% Professors; 41% Associate Professors/Senior Lecturers; 17% Lecturers and 7% UAFs (**REF5a**). Our overall gender ratio within UoA4 is 53%F:47%M. Since REF2014 we have promoted 3 lecturers to Grade 8 (2F, 1M); 15 lecturers to Associate Professor (10F, 5M); 3 UAFs to Associate Professor (2F, 1M); 4 Associate Professors to Professor (1F, 3M), made 2 new strategic appointments to Professor (2M) and 2 to Associate Professor (2M), and recruited UAFs across each of the GCs (4F, 3M). Within the promotions materials we invite staff to inform us of BAME and disability status, however this is voluntary. We have only 6% of staff within our promotion cases who identify as BAME (see item 2, EDI strategic plan below).

Specific recruitments during REF2021 include:

- A new Head of Psychology (**Halford**) to provide leadership, and enhance the obesity science group as lead for N8 Agrifood Nutrition/Behaviour Change Theme and one of three leads for the €9m **H2020 SWEET project**
- A Chair in Appetite and Energy Balance (**Stubbs**) with substantial H2020 funding on weight management (GC3 and GC4)
- Two Associate Professors to build capacity in patient safety (**Benn**) and complex behaviour change trials (**Kellar**)
- Seven UAFs across Psychology (**Fildes**, **Morehead**, **Mushtaq**), Medicine (**Bryant**) and Biology (**Filippi**, **Johnston**, **Kwok**). **Bryant**, **Kwok** and **Mushtaq** subsequently promoted to permanent Associate Professorships

Strategic Joint-Appointments: We work with our strategic partners to ensure our staff can commit time to collaborate on mission-critical, impactful research that underpins programme grants and societal benefit:

- We supported our staff to be located within the Bradford Teaching Hospital Foundation Trust (BTHFT) over the last decade. These efforts increased over REF2021 and culminated in the creation of Wolfson. In turn, BTHFT has provided salary cover for our staff to work within the Bradford NHS system. For example, 80% of **R.Lawton**'s annual salary has been covered by BTHFT, with 20% of the salary of **Benn**, **L.Hill**, **Johnson**, **Mon-Williams** covered over strategic periods during REF2021
- We collaborate closely with the University of South Eastern Norway (USN) and supported the creation of the Norwegian Centre for Immersive Technologies. USN have covered 20% of **Mon-Williams**' salary to enable this collaboration
- The **N8** covers 20% salary to support **Dye**'s Nutrition and Behaviour Change lead role

Internships: We created an industrial variant of our Psychology BSc degree to allow students to undertake paid internships within their research projects over a one-year period. We have embedded **50 fully-funded year-long interns** in our research centres (e.g. YQSR) and projects (e.g. BiB) and hosted **8 fully-funded postgraduate** Data Scientist Internships over the REF2021 period. This strategy ensures that there is a direct channel of talent developing real world experience (with existing PGRs recruited from these cohorts).

2.2 Staff development and support:
We have made significant investments in staff development across our GCs; embedded EDI processes within our strategy, and provided support for staff development and progression. The University has a Vitae HR Excellence in Research Award. A recent internal 10-year review

(01/21; **REF5a**) highlighted achievements, including: 10 days development time as an entitlement; and implementing schemes to recognise researcher contributions to supervision, funding and teaching. All these areas came from open meetings and feedback from our researchers (HR excellence Concordat).

Each staff member has a mentor for the Staff Review and Development Scheme (SRDS) and Academic Annual Meetings (AAM). These processes ensure mentorship for progression and promotion; the SRDS enables reflection on annual research achievements, goals, and needs, whilst the AAM provides a platform to plan research and impact according to workloads. We flex the workload model to accommodate periods of heightened research and impact activity, corresponding to specific leadership demands. Thus, we manage staff time flexibly to respond to the changing demands of the research environment (e.g. **COVID-19**). We specifically recognise, reward, and support Impactful research within our workload model (5%FTE allocation for each Impact activity).

Our seminar programmes encourage staff networking, and engagement with visiting researchers, e.g. Psychology have held >60 research seminars over the REF period attracting audiences from across UoL with speakers varying from ECRs to internationally-renowned researchers based in the UK and overseas. Collaborations with these external researchers have produced publications (**Billington**, **Bunce**, **Bryant**, **Fildes**, **Finlayson**, **L.Hill**, **Mon-Williams**, **Mushtaq**, **Stubbs**) and grant applications (e.g. two successful applications from the Global Challenge Research Fund: **Madill**). Our Schools have invested significantly in promoting equality by sponsoring places on career development programmes, such as Aurora (Leadership Foundation for Higher Education), to support women with leadership aspirations in academia (**Havelka**, **Hugh-Jones**, **Kwok**, **Lloyd**, **A.Waterman**).

2.3 Equality, **diversity and inclusion:**
UoA4 benefits from strong leadership to deliver on EDI goals. All staff have mandatory EDI training to raise awareness of unconscious bias. In November 2019, **Athena Swan Gold** was awarded to the School of Medicine (the first Medical School in the UK to receive **Gold Award**), and **Silver** to the Faculty of Engineering. FBS has held **Bronze** since April 2017 then **Athena Swan Silver** in May 2020. **Athena Swan Bronze** was awarded to Psychology in 2014 and **Athena Swan Silver** in May 2019.

We have an EDI committee checking progress against Action Plans to achieve EDI goals using a self-assessment process involving an ongoing cycle of information gathering, analysis, and evaluation. We embed EDI monitoring across UoA4 schools and remain vigilant to ensure that gender ratios match Russell Group (RG) benchmarks (e.g. Psychology met female RG benchmark at grade 8 in 2016/17 and at all levels in 2017/18). EDI representatives attend Faculty and School Senior Management Teams, embedding equality at every level of University business. We prepare staff for promotion through regular Promotion Workshops, mentoring, as well as our Athena Swan Champions reviewing draft promotion applications.

EDI strategic outcomes include:

- Adherence to UoL Code of Conduct and mandatory staff training on EDI
- Enhanced flexible working provision
- Extension of fixed-term contracts to the end of a period of parental leave to ensure access to redeployment and other support

- Facilities to support women on return from maternity leave to breastfeed (e.g. private rooms for feeding, expressing/storing breastmilk)
- Improved identification and reporting of unacceptable behaviour, including bullying, sexual and racial harassment
- An Academic Development Fund – awarding researchers up to £15k to maintain career trajectory during or following extended leave for family reasons or illness

Our strategic EDI plan for the next five years will tackle the following priorities:

1. Enhancing the leadership pipeline by supporting and promoting more women and BAME groups to grades 9 and 10 (Associate Professor/Professor)
2. Increasing BAME and socioeconomic diversity across our staff at all levels
3. Providing support for PGRs who need to leave their studies early
4. Targeting mental health and well-being support to staff identifying as LGBTQ+
5. Improving opportunities and access for staff with a disability, and identifying and removing barriers for career progression linked to protected characteristics

We embed strategic EDI goals across Schools in alignment with the University Framework. Regular monitoring and analyses of REF data by gender, BAME and protected characteristics help us to monitor and meet our EDI objectives.

Our investment in the **Wolfson** allows our researchers to tackle directly issues of race, place, and disadvantage with studies (e.g. BiB) investigating the factors which hinder social mobility. **Mon-Williams** is a scientific adviser to the Social Mobility Commission and our researchers provide expertise to the Department for Education's 'opportunity area' social mobility programme (**L.Hill**, **Morehead**, **Mushtaq**, **A.Waterman**). The creation of a physical presence in Bradford (where there is high ethnic and socioeconomic diversity) is part of our strategy for improving our EDI through **Wolfson** to create a future channel of talent from underrepresented groups.

2.4 Recruitment, **training and supervision of PGR students:**
We recruit International and home PGR applicants through open competition and targeted contact (where identified candidates are required for funding schemes). An investment of >£10M created 110 new PhD positions across the University for 2015 and 2016. UoA4 received eight of these (three with cross-Faculty supervision) and we have attracted other prestigious PhD funding awards including:

- White Rose Doctoral Training Partnership ESRC Network scheme ('Inequalities and Cognitive Development') in partnership with BIHR
- ESRC Collaborative awards with industry partners (e.g. Danone, Purely Nutrition)
- MRC funded PhDs between Schools of Medicine and Psychology (nutritional intervention for phenylketonuria and cognition in cystic fibrosis)
- BBSRC shared studentships between School of Psychology and FBS (stress and nutrition)
- Endowed scholarships shared between Schools of Medicine and Psychology (renal disease and patient behaviour); and Food Science and Technology (oral processing; hibiscus and cognition)
- Piers Mullan award (School of Biomedical Sciences, FBS)
- Alumni funded scholarship for UC Berkeley graduate to undertake a PhD in Leeds

We provide an interdisciplinary training environment, collaborations across Faculties, and excellent research facilities. **UoA4 supervised 364 PGRs** including professional research doctorates (PhD/MD awarded:170; current: 97; DClinPsych awarded: 87; current: 10) many of whom had cross-Faculty supervisory teams (Faculties of Arts, Engineering, Earth and Environment). Similarly, UoA4 staff supervised PGRs based elsewhere in the UoL e.g. Schools of Design, Food Science, Healthcare, Computer Science). Our Postgraduate Research Experience Survey (2019) reported 82% were satisfied with their experience of training and supervision.

We benefit from an Organisational Development and Professional Learning team (ODPL, **REF5a**) who provide training to PGR supervisors. Senior staff mentor new supervisors. We monitor PhD progress through bespoke software - GRAD (Graduate Record of Achievement and Development). Each PGR has dedicated funding to support research costs, training and travel. Supervisors meet students at least monthly and record these meetings on GRAD. Independent assessors undertake annual formal progress reviews to guide PGRs as they progress through the PhD. All schools have a Director of PGR Studies, overseeing PGR life and providing pastoral oversight.

UoL infrastructure investment ensures an engaging and responsive PGR environment. PGRs have dedicated work areas, access to labs, and laptops for flexible working. We have large, dedicated open plan offices for first year students and smaller, shared offices for final year PGRs. There are PGR social meeting areas with kitchen facilities to promote group cohesion. We provide PGRs with local inductions on arrival and, with the supervisory team, develop and agree a training plan that we review and update at least annually.

3. Income, **infrastructure and facilities**

3.1 Income:

(plain text gives total value of individual awards, **bold refers to UoA4 share of income/award value this REF period**, *italics refers to total (cumulative) award values*)

To support excellence in research we have a diverse portfolio of funding sources, which drive innovative and impactful research across GCs. The total value of research awards was *£49.8M,* (**£19.3M** UoA4 staff) and expenditure on these grants of **£15.2M** across the REF period (Table 1). Awards directly to UoA4 have more than **doubled** since REF2014 with UKRI being the greatest single funding source (**£5.3M**). This total includes strategically important EPSRC, BBSRC and ESRC Global Challenges Research Fund (GCRF) awards.

Our greatest increase in funding support since REF2014 is from UK Central Government, Local Health and Hospital authorities. The value of these specific awards has increased nearly 300% (to **£4.2M**) including NIHR awards increasing from £0.3M (REF2014) to **£2.7M** (Table 1). Research awards from the UK-based charity sector has doubled since REF2014. We have also maintained funding from other sources including EU, industry (e.g. UK based ARUP and global food brands) and non-industry funders such as Highways England, and the US Department of Defense. Grant capture was **~£2.4M** *per annum* from all sources.

		Awarded			Expenditure	
		REF2014	REF2021		REF2014	REF2021
UoA4 Value		£7,985,428	£19,303,178		£12,722,160	£15,215,359
Funding breakdown						
BIS Research Councils		£2,487,644	£5,263,873		£4,161,156	£4,150,593
UK Based Charities		£2,254,862	£4,646,701		£3,542,956	£2,707,201
UK Central Government, Local Health Authorities**		£1,139,247	£4,176,201		£2,501,290	£3,064,998
Non-EU		£325,640	£1,176,319		£483,182	£1,413,333
EU Govt		£678,439	£1,953,065		£837,152	£2,350,138
EU Other		£489,384	£462,748		£351,595	£434,966
UK Industries / Public Corporations		£603,212	£1,478,569		£835,828	£1,071,619
UK Other Sources		£7,000	£145,701		£9,001	£22,511
***including NIHR**		£334,900	£2,684,240		£58,390	£1,938,565

Table 1: Awards and expenditure REF2014 compared to REF2021

We benefit from dedicated support in generating and maintaining all funding applications, including Research and Innovation Development Managers in all Faculties. We enjoy specialist grant administrators using bespoke software (KRISTAL) for costing grants appropriately to ensure research sustainability. Our schools all have business and finance managers who assist in ensuring continuity of service from pre to post-award. A dedicated University EU research office and major grant initiative team supports applications and management of large awards.

GC funding examples:

GC1 awards align with MRC/BBSRC priorities of resilience, repair, replacement, and healthy ageing. Substantial funding supports research into the mechanisms underlying control of sensory processing, and pathological changes in spinal cord injury, neurodegeneration, chronic pain and resistance. Funding includes UKRI: MRC (**Filippi** £1.2M, **Gamper** £0.7M + £0.4M, **Gamper/Wood** £0.5M, **Kwok** £0.4M), BBSRC (**Clapcote/Johnston** £0.4M, **Gamper** £0.5M, **Deuchars** £0.4M), EPSRC (**Wilkie** £0.7M, **Billington** £1.2M); Charities including the Wellcome Trust (e.g. **Gamper** £1.1M, **Wood** £1.1M, **Deuchars** £0.5M + £0.4M, **Filippi**, **Kwok**), Leverhulme (**Billington**), the Dunhill Medical Trust (**Clapcote**, **Deuchars**); Wings for Life/International Spinal cord Research Trust (**Kwok**, **Deuchars**) and EU funding (**Inglehearn** €3.2M ITN). Collaborative research grants with partners in China, the Czech Republic, and France build on strategic partnerships established within GC1.

GC2 examines societal, educational and health determinants of childhood development and significant infrastructure funds were acquired to support these activities (e.g. *£3.6M* government funded Northern Health Science Alliance, **Bryant**, **Mon-Williams**)**.** We lead and participate in large-scale programmes to improve the life chances of children e.g. "Better Start Bradford" (**Bryant**, **Mon-Williams**, **A.Waterman**, *£49M* National Lottery Community Fund:) funded until 2025 to ensure a lasting research legacy for the community. Similarly, “ActEarly: a City Collaboratory approach” (Figure 3), involves a multistep interactive cycle with local communities at the heart of decision-making and active participation in promoting health and wellbeing (**Bryant**, **Mon-Williams,** *£7M* MRC PRP,). The Education Endowment Foundation have supported research exploring handwriting and vision interventions in the classroom (**Mon-**

Williams, £0.7M combined,). Computer based systems delivered interactive, group Physical Therapy to children with Cerebral Palsy (**Holt**, £0.4M DoH) and an EU Horizon2020 funded project SUITCEYES improves interactive communication possibilities for people with deaf blindness (**Holt**, £0.4M). The Leeds Teaching Hospitals Trust, Leeds Community Healthcare Trust and Alzheimer's Research UK have supported our healthy ageing research (**Bunce**, **Burke**). A recent rapid award was granted to examine the impact of COVID-19 related school closures on foundation skills in reception children (**Nash**, £0.6M ESRC).

Figure 3: ActEarly organogram.

GC3 addresses global health challenges from mental illness, self-harm and suicide through to malnutrition, healthy diets and improving air quality. For example, we have attracted major NIHR and HTA funding on self-harm prevention and interventions such as FRESH START (**Guthrie**, £2.4M), SHIFT (Self-Harm Intervention Family Therapy) (**Cottrell,** £2.2M) in partnership with the Institute of Psychiatry London, King's College and University of Manchester. Trials have been conducted to treat ulcerative colitis (**Guthrie**, £1.5M), investigate multimorbidity in older adults (**A.Hill**, **Traviss-Turner**, £2.3M), and evaluate multisystemic psychotherapy trials for children with conduct disorder (START11, **Cottrell**, £0.3M). NIHR PHR supports investigations into air pollution, outdoor air quality and health (**Bryant**, £1M). Mental health research has been funded via GCRF on substance abuse prevention and treatment in Assam, India (**Madill,Hugh-Jones**, £0.5M ESRC/AHRC); Mainstreaming Global Mental Health (**Madill,Hugh-Jones**, **Cardno**, £126k GCRF–EPSRC); and the SAMA Project – whole school approaches to youth mental health in India (**Hugh-Jones**; *£1M* MRC, ESRC, NIHR, and DfID). We have received international funding through partnerships with the US Department of Defense (**O'Connor**, £0.5M, *£2.4M*) examining effects of stress, cortisol and childhood trauma on suicide behaviour.

To tackle the double burden of malnutrition and obesity, we work in partnership with the School of Food Science, to prevent malnutrition in China (**Dye**, *£1M* GCRF), childhood obesity in the UK (HENRY project, **Bryant**, £0.6M NIHR CDF) and healthy eating in early life (**Hetherington,** £0.5M BBSRC-DRINC:). We continue to work on satiety targets for obesity management including a satiety map (**Stubbs**, **Finlayson**, £0.3M Slimming World). A recent rapid award has been received to investigate the impact of COVID-19 UK 'lockdown' on the family home environment (**Fildes**, £0.6M ESRC)

GC4 designs, implements and tests behaviour change interventions across a range of human health outcomes to inform practice and improve public health, e.g. smoking cessation (**Conner** £0.6M MRC/NPRI), health service and health behaviours (**R.Lawton,** £1.6M NIHR), and physical activity (**Prestwich**, Unilever). **O'Connor** and **Conner** lead on Yorkshire Cancer Research funded projects examining whether participation in bowel and then cervical screening can be increased (£0.3M); and **Conner** was part of the 5-year NIHR funded multicentre eRAPID project researching safer delivery and monitoring of cancer treatments (*£2.2M*). This GC was further supported by NIHR Applied Research Collaboration (ARC) funding on the theme of older

adults (**Benn**, **Conner**, **R.Lawton**, **Mon-Williams**, *£1.3M*). Research by YQSR group has had a positive impact on patient safety changing professional and patient behaviour, focussing on embedding health services research into NHS practice (**R.Lawton**).

In partnership with colleagues in Bangladesh and Pakistan, funds from the Joint Global Health Trials scheme (MRC/NIHR/Wellcome) enabled adapting and evaluating a smoke free homes intervention, involving a cluster RCT in 66 schools and 2,700 children aged 9-12 (**Kellar**, *£1.2M*). In the UK, we conducted a series of weight management trials funded by EU H2020, and NIHR e.g., RCT of weight loss maintenance (WILMA, **A.Hill**, £1.5M NIHR HTA); Motivating weight loss through a personalised avatar (MotiVar, £0.25M NIHR RFPB); Weight management for prevention of type 2 diabetes (**A.Hill**, £2M NIHR): Evidence-based digital approaches to longer-term weight management (NoHoW project, **Stubbs**, *£1.3M* EU Horizon 2020). We have industry funding to compare commercially available weight loss programmes to regular care (**Finlayson**, **Stubbs**, £0.4M Slimming World).

3.2 Infrastructure and Facilities:
Considerable infrastructure investment (**REF5a**) and specialist research technicians from the University Technicians Network enable us to deliver research and impact across the GCs. We also receive income in-kind via the Applied Research Collaboration (£1.4M over the REF period). The University co-founded the **Leeds Academic Health Partnership** in 2015, bringing together expertise from all the NHS organisations and universities in Leeds, alongside Leeds City Council. The Partnership, one of the biggest of its kind in the UK, accelerates innovation and improves health and wellbeing by engaging academic capabilities in education and research with the City's health and social care system.

GC1: Behavioural testing of feeding behaviour and glucose metabolism in awake, unrestrained rats is based within specialist animal neuroscience facilities (**Filippi**, **Kwok**). There is *in vivo* 2 photon imaging, optogenetics and electrophysiology (**Johnston**). Bioimaging facilities (confocal microscopy, slide scanner, combined with atomic force microscopy) has yielded high quality outputs (**Deuchars**: 7 total; **Kwok**: 2 total) and produced preliminary data leading to successful funding from Leverhulme Trust (**Kwok**). UoL has invested **£17M** in extending the Electron Microscope facilities, with methods reported in key outputs for UoA4 (**Deuchars**). Installation of the **Lightsheet** microscope in 2018 enabled investigations into changes in neuronal connections and vascularisation in 3-dimensions after plasticity treatment in spinal cord injury models. UoA4 staff use the Leeds Clinical Research Facility at Leeds General Infirmary for investigating human cardiovascular function (**Deuchars**). State-of-the-art basic and clinical science facilities create the capacity for world-leading research in neuroscience, including links to the Astbury Centre (**REF5a**).

GC1&2: Cutting-edge immersive technology facilities (**Billington**, **Burke**, **Coats**, **Mon-Williams**, **Morehead**, **Mushtaq**, **Wilkie**) are used to stimulate, simulate and measure human perception, action and cognition: Visual perception (VR graphics workstations and headsets, UNITY and Vizard 3D rendering software and libraries), Motoric action (optotrak, haptic master, simodont, phantom omni, force feedback steering devices) and Cognitive function (eye-tracking and EEG systems). These laboratory systems link with larger-scale facilities within the Centre for Immersive Technology, Virtuocity (Omnideck, Car Simulator, Truck Simulator, HIKERlab), and the School of Dentistry (UoA3; Simodont suite: 30x Moog haptic dental trainers). Psychology houses electroencephalography (EEG) and MRI compatible equipment for studying

all aspects of the human somatosensory system (including touch, pain and itch; **Lloyd**) combined with transcranial electrical stimulation systems that modify electrical activity in the brain (**Burke**, **Wilkie**). Electrophysiological data are recorded using the Biosemi Active EEG or the NeuroScan SynAmps EEG system. We have integrated a functional near infrared spectroscopy system (Oxymon, Artinis Ltd) with transcranial magnetic stimulation equipment to induce cortical plasticity and assess cognition interventions (**Burke**).

Opportunities for world-class research are also supported by our large-scale datasets. We design and lead research within the BiB cohort (**Bryant**, **L.Hill**, **Mon-Williams**, **A.Waterman**, *£3.5M* MRC and ESRC). BiB is one of the world's most important longitudinal cohort studies comprising 12,453 women and their 13,818 children recruited during pregnancy between 2007 and 2011, living within the 20% most deprived wards within England, 45% of Pakistani origin and half of these parents born outside the UK. BiB provides an exemplary, interdisciplinary test-bed to explore how socioeconomic and ethnic factors interact in determining a child's health and educational trajectory. **Fildes** is co-director of the UK-based birth cohort Gemini involving 2,402 families with twins. Gemini has one of the richest datasets of DNA and early life growth, with anthropometrics collected every 3m from birth. Gemini also has the largest contemporary dietary dataset of British toddlers, collected via 3d diet diaries at 21m, and repeated at 7 years with repeated measures of child behaviours, and the early home food environment. Gemini supports essential gene-environment research on early life obesity supported by CRUK and MRC.

GC2&3: The Human Appetite Research Unit (HARU, **Blundell**) is the first custom-built appetite research laboratory of its kind. HARU has dedicated space for food preparation, measurement of food intake, physical activity laboratories and state-of-the-art equipment for body composition, energy expenditure, and utilisation (**Finlayson**, **Gibbons**, **Stubbs**). Facilities include wearable technology to measure sleep, physical activity, and sedentary behaviour, and the iDXA, Bodpod and Bioelectrical Impedance for body composition. A dedicated blood biochemistry lab allows blood draws, handling and storing samples, and performing glucose monitoring. The exercise suite contains treadmills, bicycles, cross trainer, rowing machine and metabolic fitness equipment. Feeding and cognitive testing facilities include equipment for stress testing (**Dye**, **C.Lawton**) and video equipment for measuring/coding infant feeding (**Birtill**, **Fildes**, **Hetherington**). Facilities for measuring all aspects of energy balance, cognitive function and parent-infant feeding is unique, leading to an internationally recognised reputation for nutrition research across the lifespan, attracting continuous UKRI, EU and industry funding for 30+ years.

GC3: A suite of state-of-the-art laboratories equipped with specialist equipment, PCs, and software e.g. for the NoHoW trial ~550 participants were linked to digital tracking technologies to record body weight and physical activity across 18 months (**Stubbs**). We have furnished these laboratories with high-level computing, video and audio-recording, blood pressure and heart rate monitoring equipment. A dedicated -80°C freezer provides secure storage for human tissue samples.

GC4: Dedicated laboratories for Stress and Health Research (STARlab) (**Conner**, **O'Connor**, **Prestwich**) enable large-scale stress reactivity and recovery testing (pre-test relaxation, stress induction and recovery suites, two-way mirror viewing facilities). The **Wolfson** provides bespoke space for supporting engagement with patients and practitioners within Bradford.

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

4.1 Collaborative Research Centres, Partnerships and Networks:
Aligned to the University and UoA4 R&I strategy, we drive cross-faculty collaborations, lead regional and national research centres, and support international networks. We recognise the importance of partnerships and work closely with the Yorkshire Universities (particularly York, Sheffield and Bradford through the '**White Rose Network**') and the eight research intensive universities of Northern England (the '**N8**').

4.1.1 Research centres: We have outstanding collaborations and policy influence through our research centres:

The **Centre for Immersive Technologies** (**CfIT**) was founded by UoA4 researchers (**Mon-Williams**, **Mushtaq**, **Wilkie**). HEIF support allowed the appointment of a Senior Project Manager, Project Manager and five academic leads. CfIT is an integral part of the University's commitment to data science and completes the third apex of the 'digital triangle' within the University, with **Leeds: Artificial Intelligence** and the **Leeds Institute of Data Analytics** comprising the other two apexes (**REF5a**). In 2018, the University became a partner in the **Alan Turing Institute** (ATI), the UK's national institute for data science and artificial intelligence, reflecting our investment in data science. The University provided a matched investment of *£5M* to address a range of ambitious challenges facing science, society and the economy (**Mon-Williams** and **Mushtaq** both Turing Fellows; 3 of our Postgraduate students are now employed by ATI). PriceWaterhouseCooper's (PwC) 2020 report identified the University as the UK's leading university for immersive research, a conclusion reflected by the UK's Digital Catapult report highlighting CfIT as a major economic opportunity for the West Yorkshire Region. CfIT works in partnership with KPMG and PwC to showcase immersive technologies to businesses, and works closely with global businesses (e.g. Facebook, Barclays, CISCO). Matthew Gould, UK Government's first Director General for Digital and Media, *Department for Digital, Culture, Media, and Sport* is a visiting professor, and connected CfIT with policymakers who continue to provide strategic direction to this centre.

The **Wolfson Centre for Applied Health Research** (Wolfson) is a large (*£3M*) capital build project on the Bradford Royal Infirmary site. Wolfson is a partnership between the University of Leeds and the University of Bradford with the Bradford Hospitals NHS Foundation Trust. **Mon-Williams** is the academic Director of Wolfson, with three themes: Child Health (led by **A.Waterman**), Patient Safety (led by **R.Lawton**) and Older Adult Healthcare (led by Clegg, UoA2).

Wolfson houses the **Yorkshire Quality and Safety Research** (YQSR) centre led by **R.Lawton** as part of the Patient Safety theme. YQSR delivers collaborative research with healthcare organisations across Yorkshire and Humber. This group includes three posts joint funded with School of Psychology (**Benn**, **Johnson**, **R.Lawton**), 21 staff and 6-8 externally funded PGRs. Currently the group has *£8.5M* of income, including MRC and NIHR (Programme and HS&DR) funding, and hosts one of only three **NIHR Patient Safety Translational Research Centres** in England, attracting *£3M* funding over 5 years (2017-2022). The YQSR group has an exceptionally strong relationship with local and regional clinical teams and the AHSN Improvement Academy for Yorkshire and Humber.

Wolfson also houses the **Centre for Applied Education Research** (CAER) within the Child Health theme. The Department for Education, the Educational Endowment Foundation and Bradford Local Authority directly support CAER, which allows a critical mass of applied education and health researchers to explore and apply holistic approaches to improve health and education outcomes for children. Our researchers created an 'Evidence Active Network' across the schools in Bradford (launched by Education Minister Zahawi, 2018). School-based public health partnerships are also evident in our well-established **smoking prevention** research. We have received >20 years continuous funding to develop then pilot psychology interventions to reduce **adolescent smoking**. This has reduced smoking initiation, transition from e-cigarettes to smoking and health costs (**Conner**). Links to the BiB cohort have resulted in a programme grant to identify early markers of risk for obesity in childhood within a multi-ethnic population (**Bryant**, **A.Hill**).

4.2.1 Partnerships - Regional and National: We have formed University-wide interdisciplinary partnerships through joint-funded PhD and ECRs including Language@Leeds (**Nash**); Institute for Transport Studies (EPSRC, **Wilkie**; Leverhulme, **Billington**); and the School of Computing (EPSRC; **Mon-Williams**, **Mushtaq**). Our external networks involve partnership working with **Leeds City Council** (LCC) and **Bradford City Metropolitan District Council** (BCMDC), with formal partnership agreements created over REF2021. We have supported LCC to roll out the '50 things before 5' app (**Mon-Williams**), MindMate 2U (**Hugh-Jones**) and curate the longstanding LCC "My Health My School" dataset to address policy and planning needs (**Dye**). We work closely with the **Clinical Commissioning Groups** in Bradford and Leeds, and trial innovative interventions across both cities and the region (e.g. **ICS#UOA4-2**).

The **Better Start Bradford** project unites our researchers with Bradford and York researchers within the *£49M* Big Lottery funded programme. Over ten years (2015-2025), Better Start Bradford is implementing 20 projects for pregnant women and families with children aged 0-3 years. The projects test interventions to improve children's emotional and social development (**L.Hill**, **Mon-Williams**, **A.Waterman**), communication and language development, and nutrition (**Bryant**).

Matched investment of *£1M* by UoL to the **N8 Agri-Food** programme has achieved substantial success across research and policy environments. The **N8** Agri-Food programme underpinned funding awards of *£28M* (with N+2 partners) since April 2015; and reported *£10m* value of applications in 2019, 149 PhD studentships at UoL with 9 new collaborative PhD studentships (three iCASE). **N8** research has attracted funding from UKRI (2014-2019 *£40.5M*) and industry (2014-2019 *£2.6M*). **N8 AgriFood** members have influenced the Co-op's Future Food Strategy, given evidence to Parliamentary committees, provided advice and consultancy to government departments and food companies, and contributed to UK and EU policy. **N8** networks, investment and funding have produced new partnerships, generated income across the north of England, attracted research awards and supported 147 strategic and local **pump priming awards.** For example, Psychology received grants to research household food insecurity (**Fildes**), and improving access to food for older people (**Dye**). **N8** funded an interdisciplinary seminar series on Psychological Approaches to Food Values (**Birtill**); and an ESRC Seminar series on Food, Options, Decisions and Waste was held with **N8** partners across the UK. In total, 30 student placements with food companies have been organised, and 29 industry partners are involved in externally funded projects.

We provide leadership to the Yorkshire and Humber **Applied Research Collaboration** (known as CLAHRC before 2019). The ARC ensures research evidence improves priority health services by conducting applied research, translating research into healthcare practice, and increasing the capacity of health services to undertake more applied research and translation (Figure 4). **R.Lawton** leads the multi-disciplinary team of researchers across UoL, York, Sheffield, Bradford and Hull within the ARC's Improvement Sciences theme. The Improvement Science theme funds 6 PGRs and 6 industrial placement students across 5 years within School of Psychology. **L.Hill**, **Mon-Williams** and **A.Waterman** provide leadership within the Early Life and Prevention theme.

We are an integral part of the **Bradford Opportunity Area** (BOA). The BOA seeks to help all children reach their full potential in life. With partners in local government, employers, the voluntary sector, researchers, schools, nurseries and colleges, the BOA has developed an ambitious plan, backed by over *£16M* of new government funding. The BOA is committed to ensuring that evidence underpins is activities and this is overseen by the 'Priority 4' partnership board (chaired by **Mon-Williams**).

We play a major role within an **MRC Prevention Research Partnership** (PRP) award (*£10M*). The PRP award underpins the creation of a network that is exploring how 'upstream' influences (e.g. the built and natural environment including housing, education, transport and communication systems) can be modified to decrease the prevalence of non-communicable diseases including: diabetes, obesity, CVD, musculoskeletal disorders, respiratory disease, cancer and poor mental health. The PRP bid has three pillars: 'healthy learning' (led by **Mon-Williams**), 'healthy location' and 'healthy livelihood' with an 'evaluation' crosscutting theme (led by **Bryant**).

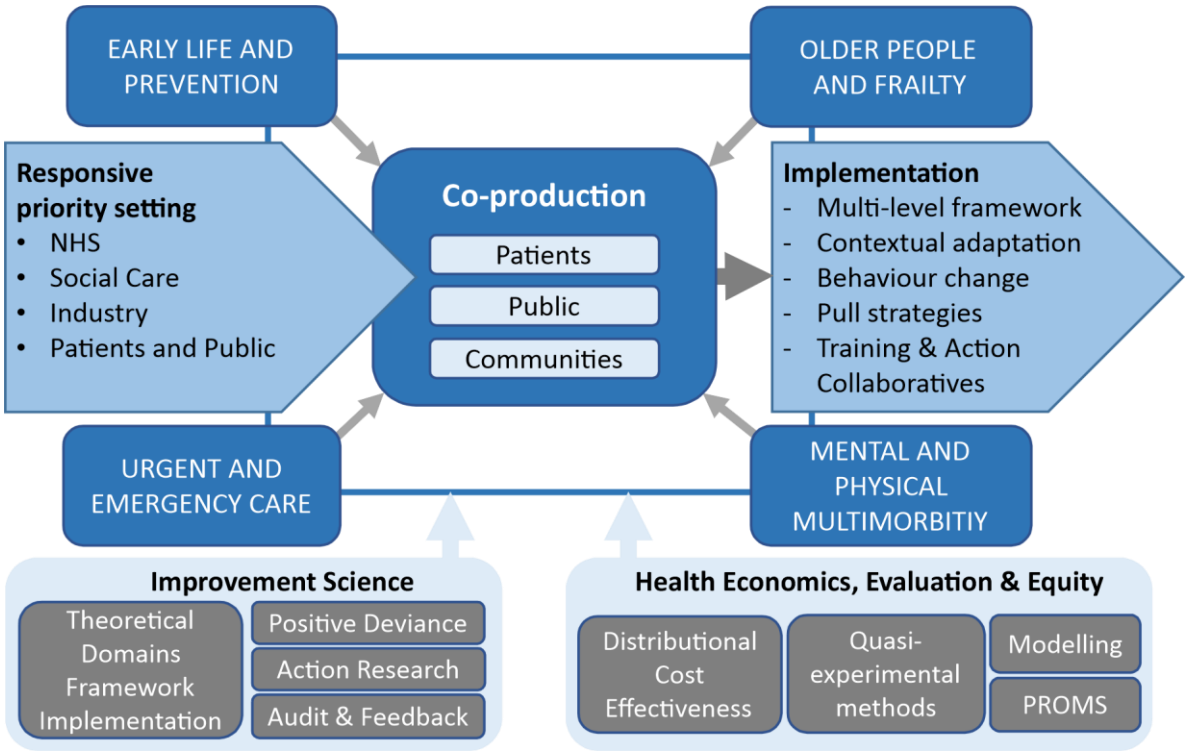


Figure 4: Yorkshire and Humber ARC organisational structures.

4.2.3 Partnerships – International: We have created two key international partnerships over REF2021 that were built upon collaborations supported by Researcher Mobility Awards (**L.Hill** and **Mushtaq**). The University VC and DVC for R&I visited **UC Berkeley** in 2019 with **Mon-Williams** and agreed a memorandum of understanding that will allow an exchange of researchers and students between our organisations. In 2020, we entered a partnership with **Stanford University** and collaborated on projects aimed at supporting children during the *COVID-19* pandemic. We have identified four specific programmes of work (Digital Divide; Classroom Inequalities; Mental Health; Food Insecurity) that will be our collaborative focus over the next five years.

GC1: Erasmus+ exchanges with University of Helsinki have led to EPSRC funding, industrial collaboration with Volvo (Sweden) and high-quality publications (**Wilkie**). Industrial links with Lilly (MRC Case studentship, **Gamper**) and Autifony (BBSRC iCase, **Deuchars**) are ongoing while partnerships (**Kwok**) with DB Pharma (France) and NeuroSolv (Ireland) aim to develop new therapies for spinal cord injury and have led to a *provisional patent* application in 2019. Collaboration with the Czech Academy of Science (**Kwok**) has led to funding from the EU and Czech Science Foundation. Our focus on interdisciplinary research across both the university and further afield has contributed to these successes (**Kwok**, BBSRC 16ALERT, Leverhulme Trust and Wellcome Trust).

GC2: Collaboration with colleagues at the Centre for Healthy Brain Ageing, University of New South Wales, evaluates and compares computerised neuropsychological assessment devices used in the identification and diagnosis of mild cognitive impairment and dementia in older persons, funded by the Australian National Health and Medical Research Council (Co-I **Bunce**: AU$0.7M). Over the past 3 decades our **GC3** researchers have collaborated with major global industries in the food/ingredient, weight management and pharmaceutical sectors (**Dye & C.Lawton** e.g. Arla and Sanofi; **Blundell & Finlayson** e.g. Novo Nordisk, Almond Board California; **Hetherington** e.g. Danone; **Stubbs**, e.g. Slimming World). We have longstanding involvement in large European consortia with funding from EU FP5, FP6 and FP7 to EUH2020 (**Blundell**, **Finlayson**, **Gibbons**, **Halford**, **Hetherington**, **Stubbs**).

GC3: Research into psychological processes predicting suicide has been funded by the US Department of Defense (STARlab; **O'Connor**). Our nutrition and behaviour research on the importance of breakfast (**ICS#UOA4-3**) has been presented within the European Parliament to MEPs and Industry to review the national policies and health campaigns of 16 EU member states (**Dye**, **C.Lawton**); this also involved the European Food Information Council (EUFIC), representation from Danish Food Banks and Cerealia -the European network of cereal producers.

GC4: Behaviour change collaborations have been established across the world: in India to improve mental health and reduce drug use (**Hugh-Jones**, **Madill**); in Bangladesh to investigate the effects of smoke-free home promotion and indoor air quality feedback on lung health, general quality of life, and health service use (**Kellar**: @ASTRA_NIHR). @IMPACT_NIHR - Improving Outcomes in Mental and Physical Multimorbidity and Developing Research Capacity (IMPACT) in South Asia (**Kellar**); in Canada to promote the return of lapsed blood donors (**Conner**). The EU H2020 funded NoHoW project involves three EU countries delivering a trial to 1,627 European adults using digital technologies to deliver evidence-based behaviour change

techniques for weight loss maintenance and developing digital technologies to track objectively energy balance and health behaviours.

4.3 Activities and contributions to the wider research base, **economy and society:** We ensure that our research remains responsive to the priorities of key end-users and achieves impact by participating in national and international policy and advisory boards, funding committees, government bodies and research networks.

Government advisory positions, include: Expert witness House of Commons Science and Technology Committee on e-cigarettes (**Conner**); Honorary Academic for Public Health England (**Flint**); SACN (maternal and child nutrition) (**Hetherington**); Obesity Review Group, Department of Health (**A.Hill**); College of Experts on Global Effort on COVID-19 Health Research (**Hugh-Jones; Kellar**); District Gold Command COVID-19 Scientific Advisory Group; Department for Education Opportunity Area Partnership Board; Digital Futures Commissioner; Cross Whitehall 'Data Improvement across Government' group (**Mon-Williams**).

Science advisory roles, including: Yorkshire & Humber AHSN Improvement Academy (**Benn**); NIHR Steering Committee (**Bryant**); NIHR Data Monitoring & Ethics Committee (**Cottrell**); Brain Research UK (**Kwok**); NIHR Programme Grants for Applied Research (**R.Lawton**); NIHR Policy Research Programme Commissioning Committee (**A.Hill**); Wellcome Trust Molecular and Cellular Neurosciences Panel (**Inglehearn**); Social Mobility Commission Scientific Advisory Board (**Mon-Williams**); British Standards Institute (**Mon-Williams**, **Mushtaq**); NIHR (ARC) (Yorkshire & Humber) Steering committee (**A.Waterman**).

Honorary awards, include: Lifetime achievement award from the Association for the Study of Obesity (**Blundell**); Yanzhao Friendship Award; 100 Foreign Experts of Hebei Province; International Collaboration awards, Hebei Provincial Government; Wellcome Trust Investigator Award (**Gamper**); F Wiley Distinguished Scientist award, International Society for Developmental Psychobiology; Aristotle prize from the Hellenic Biomedical Technology Society (**Mon-Williams**).

Prestigious international professorships, including: Distinguished Visiting Scholar to Sydney University of Technology (**R.Lawton**); Danish Diabetes Academy and Flinders University (Norman Munn Visiting Professorship : **Finlayson**), Adjunct Professor of Pharmacology, Hebei Medical University, Shijiazhuang, China (**Gamper**), Australian National University and University of New South Wales (**Bunce**), University of New South Wales (**Johnson**); Affiliate Professor in Nutrition, Penn State University (**Hetherington**).

Peer recognition for professional services, including: the American Psychological Association, European Health Psychology Society, Academy for Behavioral Medicine Research, Royal Society of Arts (**O'Connor**); BPS Fellowship and Academy of Social Sciences (**Madill**); Association for the Study of Obesity (elected chair: **Bryant**).

Professional committees, including: Association for the Study of Obesity, Chair (**Bryant**); Danish Diabetes Association (**Finlayson**); Obesity UK, Director (**Flint**); European Association for the Study of Obesity (President Elect, **Halford**); Founding member of European Retinal Disease Consortium (**Inglehearn**); UK Society for Behavioural Medicine (**Kellar**); International Neurotrauma Society (**Kwok**); European Federation of Psychology Associations (Chair,

O'Connor); Biochemical Society Grant Awards (**Wood**); National Organisation for the Treatment of Abuse Board member (**M.Waterman**); Road Safety and Simulation Scientific Review Committee (**Wilkie**).

UKRI committee membership, including: BBSRC – DRINC steering group (**Conner**, **Dye**); ESRC Peer Review College (**Hetherington**, **Hutter**, **Wilkie**); ESRC Mental health Networks; BBSRC Biosciences for Health; BBSRC Neurosciences working group (**Dye**).

Prestigious personal fellowships, including: Leverhulme (**Billington**, **Kwok**), Wellcome Trust (**Nash**), Alan Turing Institute (**Mushtaq**, **Mon-Williams**).

Journal editorships, including: Memory; Psychonomic Bulletin & Review (**Allen**); Editors-in chief Psychology and Health (**Conner**, **O'Connor**)**;** Senior Advisory Editor, Social Science and Medicine (**Conner**)**;** Frontiers in Endocrinology (**Filippi**)**;** Deputy Editor-in-Chief Appetite (**Hetherington**)**;** European Journal of Neuroscience (**Kwok**)**;** European Journal of Nutrition (**C.Lawton**)**;** BMJ Simulation & Technology Enhanced Learning (**Mushtaq**)**;** Psychology of Sport & Exercise (**Prestwich**).

4.3.1 Activities and contributions to the economy: We support the **West Yorkshire Combined Authority** (WYCA) to drive Regional economic growth (e.g. **Mon-Williams** giving a keynote talk at the **Smart Cities Exposition** in Barcelona to promote digital businesses within West Yorkshire). Our researchers work closely with the **Local Enterprise Partnership** to provide research capacity to local businesses (e.g. **Mushtaq** supporting the 'kids research agency' **Dubit**). Our regional work feeds into our wider strategy of supporting the national economy through the development of data science (especially immersive technologies) within the creative, health, education and transport sectors. We work closely with the **Alan Turing Institute** and the **Digital Catapult** to realise these goals.

We maintain excellent partnerships with **national and international companies**, including: Zoe Global (**Blundell**)**;** British Nutrition Foundation (**Blundell**, **Hetherington**)**;** Danone (**Hetherington**)**;** ILSI Expert Group (**Dye**, **Halford**)**;** Dubit (**Mushtaq**); Dupont; Boehringer Ingelheim; International Sweeteners Association; Mars International; Orexigen Therapeutics; Novo Nordisk ACTION-IO: UK; TEEN International (**Halford**)**;** Novo Nordisk UK (**Blundell**, **Halford**); Slimming World (**Stubbs**).

4.3.2 Wider Public/Patient Involvement and Engagement (**PPIE**): Patients and the public are at the centre of what we do: from early development of research ideas to dissemination activities. We have a track record of developing innovative approaches to Patient and Public Involvement and Engagement (PPIE). UoL has ten support staff who facilitate PPIE work, with over 770 patients, carers and service users involved in research every year, and who provide advice and guidance for applying PPIE within research. The PPIE team organise and facilitate PPI meetings, advertise for and invite members of the public to specific PPI activities, and collect information to monitor and assess the impact of PPIE activities. The **Engaged Research Team** draws together all areas of stakeholder engagement, providing both pre- and post-research proposal support including funding for PPIE at the research design phase, signposting access to patients and public for specific projects, a repository to share best practice, including a range of PPIE compliance issues (e.g., GDPR). Through the **Yorkshire and Humber Research Design Service**, our researchers have access to PPIE support for developing research ideas into NIHR grant applications; this includes a feedback service and access to funding to involve patients and

the public in the design of research. PPIE ensures that our research addresses issues that matter, ensuring that recruitment approaches and materials are relevant and accessible, that studies are respectful of participant needs, and dissemination is effective. Patients and the public are involved in our research advisory groups ensuring input throughout the research process, e.g. identifying appropriate outcome measures, training clinical recruiters or, with appropriate support and training, directly collecting data via interviews or focus groups. An example is the award winning NIHR PGfAR-funded **DIAMONDs** project which developed and tested a bespoke educational package to support people with severe mental illness and diabetes (**Kellar**). In terms of broader dissemination, UoA4 researchers have contributed to The Conversation, local, regional and national **public engagement** activities including radio and TV broadcasts. **Be Curious** is our annual research open day (established 2016), a free event attracting >1200 people each year and nominated at The Child Friendly Leeds Awards 2019 for its contribution to making Leeds a child-friendly city.

Locally organised panels involving clinicians and older adults have participated in focus groups to support grant applications and proposed devices (**Deuchars**); focus and priority setting for: spinal cord research (**Kwok**), Alzheimer's disease (**Kwok**) and cerebral palsy (**Chakrabarty**). **Hetherington** is a Trustee of Give A Child A Hope supporting education for vulnerable children in Uganda. **Clapcote** is a regular presenter at the biennial Family Meeting of the Alternating Hemiplegia Support Group (AHCUK). We hold public talks with artists and engineers and have active collaborations with artists (e.g. Benedict Phillips and Anzir Boodoo). Ageing research is enhanced by our thriving Older Adult Participant Panel with Open Days for knowledge sharing on healthy ageing (**Burke**, **Coats**). Specialist public events include the Bradford media museum 'In your face' interactive exhibition for face composites and facial recognition; workshops for police on face composite systems (**Brown**); and digital space workshops (**Hugh-Jones**). We contribute to clinical training regionally, e.g. Yorkshire School of Psychiatry Management; West Yorkshire Core Psychiatry Training Committee (**Cardno**).

UoA4 are committed to co-producing our research with the communities we serve**, **and to building the research infrastructure that enables evidence to drive societal benefit. This underpins our five year vision to improve psychological health and wellbeing through research and innovation.