Institution: University of Manchester

Unit of Assessment: 04 Psychology, Psychiatry and Neuroscience

1. Unit context and structure, research and impact strategy

1.1 Overview

The overarching research aim of UoA4 (94.72 FTE) at The University of Manchester (UoM) is: *to integrate multi-disciplinary discovery, translational and applied research in psychology, neuroscience and mental health to deliver local, national, and global impact.*

Our research spans the translational pipeline, discovering fundamental mechanisms in health and disease, developing and delivering improved diagnostics, prognostics, and interventions to improve neurological and mental health nationally and internationally. We have four broad research themes: translational neuroscience; mental health; language and communication; and vision science, and have achieved successes against our strategic goals from REF2014:

- developed new treatments and interventions for stroke, mental illness and autism, delivered nationally and internationally (sections 1.4.1, 1.4.2);
- shaped policy nationally and internationally, including clinical dementia guidelines (section 1.4.1), suicide and self-harm policies (section 1.4.2) and crucial guidance on public health messaging during the COVID-19 pandemic (section 1.8);
- innovated new technologies for health with industry partners, including approaches for restoring vision in retinal degeneration (section 1.4.4) and digital health technologies for mental illness (section 1.4.2);
- established a state-of-the art regional centre to discover new insights into how children communicate with language (LUCiD; £9.5m ESRC funding 2014-2024, section 1.4.3);
- generated a strong portfolio of research outputs across the translational pipeline, ~500 cited in the top 10% (field-weighted), 95 in the top 1%;
- expanded our interdisciplinary, multicentre and international collaborations (34% submitted outputs with researchers in 14 other UoAs, 52% other UK centres, 41% international);
- achieved external recognition of our researchers through 25 personal awards: seven NIHR senior investigators, one NIHR research professorship, seven intermediate fellowships, and ten early career fellowships (section 2).

To drive our research forward and achieve the successes above, we have:

1. ***Generated an innovative interdisciplinary translational infrastructure for neuroscience and mental health.*** The new Faculty of Biology, Medicine and Health (FBMH, section 1.5) was specifically designed to bring together fundamental and translational science. It identified and facilitated our key research strengths (section 1.4) through the formation of translational research domains and a range of human resource and infrastructural initiatives and awards (section 1.6.1).

2. ***Maximised translational opportunities in neuroscience and mental health by building formal, multi-level interactions with key partners and stakeholders.*** The devolution to Greater Manchester (GM) of £6bn p.a. health and social care budget provided a unique opportunity to pull translational research through to clinical unmet need. We established Health Innovation Manchester (HInM), an academic health science and innovation system to transform the health and wellbeing of GM. Through HInM, UoA4 researchers link to NHS Trusts serving the GM population of 2.8m (section 4.2.2). Redesignation (in 2020) of the Manchester Academic Health Science Centre (MAHSC) includes a new Neuroscience domain, alongside the established Mental Health domain, to drive UoA4's translational research (section 1.6.2).

3. ***Extended our portfolio of research funding.*** We have increased our funding from £68m (REF2014) to £148m (total value of awards to which UoA4 contributes), with 26 new awards >£1m and £6.7m industry funding (sections 3.2, 3.3). These include £8m NIHR Collaborations for Leadership in Applied Health Research and Care (CLAHRC-GM) (2014-2018) and £11.3m NIHR Applied Research Collaborations (ARC-GM) in 2019 with core themes in mental health (section 1.4.2).

4. ***Enhanced our funded national and international partnerships and networks.*** We are one of the first academic partners in Dementia Platform UK: Integrated Dementia Research Environment (£6m UoM). We lead the South Asia Self-Harm Initiative (GCRF, £4m total, £3m UoM) and the Leducq Foundation Transatlantic Network of Excellence to study post-stroke cognitive decline (£4.4m total, £1.4m UoM).

5. ***Fostered an environment where research students and staff are supported and valued.*** 477 PhDs were awarded to students supervised by UoA4 academics (5.04 per FTE); 39 (18 female) academic appointments/promotions (sections 2.4, 2.5, 2.7).

6. ***Invested in cutting edge research facilities*** which support interdisciplinary UoA4 research including an MR-PET Scanner (£5.9m), a Hyperion Imaging Mass Cytometer (£500k), an Induced-Pluripotent Stem Cell Suite (£200k), a Virtual Reality Suite (£190k), and an extensive Biological Services Facility (sections 3.6-3.8).

1.2 Research and Impact Strategy

UoM's overarching research strategy embraces interdisciplinarity as a fundamental driver of international research with impact. Within that context, FBMH's strategic research vision is to:

- discover novel biological, psychological and social mechanisms;
- develop new approaches to prevention and early detection of disease;
- develop next generation person-centred therapies, interventions and care pathways.

UoA4 implements the FBMH vision in our specific research themes (section 1.4), collaborating closely with colleagues in other UoAs across all UoM faculties. The UoM and FBMH research strategies emphasise impact beyond academia, seeking to deliver research with health, economic and social benefits. Our institutional environment statement (see REF5a section 2) outlines our focus on impact, where we were first in Europe in the 2018 *THE* University Impact Rankings. Our UoA4 environment facilitates and maximises three types of research impact, exemplified by seven submitted impact cases (section 1.4).

- *Health:* translating research into new treatments, practices and policies to deliver improvements in neurological and mental health and wellbeing. *REF impact cases:* new treatments for psychosis (**Morrison**); anxiety and depression (**Wells**); autism (**Green**); and support for stroke survivors (**Bowen**).
- *Social:* engaging with patients, the public, educators and public health, stimulating debate and influencing policy decisions. *REF impact cases:* reducing foetal exposure to anti-epileptic drugs (Bromley, UoA1); policy guidelines for suicide (Turnbull**, Appleby**)**.**
- *Economic*: creation and commercialisation of new products and industry investment in innovative research. *REF impact case:* new artificial lighting standards (Brown, **Lucas**).

1.3 Future Research and Impact strategy (next 5 years)

UoA4's future research strategy has three overarching objectives:

1. Extend translational research and societal impact with HInM and NHS/Industry partners by securing major external funding in strategic partnerships:
- develop the Geoffrey Jefferson Brain Research Centre for translational neuroscience and establish a Northern Powerhouse for Mental Health (sections 1.4.1, 1.4.2);

- secure neuroscience and mental health themes in our NIHR Biomedical Research Centre (BRC) renewal bid in 2022 (sections 1.4.1, 1.4.2);
- increase partnerships with industry, translating our discoveries in neuroscience (section 1.4.1), vision science (section 1.4.4) and digital mental health (section 1.4.2).

2. Capitalise on UoM's interdisciplinary strengths to improve health locally, nationally and internationally by establishing new collaborative programmes with:

- The Turing Institute for Data Science and Artificial Intelligence (sections 1.4.2, 1.6);
- UoM's new £25m Christabel Pankhurst Institute for Health Technology (section 1.6);
- UoM Digital Futures Programme (section 1.6);
- The Lydia Becker Institute of Immunology and Inflammation and The Wellcome Centre for Cell-Matrix Research (sections 1.4.1, 1.6);
- UoM international partners via our emerging links with universities of Melbourne, Toronto, Peking, Shanghai Jiao Tong and institutes in India and Pakistan (section 4.1.1).

3. Recruit and develop talented researchers by:

- increasing externally funded fellowships through FBMH support programmes (section 2.4);
- developing a new generation of clinical academics via investment plans with NHS trusts to spearhead neuroscience and mental health research translation (sections 1.4.1, 1.4.2);
- targeting strategic recruitment of research leaders to our four themes (section 1.4).

This overarching strategy supports specific future research priorities articulated in each research theme below.

1.4 Research Themes

Our interdisciplinary, translational research strengths are reported across four Research Themes: (1) Translational Neuroscience; (2) Mental Health; (3) Language and Communication; (4) Vision Science. These themes are all underpinned by cross-cutting methodologies and expertise in basic neuroscience, cognitive neuroscience, experimental psychology, imaging, and computational methods.

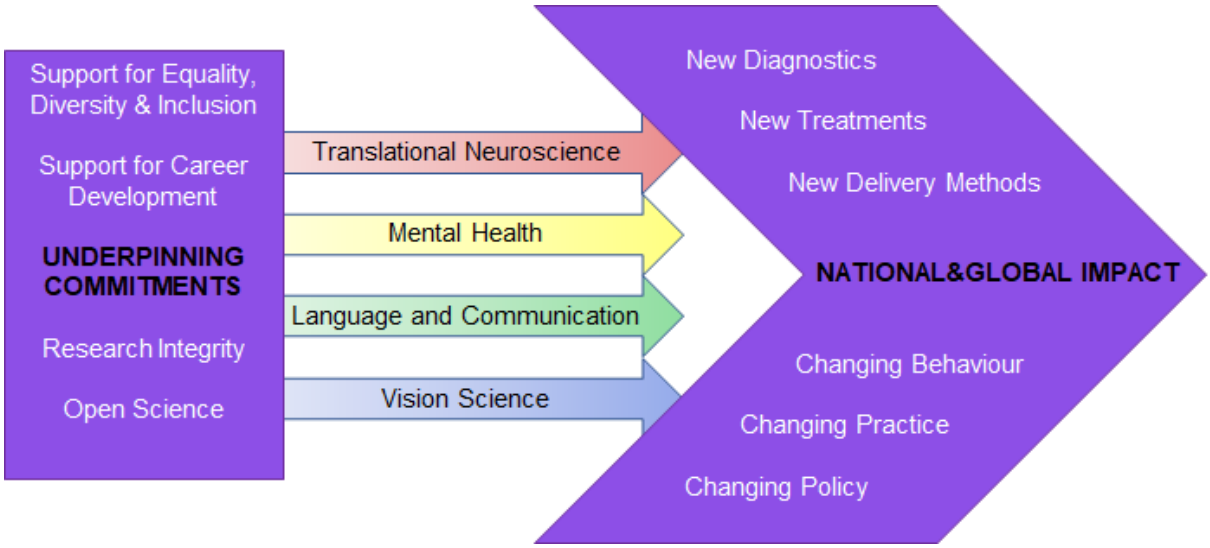

Figure 1: *UoA4's translational research pipeline*

1.4.1 Translational Neuroscience (35.32FTE)

The Translational Neuroscience theme delivers interdisciplinary research covering: (i) discovery neuroscience to understand fundamental mechanisms underpinning brain function, damage and recovery; (ii) translational science to improve diagnostics, prognostics, and treatment for neurodegeneration and neurological disease, particularly stroke and dementia; (iii) impact through clinical trials of interventions and changing policy and practice, nationally and internationally. Our comprehensive research programme with forward and back-translation

involves interdisciplinary collaboration with UoAs 1, 2, 3 and 5. We work closely with the Northern Care Alliance (NCA), an NHS Group bringing together Salford Royal NHS Foundation Trust (SRFT) and The Pennine Acute Hospitals NHS Trust.

Research is underpinned by major funded programmes involving UoA4 researchers with a total value of >£70m. In UoA4-led programmes we are discovering molecular and cellular mechanisms of dementia (**Hooper**, **Pickering-Brown** MRC >£5m), roles for interleukin-1 family and inflammasomes in dementia and stroke (**Brough** MRC £1.5m), neuroimaging biomarkers for dementia (**Herholz**, **Parker** MRC, EPSRC, ERC >£3m) and cognitive neuroscience mechanisms of language and cognition deficits after stroke and in dementia (**Lambon Ralph**, **Woollams,** MRC, ERC >£3m)

We were one of the original academic partners in the multi-million pound DPUK: Integrated Dementia Research Environment (**Lambon Ralph, Hooper** £6.1m UoM), the only academic institution involved in all three networks (molecular imaging, stem cells and informatics). We led (**Herholz**, £1m, total multisite award) and were co-investigators (**Hooper**, £1.2m, total multisite award) in MRC DPUK Partnership awards on imaging and stem cells. We were one of five institutions to be awarded an MRC Momentum Award, Dementias (**Hooper**, £500k) to encourage high risk projects and bring interdisciplinary expertise into dementia research. An international Leducq Foundation Transatlantic Network of Excellence Award (Stroke IMPaCT, **Allan,** European Lead, £1.4m UoM) will discover how changes in immune function after stroke cause cognitive decline, and how complicating infections affect later dementia risk. Other notable collaborations include a Wellcome Investigator award on developmental mechanisms of motor network tuning with the University of Cambridge (**Baines**, £1.8m, total multisite award).

Basic Neuroscience

New insights from our research include demonstrating:

- roles for SNORD118 mutations in cerebral vascular homeostasis (**Kasher**, *Nature Genetics, 2016*), and C9orf72 in frontotemporal dementia (**Pickering-Brown**, *Science, 2014*);
- seizure suppression through manipulating splicing of a voltage-gated sodium channel *(***Baines***, Brain, 2015*);
- reduction of amyloid-β toxicity through promoting ADAM10 shedding of the prion protein (**Hooper**, *Journal of Biological Chemistry, 2019*);
- neurocomputational architecture of reading and dyslexia (**Woollams, Lambon Ralph,** *PNAS, 2015*).

Neurodegeneration

We have identified new biomarkers and targets for diagnosis and treatment:

- fenamate NSAIDs protect against Alzheimer's disease in rodent models (**Brough**, **Allan,** *Nature Communications, 2016*);
- neuroimaging biomarkers for dementia (**Parkes**, *Magnetic Resonance in Medicine, 2015*);
- neuroimaging techniques to predict cognitive outcomes (**Halai, Woollams**, *Nature Human Behaviour, 2020*);
- monitoring computer mouse and keyboard use detects cognitive impairment (**Burns**, *Healthcare Informatics, 2016*).

Neuroinflammation and Stroke

We have demonstrated the important role and therapeutic translation of inflammation in stroke:

- NLRP3 inflammasome amplifies inflammatory response (**Brough**, *Nature Immunology*, *2014*);
- inflammasome targets for improving stroke outcomes (**Brough**, **Allan**, *PNAS, 2015; Stroke, 2019*);
- mechanisms underpinning the role of IL-1 in stroke (**Allan**, **Boutin,** *Brain, Behaviour Immunity, 2019*);
- Anakinra reduces inflammation in stroke (**Allan**, *Stroke, 2018*);
- opportunities for targeted therapies (**Schiessl**, **Allan,** *ACS Nano, 2019*).

Translational Neuroscience Impact:

Our research has had major impacts on diagnostics and treatments, including: genetic testing for rare familial neurodegenerative conditions (**Pickering-Brown**); new interventions for people with sensory and cognitive impairment (**Leroi, Pendleton, Armitage**, SENSE-Cog, ERC €6m); and collaborative clinical trials of behavioural interventions for persistent deficits after stroke (**Bowen** CACTUS and SPATIAL, NIHR >£1.5m).

Our findings have led to changes in policy and practice including: significant change to NHS clinical dementia guidelines (NICE 2018, **Burns**), new partnership model of support for carers of stroke survivors (**Bowen**, **Patchwood**, OSCARSS, £500k project within NIHR CLAHRC-GM).

We have built partnerships with patient groups to engage stakeholders in research outcomes. For example, the UoM Engaging Our Communities fund supported a Stroke, Self and Brain art project in 2017 (**Pinteaux**), which led to an ongoing collaboration with the Stroke Association to build understanding of the impact of strokes.

REF Impact cases:

- Transforming long-term support for stroke survivors with toolkits and measures that change national policy and service provision, and international practice (**Bowen**)
- Worldwide reduction in the number of children exposed to harmful antiepileptic drugs in the womb (Bromley, UoA1)

Translational Neuroscience Future Research Priorities:

We established the Geoffrey Jefferson Brain Research Centre in 2020 (leads **Allan**, King), in collaboration with the MAHSC Neuroscience Domain and the NCA (section 1.6) with an initial focus on neurovascular disease, brain tumours and brain inflammation. The Centre provides a strategic focus for:

- developing new interdisciplinary programmes with cross-theme research in brain rehabilitation (**Bowen**), neuroimaging (**Parkes**) and brain pathology (**Roncaroli**);
- developing new treatments and implementing optimal care pathways to provide better outcomes and transform patients' lives, in collaboration with our industry partnerships established for developing Anakinra as a potential treatment for stroke;
- becoming a leading UK centre for translational brain research by 2025, combining discovery science and experimental medicine to translate our research into healthcare benefit;
- targeting external funding (e.g., UKRI, NIHR, philanthropic, charitable) for 10 new academic positions over the next five years;
- building on close interdisciplinary collaboration with the Lydia Becker Institute of Immunology and Inflammation (Hussell, UoA1, section 1.6), for example through an externally funded interdisciplinary clinical PhD programme and joint ECR fellowships;
- including a neuroscience theme in the UoM BRC renewal bid, 2022;
- deploying the transatlantic Stroke-IMPaCT network to collate clinical and pre-clinical data internationally and discover new ways of preventing post-stroke cognitive decline.

1.4.2 Mental Health (42FTE)

The mental health theme combines expertise in psychology, psychiatry, cognitive neuroscience and neuroimaging. Underpinned by total funding of >£70m to UoA4 and interdisciplinary collaborators, particularly in UoAs 2 and 3, our researchers: (i) discover mechanisms of mental health problems; (ii) develop new biological and psychological treatments; and (iii) implement these into services.

Suicide and self-harm

Research is undertaken by a multidisciplinary group and cross-faculty collaborations with social care, criminology, law, and sociology (UoAs 18, 21). The group hosts two of GM Mental Health NHS Foundation Trust's (GMMH; section 1.6) flagship research units (Patient Safety, **Pratt, Haddock**; Forensic Healthcare, **Shaw**) and the National Confidential Inquiry into Suicide and Safety in Mental Health (NCISH, **Appleby,** Kapur (UoA2), **Shaw** HQIP £3.7m). We have

developed and evaluated cognitive-behaviour therapy (CBT) and psychological interventions for clinical groups at high risk of suicide or self-harm (MRC, NIHR £5.3m). We lead a major international programme on self-harm in South Asia (**Husain** GCRF £3.1m).

Our research has:

- provided an evidence base for self-harm prevalence (**Appleby,** *Lancet Psychiatry, 2019*);
- identified critical factors influencing suicide in children and young people (**Shaw, Appleby,** *Lancet Psychiatry, 2016*) and perinatal women (**Hunt, Appleby,** *Lancet Psychiatry, 2016*);
- demonstrated increased risk of premature death after discharge from psychiatric inpatient services (**Shaw**, *JAMA Psychiatry*, 2017);
- developed a stepped-care recovery pathway of self-harm interventions in prison (**Abel** WORSHIP I, II, II studies, MRC £1.4m).

Severe mental illness (SMI)

Interdisciplinary research focuses on discovering biological, psychological and social mechanisms, and developing and delivering new interventions. Major programmes include developing molecular and cognitive biomarkers for translational treatment (**Deakin**, **Talbot** MRC, NIHR £3m), psychological treatment trials (**Berry**, **Haddock**, **Bucci** NIHR £1.3m) and developing new culturally adapted family interventions for psychosis patients from Black and Minority Ethnic groups *(*BAME; **Abel**, **Berry**, **Morrison** NIHR £2.3m).

With NHS and industry partners, we are developing and delivering new digital health technologies for SMI (**Bucci**, **Lewis,** total £5m from MRC Developmental Pathway Funding Scheme). We lead an EU FP7 funded project (**Lewis, Drake**, Optimise, €15m) to develop and improve mobile phone medication management across 22 European centres.

Our research has:

- established the effect of prenatal and childhood stress on risk of psychosis in a national cohort (**Abel,** *BMJ, 2014*);
- identified inflammatory markers for recent onset and established schizophrenia using PET (**Deakin, Talbot,** *Molecular Psychiatry, 2020*);
- demonstrated the effectiveness of CBT in clozapine-resistant schizophrenia (**Morrison,** *Lancet Psychiatry, 2018*);
- evaluated the impact of interventions to improve physical health outcomes in schizophrenia (**Firth,** *World Psychiatry, 2020*).

Child and adolescent mental health

This group undertakes research on early psychological and neuro-development in familial autism and rare monogenic syndromic models of autism. A Francis Collins International Fellowship (**Garg** £400k) funds pre-clinical work with drosophila and stem cells, and experimental trials of a brain stimulation intervention on working memory. We lead translational programmes developing and evaluating new interventions for autism delivered worldwide (**Green**, MRC, NIHR >£4m).

Our research has:

- established population-based prevalence of autism in NF1 (**Green,** *Nature Genetics, 2017*);
- reported the first experimental medicine trial of medication in NF1-autism with neural system mechanism testing (**Garg**, **Montaldi**, **Green**, *Molecular Autism 2018*);
- developed and evaluated the first autism intervention internationally to show sustained reduction in symptom severity (**Green, Wan**, *Lancet Psychiatry, 2015*; **Green,** *Lancet, 2016*).

Health Psychology

The Manchester Centre for Health Psychology has an established research programme on behaviour change interventions for mental and physical health and wellbeing. UoA4 researchers provide expertise to interdisciplinary programmes across FBMH (funding total £21.5m). The Centre has deployed complex interventions at scale and tested them in clinical settings,

including research to enhance the quality of psychological interventions for mental health delivered by phone (**Armitage,** NIHR £3m).

Our research has:

- developed a brief psychological intervention to reduce repetition of self-harm (**Armitage**, *Lancet Psychiatry, 2017*);
- demonstrated impact of communicating genetic risks of disease on risk-reducing health behaviour (**French**, *BMJ, 2016*);
- demonstrated effectiveness of interventions to reduce adolescent smoking initiation (**Armitage**, *Journal of Consulting and Clinical Psychology, 2019*).

Mental Health Impact:

Our research has major impacts on treatment, policy and practice. NCISH recommendations on suicide prevention, including improved physical safety of wards and early follow-up after discharge, are cited widely in national policy, guidance and suicide prevention strategies: Cross-government suicide prevention work plan (2019), Northern Ireland's Protect Life 2 (2019), Scotland's Every Life Matters (2018). We have informed ministers on self-harm and suicide in the criminal justice system (**Shaw**: Independent advisory panel on deaths in custody).

Bucci and **Lewis** have led major developments in real-time assessment of symptoms (ClinTouch; CareLoop) and real-time delivery of psychological therapy (Actissist) through platform smartphone technology. A spin-out company, Affigo, provides digital mental health apps to the NHS. We collaborate in a multicentre UK project testing delivery of a technology-based intervention for distressing voices in psychosis (**Haddock, Bucci**, Wellcome AVATAR trial £3.4m) and are evaluating the implementation of virtual reality therapy for psychosis (**Morrison**, NIHR i4i Gamechange trial, £4m).

We have led some of the world's largest psychological treatment trials in SMI. Assessments and treatments developed at UoM have improved outcomes for people with schizophrenia internationally (**Morrison**). One of the clinical evaluation tools has been adopted by the NHS and included in NICE guidance and Government policy on Improving Access to Psychological Therapies. Our parent-mediated social communication therapy (**Green**) for young children with autism has been incorporated into a spin-out, 'IMPACT', which disseminates training and implementation internationally, reaching >600 practitioners in 21 countries. IMPACT received UoM's 'Social Impact through Research' Award 2017.

We have translated two potential antipsychotic drugs to clinical development by demonstrating they engage GABA and cognitive targets in early phase human studies using our novel fMRI techniques (**Deakin, Elliott** Confidential Scientific Reports with our CRO partner P1vital, Sunovion and Autifony).

REF Impact Cases:

- Shaping UK policy and guidelines for suicide prevention (**Appleby,** Turnbull)
- World's first effective treatment to prevent psychosis has been implemented as standard treatment in NHS mental health services across England (**Morrison**)
- Transforming autism treatment worldwide: the Manchester-led Paediatric Autism Communication Therapy (PACT) (**Green**)
- Metacognitive therapy improves outcomes for patients with anxiety and depression worldwide (**Wells**)

Mental Health Future Research Priorities:

Our forward strategy will strengthen partnerships with stakeholders locally, nationally and globally, and take advantage of emerging interdisciplinary opportunities at UoM, particularly developing our digital mental health programme. Specifically, we will:

- enhance our multi- and inter-disciplinary mental health research to create a Centre for Translational Mental Health supported by external funding, and secure a mental health theme for BRC 2022;
- work with NHS England to have a key role in a multi-centre, cross-university, Northern Mental Health powerhouse;
- expand our digital mental health capability, working with our established industry partners and spin-out company (Affigo), to meet the needs of the population of GM and beyond, aligned to HInM strategic objectives;
- increase our global mental health collaborations and funding to ensure world leading impact, particularly in low- and middle-income countries, by strengthening research capability in line with the 2030 Sustainable Development Goals identified by the United Nations;
- target senior academic and clinical appointments in neurobiological research in neurodevelopmental disorders and mental illness;
- strengthen and further integrate our PPIE capability and partnerships.

1.4.3 Language and Communication (6.8FTE)

Our research aims to understand how children learn to communicate using language, and, based on this understanding, provide information, advice and technologies to support children's language development. This area is underpinned by the ESRC International Centre for Language and Communicative Development (LuCiD, lead **Lieven**), established in 2014 (£7.6m) and extended in 2019 (£1.9m) in collaboration with Lancaster University, the University of Liverpool, and international partners in Europe, the US and Australia.

Our research has discovered that:

- infants build links between concepts and morphological regularities much earlier than previously thought (**Ferry**, *Developmental Psychology, 2020*);
- newborns are sensitive to multiple cues for word segmentation in continuous speech (**Fló**, **Ferry**, *Developmental Science, 2019*);
- pre-schoolers refer to indirect as well as direct evidence in their collaborative reasoning (**Köymen**, *Journal of Experimental Child Psychology, 2020*).

Language and Communication Impact:

LuCiD received an ESRC knowledge exchange uplift grant (**Lieven** £70k) to develop and roll-out nationally a mother and baby English language programme. The project, set up as a social enterprise, was a finalist in the British Council's ELTon awards 2019. LuCiD's research was featured in PHE-commissioned training delivered to over 1000 health visitors (**Theakston**).

Language and Communication Future Research Priorities:

We will further uncover the mechanisms and processes underpinning early communicative development and translate fundamental discoveries to support developmental speech, language and communication needs. Specifically, we will:

- build on our inter-institutional and international collaborations, with Australian National University, Cornell University and Max Planck Institute for Psycholinguistics to further understand how children learn to communicate in interaction with their environment;
- foster interdisciplinary collaborations with researchers working in atypical language development (UoA3) to enable the robust testing and development of the theoretical accounts of language learning needed to underpin the design of effective interventions;
- translate the findings from our basic science research into evidence-based advice, information and interventions for caregivers, practitioners and policymakers to support language and communicative development.

1.4.4 Vision Science (10.6FTE)

Discovery and innovation in vision science is an established interdisciplinary strength at UoM, linked to The Manchester Royal Eye Hospital (Manchester University NHS Foundation Trust, MFT). We discover mechanisms of vision and visual impairment and develop new therapeutics, including approaches to restore vision in advanced retinal degeneration. Our research is underpinned by ERC funding (£2m, **Lucas**), a Wellcome Investigator award (£1.4m **Lucas**) and a Sir Henry Dale Fellowship (£800k **Storchi**).

Our research has discovered:

- melanopsin-driven light adaptation in mouse vision (**Lucas, Montemurro,** *Current Biology, 2014*);
- photoreceptive retinal ganglion cells control the information rate of the optic nerve (**Lucas, Petersen, Storchi,** *PNAS, 2018*);
- restoration of vision with ectopic expression of human rod opsin (**Lucas,** *Current Biology, 2015*);
- individual differences in target sensitivity during visual processing (**Gowen, Warren**, *Vision Research*, 2017).

Vision Science Impact:

Our discoveries pave the way for interventions to restore vision, developed with industry partners. Our technology for restoring vision in retinal degeneration has been licenced by Acucela Inc (Japan) for clinical development. Our research has changed practice for artificial lighting with a new metric that has been adopted as an international lighting standard. This forms the basis of a new set of scientific consensus guidelines for healthy lighting and is used by the lighting industry to develop products and systems maximising the biological potential of light.

REF Impact case:

- A new international measurement standard and guidelines for healthy lighting *(*Brown, UoA5, and **Lucas***).*

Vision Science Future Research Priorities:

We will strengthen interdisciplinary and cross-faculty vision research (section 1.6) and translate fundamental discoveries for health and social benefit by:

- using UoM pump-priming initiatives to establish Vision@Manchester as a recognised centre for excellence in basic and translational vision science. This will develop a BRC vision health strand and enhance translational collaboration with Manchester Royal Eye Hospital;
- fostering collaboration with Hearing Sciences (UoA3) to develop novel multi-sensory research in hearing and visual health;
- using recent UoM investment (£200k) in virtual reality infrastructure (VR@Manchester) to enable novel cutting-edge applications studying basic mechanisms of vision in health and disease measuring functional improvements associated with new therapies;
- translating basic vision research in inner retinal photoreception to develop technology for restoring vision in retinal degeneration (through established relationships with international industry partner Acucela, a subsidiary of Kubota Vision Inc.);
- translating research in photoreceptive cells to develop new display and lighting technology, developing our relationships with international industry partners (e.g., Phillips).

1.5 Unit context and structure

UoA4's submission covers 94.72FTE spanning from fundamental discovery science to applied health research. All staff sit within FBMH, one of three large, multi-school UoM faculties. FBMH was established in 2016 to facilitate interdisciplinary, translational research by merging the previous Faculties of Life Sciences and Medical and Human Sciences. Within FBMH, research during the REF2021 period has been facilitated via interdisciplinary, integrative Research Domains which were created to align basic scientists, clinical scientists and NHS clinicians and

commissioners to enable research agility, dynamism, interdisciplinarity and responsiveness and to optimise research impact. Interdisciplinary, translational UoA4 research has been facilitated by the Neuroscience and Mental Health Domain (NMHD; Lead: **Allan**). Day-to-day management of staff in FBMH occurs in three schools (Biological Sciences, Medical Sciences, and Health Sciences) which include 18 Divisions. UoA4 staff sit mainly within the School of Biological Sciences (Division of Neuroscience and Experimental Psychology, 49.9FTE) and the School of Health Sciences (Divisions of Human Communication, Development and Hearing, 5.8FTE, and Psychology and Mental Health, 35.7FTE).

1.6 UoA4's Interdisciplinary Research Environment

1.6.1 Within UoM

Interdisciplinary collaboration at UoM is complemented by funding arrangements that stimulate and incentivise cross-discipline and cross-faculty working from rolling awards: Wellcome (ISSF consolidator awards, £4.5m), RC DTP/CASE Studentships and the UoM Research Institute (UMRI) Interdisciplinary Research Pump-prime Competition (8-10 awards p.a. of £10k-£50k).

Interdisciplinary collaborations involving UoA4:

- Neuroimmunology Branch (**Brough**) of the Lydia Becker Institute of Immunology and Inflammation (lead Hussell, UoA1) established after a joint workshop (2018) with NMHD;
- Manchester Vision Network involving FBMH colleagues from other UoAs, colleagues from the Faculty of Science and Engineering (FSE) and clinicians from Manchester Royal Eye Hospital. Annual Manchester Vision Network conference (in its 3rd year);
- Manchester Institute for Collaborative Research on Ageing (MICRA) is a cross-faculty interdisciplinary institute (**Burns** executive director; **Pendleton** management board);
- Manchester Centre for Biological Timing (lead **Lucas**), spanning UoAs 1, 4, and 5, and other UoM faculties (Science and Engineering, Humanities), supported by UMRI (£30k) and ISSF (£200k) funding;
- VR@Manchester, a cross-UoM network of researchers who use VR for research, teaching and public engagement, supported by UMRI funding (£200k **Warren**);
- ISSF support (£300k) for developing models to understand the dynamic tumour microenvironment (**Roncaroli**, Swift, Gilmore, UoA1);
- EPSRC-funded Wearables clinic (£1.2m), involving UoA4 researchers and data scientists and informaticians in UoA2.

Emerging interdisciplinary opportunities, particularly from investment in digital technology and data science, which align with UoA4 future research priorities (section 1.4.2):

- *Christabel Pankhurst Institute for Health Technology,* a new £25m UoM-led research institute to maximise our strengths in digital health/AI and advanced materials for innovative health solutions. The consortium includes UoM, Manchester Science Partnerships, Manchester University NHS Foundation Trust, and HInM (£5m GM Combined Authority's Local Growth Fund; £2.4m InnovateUK; £2.1m Roche Diagnostics and GE Healthcare);
- *Digital Futures programme* (Taylor UoA11), with members from all three UoM faculties;
- *Thomas Ashton Institute* (Tongeren, UoA2), a collaboration between the Health and Safety Executive and UoM to understand failures in the workplace leading to ill-health;
- *Institute for Data Science & AI* (Guo, Peek, UoA2), an access point to UoM expertise in data science and AI, facilitates interactions between researchers and stakeholders, drives data science strategy, and delivers sustainable support for the community;
- *Alan Turing Institute*, a national institute which UoM joined as a partner in 2017;
- *Manchester Cancer Research Centre* (Bristow UoA1), includes the £40m CRUK Manchester Institute and £35m CRUK Major Cancer Centre and provides opportunities for UoA4's emerging neuro-oncology programme;
- *Wellcome Centre for Cell-Matrix Research* (Kadler, UoA5) collaborative opportunities with UoA4 discovering extra-cellular mechanisms in neuroinflammation and neurodegeneration.

1.6.2 Within NHS: The "One Manchester Approach"

UoA4 researchers work under the umbrella of MAHSC, one of eight NIHR, NHS England and NHS Improvement AHSCs. The six priority MAHSC domains include Mental Health (lead **Lewis**) and a new Neuroscience domain (lead **Allan**). MAHSC domains are integral to HInM which aligns UoM with NHS providers and GM commissioners in the context of the devolved £6.2bn p.a. health and social care budget to GM Health and Social Care Partnership (GMHSCP).

The NIHR Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) GM (2012-2019) preceded the newly awarded NIHR Applied Research Collaboration GM (ARC-GM) which is part of HInM. **Bucci**, **Green**, **Armitage** and **Abel** are Co-Investigators in NIHR ARC-GM; **Armitage** is deputy theme lead for Hearing Health in the NIHR Manchester BRC and behavioural science lead for the NIHR GM Patient Safety Translational Research Centre (UoA2) and sits on the Digital Health Domain Steering Committee.

Figure 2: *UoA4 researchers within the GM healthcare infrastructure*

UoA4 translational neuroscience research is facilitated by Manchester Centre for Clinical Neurosciences, part of the Northern Care Alliance (NCA) and based at Salford Royal Foundation NHS Trust (SRFT). The new Geoffrey Jefferson Brain Research Centre will be a partnership between the UoM and NCA, led by **Allan** and King (NCA/UoM) and will link to neuro-oncology at the Christie NHS Trust.

UoA4 mental health research is integrated with GMMH (Research and Development Director **Morrison**). UoM hosts six of the nine GMMH flagship research units: Psychosis (**Morrison)**, Complex Trauma and Resilience (**Varese, Bucci, Berry, Brown**), Perinatal Mental Health (**Wittkowski**, **Abel**, **Gregg, Wan**), Anxiety, Depression and Psychological Treatments (**Wells**), Digital Health (**Abel**), Youth Mental Health (**Yung**).

1.6.3 Enabling and facilitating impact

UoA4 is supported by a dedicated Knowledge Exchange and Impact Officer and two academic "Impact Ambassadors" (**Bowen**, **Mansell**). UoA4 researchers, with Policy@Manchester and UoM Library, have developed and delivered 1-day workshops on 'Enhancing Research Reach and Impact'; 1-2 yearly with 75 participants/ workshop, including external sessions delivered by Kudos, The Conversation, and Westminster Parliamentary Engagement Team. Our researchers are supported by the Business Engagement Team, UoM Intellectual Property, Small and Medium Enterprise and Knowledge Exchange Managers, Library, Press Office and other specialist academic networks.

UoA4 researchers have access to University impact awards (£300k BBSRC Impact Acceleration Account, MRC CiC, Wellcome Trust Institutional Translational Partnership Award). These funds accelerate the transition from discovery research to translational development by supporting preliminary work or feasibility studies to establish the viability of an approach. Awards in UoA4 have funded development of action imagery in neurorehabilitation for Parkinson's disease (**Poliakoff**), clinical imaging techniques to optimise therapy for aphasia (**Woollams**), a digital health intervention for self-harm in children (**Abel**) and a partnership between NHS autism services and Autism@Manchester (**Gowen**).

1.7 Research Best Practice

1.7.1 Research Openness and Reproducibility

UoA4 is committed to open research and benefits from UoM and FBMH initiatives to promote open research, including pre-registration of research, transparency in research methodology, public availability and reusability of research data and analysis code, public accessibility and transparency of research communication, and using web-based tools to facilitate collaboration.

To support these initiatives, UoM provides:

- guidance and training for all researchers, through relevant expert teams including the Library, Research and Business Engagement, Research IT, and the Open Research Working Group;
- access to systems to facilitate open research, including Pure, the library's Open Access Gateway, ORCID, the UoM Data Repository;
- support for sustainable open access options include UKRI (£1.2m) and Wellcome (£170k) block grants and UoM's Open Access Fund (£300k).

The University-wide Open Research Working Group (ORWG) was founded by **Stewart** and Jay (UoA11) and arranges training events and workshops around Open and Reproducible Research. **Stewart** represents Manchester within the UK Reproducibility Network and acts as UoM Lead for Open and Reproducible Research. There are close ties between the ORWG, the University-wide R Users' Group, Research IT, and the Software Sustainability Institute. The ReproducibiliTea journal club runs cross-faculty and was initiated by an ECR team including members of UoA4. UoA4 researchers work within the Research Openness framework defined in UoM's Position Statement which was jointly developed by **Stewart**.

1.7.2 Research governance

UoA4 researchers recognise that conducting research includes responsibility to ensure its probity, quality and ethical base. UoM governs these standards and creates the highest levels of research integrity as set out in UoM's Code of Good Research Conduct. All UoM research is conducted in accordance with the "Ten Principles" (Excellence, Honesty, Openness, Rigour, Safety, Ethical Responsibility, Responsible Management, Regulatory Compliance, Professional Standards, and Reporting Misconduct). UoA4's research governance is remitted by the Research Governance Team (RGT), acting for UoM as Research Governance Sponsor, and ensuring adherence with the UK Policy Framework for Health and Social Care Research. Within UoM, RGT works alongside the Research Governance, Ethics and Integrity Team ensuring alignment with the principles in Universities UK's Concordat to Support Research Integrity.

1.7.3 Animal research

UoM animal research has received awards for its openness: 2016 Openness Award from Understanding Animal Research (UAR) for our website. The website publishes ethics committee minutes, welfare policies, governance information, infographics on number/species of animals used each year, and studies on medical advances made resulting from animal and 3Rs (Replacement, Reduction and Refinement) research. In 2019, UoM was in UAR's top 10 organisations for animal research.

1.8 Research Impact Related to COVID-19

Our translational approach responds to the changing health, including mental health, needs of our population, locally and nationally. The effectiveness of this strategy has been demonstrated by our response to COVID-19:

- ***Translational Neuroscience:*** UoA4 research on the importance of inflammasomes and IL-1 to COVID-19 includes a new MRC DTP CASE PhD studentship, in an industry collaboration with Sobi (**Allan**).

- ***Mental Health:*** UoA4 researchers contributed to improved sector understanding of COVID-19 and its impact on mental healthcare. **Varese** and **Morrison** were invited representatives on the GM Psycho-Social Expert Reference Group convened by GMCA /GMHSCP to provide expert advice on psychosocial support for vulnerable groups affected by the pandemic. **Varese** secured a NIHR COVID-19 Cross-programme grant evaluating a new 'Resilience Hub' service to support the mental health needs of vulnerable groups (£500k). **Bucci** and **Lewis** received MRC funding for remote digital symptom monitoring in schizophrenia patients (£41k). **Abel** examined changes in adult mental health in the UK population before and during lockdown (*Lancet Psychiatry, 2020*). **Berry** developed COVID-19 guidelines for psychological therapists on in-patient mental health wards.

- ***Suicide:*** NCISH (**Appleby**, **Shaw**) worked with NHS England, Public Health England and other academics to form a national academic response to suicide prevention and COVID-19. **Steeg** received funding from the COVID-19 Rapid Response Call (£150k) for a cohort study to examine self-harm and risks of suicide associated with COVID-19. **Appleby** and Kapur (UoA2) highlighted suicide risk and prevention during COVID-19 (*Lancet Psychiatry, 2020*) while **Taylor** examined their impact (*Lancet Psychiatry, 2020*).

- ***Health Psychology:*** **Armitage** was a founding member of the British Psychological Society's Behavioural Science and Disease Prevention Taskforce that has published guidance documents on preventing the spread of COVID-19 through self-isolation, encouraging hand hygiene in the community and use of contact tracing apps. The work was presented at SAGE and endorsed for use by Public Health England/Public Health Wales. UoA4 Health Psychologists examined public perceptions and experiences of social distancing and social isolation during the pandemic (**Armitage, Dienes,** *BMJ, 2020*).

2. People

2.1 Staffing Strategy

UoA4 academics work within a supportive and structured environment defined and implemented by UoM (see REF5a, section 3).

UoA4 staff recruitment, development and retention is enabled by a framework that maximises opportunity at all career points and fully encompasses the Researcher Development Concordat and is guided by UoM commitment to the principles of equality, diversity and inclusion (EDI, section 2.5; REF5a, section 3.2).

Continuous staff development provides UoA4 researchers access to: 10 days development training annually; "Researcher Development Planner and Framework" to map and guide career development and training; annual Performance and Development Review (P&DR) managed through online appraisal documentation; face-to-face interviews with trained PIs alongside research staff specific appraisal guidance linking to development opportunities, reward and recognition processes; >1000 comprehensive online/face-to-face training programmes; and "Investing in Success" funding with > £1m invested in 2018 to support innovative career development for individuals/teams; International Conference and Research Collaboration Funding Schemes.

UoA4 researchers also benefit from university-wide events (see REF5a, section 3.3). All staff and postgraduate students have access to Manchester Gold mentoring schemes, coaching through an in-house pool of accredited coaches, and grant retreats run by school research directors.

Recognition and reward come through P&DR, annual promotions processes, internal prizes and awards (e.g., Researcher, Teacher, Supervisor of Year awards, Making a Difference awards). Researchers are supported in building promotion cases ensuring parity of esteem across all three of our academic pathways (research, teaching and learning, teaching and learning only and research only) through workshops, School/Divisional promotion champions and shared online experiences.

Careers of researchers on short-term contracts: research staff are supported by UoM's sector-leading open-ended contract policy carrying additional benefits for researchers with more than four years continuous service, including: three months' salary beyond statutory notice periods; providing development opportunities (e.g. specific training, job shadowing); redeployment for six months to bridge funding gaps; Extended Access Policy (applauded in feedback on UoM's HR Excellence in Research award renewal 2017) providing 12 months access to email and e-resources after contract termination.

2.2 Staff Support and Development Structures

Athena SWAN and Project JUNO dedicated roles are embedded at all levels. Our positive commitment to the career advancement of BAME staff is evidenced through our bronze Race Equality Charter Mark and use of the Stellar HE programme. We have dedicated staff resources to support disabled staff through engagement with the Business Disability Forum's Disability Standard and the Stonewall Diversity Champions Programme. We are a Disability Confident employer which includes a guaranteed interview scheme for disabled job applicants who meet the essential job criteria which we actively monitor. We are a Stonewall top 100 employer for LGBTQ+ inclusion in the workplace.

2.2.1 UoM

UoM's key institution-level support elements are represented in Figure 3, and include:

- staff and student mentorship programmes;
- Staff Learning and Development Unit (SLDU);
- award-winning University Careers Service (UCS);
- library-based researcher information including researcher profiles and altmetric data.

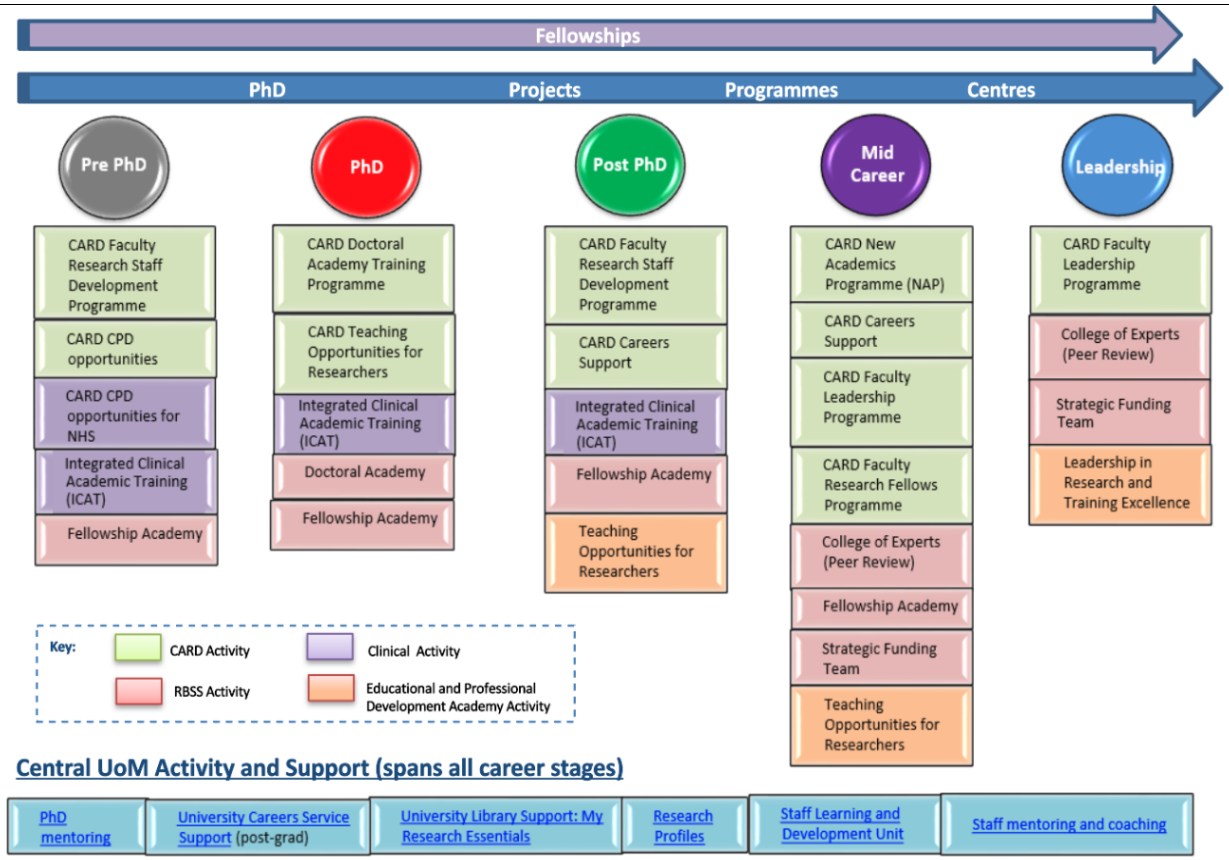

Figure 3: *FBMH researcher development continuum*

2.2.2 FBMH

FBMH provides a continuum of researcher development to support progression along clinical and non-clinical researcher career pathways and provides co-ordinated support at all career stages. Staff development is strategically aligned to our ambitious Faculty Research and Innovation Strategy which has the development of people and support for a nurturing research environment at its core.

To support and develop our researchers to achieve their ambitions and our research goals, we provide specialised Support Services including:

Research Strategy and Innovation Team (RS&I) brings seamless functionality to Research Management, Postgraduate Research, Business Engagement, Knowledge Exchange, Internationalisation and Strategic Funding Teams, it provides guidance and practical support to academics in all aspects of research engagement.

Centre for Academic Researcher Development (CARD) delivers high quality programmes supporting development of established academics and ECRs. Three teams specifically support postgraduate researchers and ECRs:

i) ***Doctoral Academy (DA)*** engenders a culture recognising the value of PGR activity, encourages aspirational goals and supports programme completion (section 2.4.1);

ii) ***Fellowship Academy (FA)*** provides advice and support for all levels of fellowship from initial planning to interview training (section 2.4.3);

iii) ***Integrated Clinical Academic Training Team (ICAT)*** partnership between FBMH and Health Education North-West (renewed 2017) ensures harmonised clinical and academic training and supports aspiring clinical academics.

2.3 FBMH's Researcher Development Continuum (RDC)

All UoA4 researchers are supported by RDC through career point avenues of support and development.

Figure 3 shows when and how specialist support is offered in the RDC and how it maps on to/complements University-wide support. Oversight is through FBMH's Researcher Development Group (FRDG), chaired 2016-2020 by **Hooper** (Vice Dean for Research) that coordinates FBMH's researcher development provision and ensures equality of access and opportunity. FRDG delivers researcher support through Schools/Divisions and CARD.

CARD delivers training, development, mentoring and coaching to all UoA4 researchers, students and NHS partners, enabling personalised professional development:

- ***New Academics Programme (NAP)*** for all new staff. Accredited by Advance HE, NAP is flexible, dovetailing with academics' career aspirations and prior experience, supporting research, teaching, learning and leadership at the highest level. All participants have an independent academic mentor. Successful completion leads to HEA Fellowship;
- ***Faculty Leadership Programme***. This two-year programme promotes exceptional academic leadership through example, tutorial and practical experience, building research capability, teaching and learning best practice and accreditation, leadership and management capacity, personal effectiveness and strategic career management;
- ***Leadership in Education Awards Programme (LEAP*)** provides pedagogic training and development, and teaching opportunities across FBMH and is accredited by the HEA, Advance HE;
- ***Researchers Development Programme*** provides intermediate level training to maximise outputs/impact, develop transferable skills and independent research careers through grants/fellowship support, proactive career management, CV development, interview skills, and career planning using accredited careers consultants and coaches;
- UoA4's ***Academic and Research Staff mentoring programme***, enhances performance and fulfilling potential for individual researchers by working with mentors for 12 months;
- ***FBMH's Research Staff Representatives Forum***, a comprehensive network of >30 Research Staff Representatives, with at least one member from every Division, to promote the interests of >1060 clinical/non-clinical researchers.

Nationally, CARD represents UoM on the Researchers14 network, contributing to the national review of the "Concordat to Support the Career Development of Researchers".

2.4 Developing Tomorrow's Researchers

2.4.1 Doctoral Academy

The Doctoral Academy Training Programme provides foundation- and intermediate-level training at key stages of the postgraduate research degree to ensure skills development, timely degree completion, and increased future employability.

All PGRs initially undertake a skills-needs analysis to identify areas for development and, throughout their programme, undertake specific research skills training. Postgraduates are encouraged to participate in a broader programme of training and personal development provided via the University SLDU or the library. PGRs are also encouraged to enrol in discipline-specific research methods taught programmes, and those who are part of DTPs (MRC, BBSRC) have access to bespoke training.

The DA provides online training in core skills (particularly attractive to part-time students). £5.5m UoM funding has allowed us to create the Integrated Interdisciplinary Healthcare Science Hub to drive digital-based learning across FBMH.

Multiple student wellbeing initiatives across UoM and FBMH include appointment of PGR representatives to advise on mental health and, via online 'Pulse-Check' initiative, to self-check general wellbeing. In UoA4, a successful Office for Students-funded bid (£150k) has allowed us

to investigate mental health prevalence and trigger points and to promote self-help using Wellbeing Apps.

2.4.2 Research Students

UoA4 academics are directly involved in encouraging and supporting a dynamic research culture from the earliest stage of students' careers.

2.4.2A Clinical Psychology (ClinPsyD) PGR students

ClinPsyD is a professional doctorate combining clinical skills training, academic teaching and independent postgraduate research. The research component represents ~50% of the degree and forms a doctoral thesis. Students produce a clinical audit whilst on placement using formal audit methodology. Within each graduating cohort, over half publish their work in peer-reviewed journals and/or present at major professional conferences. Many graduates go on to conduct research as part of their clinical careers or pursue clinical academic paths. In the REF period, 170 Clinical Psychology Doctorates were awarded to students supervised by UoA4 academics.

2.4.2B PGR students

PGR students in UoA4 are funded primarily via MRC and BBSRC DTPs, and the ESRC DTC with other sources including the interdisciplinary SOC-B scheme, the EPSRC, charities including the Stroke Association and Alzheimer's Research UK, and multiple international partnership schemes (Chinese Scholarship Council, A*STAR Institute in Singapore, the Weizmann Institute of Science, Israel, and the Universities of Melbourne and Toronto). All PGR students have at least two supervisors with complementary interdisciplinary expertise. In line with UoM policy, new PGR supervisors must undertake the Higher Education Academy (HEA)-accredited NAP and initially act as a co-supervisor until successful completion of the degree, prior to holding primary supervisory responsibility. In the REF period, 477 PhDs were awarded to students supervised by UoA4 academics (83% UK, 8% EU, 9% rest of world). The quality of their research is attested by the fact that 46% of our returned outputs have a UoA4 supervised PhD student as a co-author.

Recruitment: Robust and standardised selection processes for all new research students include independent project and supervisory assessment by the DA, and panel interviews for competitively awarded funding. Mentoring schemes identify exceptional candidates, support them through competitive application processes and, post-funding, provide bespoke supervision.

Student progress and monitoring: PGR students engage with online progression monitoring systems, providing clear direction on critical milestones, recording evidence of engagement with training, progress and personal development. Online systems ensure continual supervisory feedback, and timely thesis submission/degree completion.

Experience and Careers: UoA4 students are advised by the UoM award-winning Careers Service, specialising in bespoke careers training, CV writing workshops and networking events with industry. "Student of the Year" awards give peer recognition of research excellence.

2.4.3 Fellowship Academy

The Faculty Fellowship Academy (FA, lead Hanley, UoA1) supports clinical/non-clinical researchers to obtain external fellowships, providing support from initial planning through to interview practice.

Researchers access "CV clinics" (run by senior Faculty academics), bespoke advice and peer review, mock interviews, pump-prime funding, and Institutional Fellowship awards (e.g., Presidential Fellowships). Over 500 people have attended a clinic session since February 2013, with many returning for a further session. FA also manages the "Fellows Network" providing peer support, networking and collaboration opportunities.

Post-award, all Fellows are mentored; clinical Fellows by at least one clinical academic from her/his Research Grouping. Career guidance is provided by constructive dialogue with senior colleagues, formalised faculty-level objective setting and mid-term review by a Fellowship Review Committee (section 2.4.4).

2.4.4 Early career researchers (ECRs)

UoA4 ECRs (12%, sections 2.6 and 2.7; REF5a, sections 3.3.1, 3.3.2) are extensively supported by Schools/Faculty, including: NAP (section 2.3); careful supervision and mentorship; and reduced teaching/management responsibilities for four years, to ensure a clear research base and direction. We actively support Fellows towards permanent positions or further externally funded Fellowships via a mid-term Fellowship Review Committee. The committee reviews progress against objectives set at the outset of the Fellowship, typically at ~18 or 36 months for three and five-year appointments. The review provides a supportive environment to reflect on achievements against objectives, discuss any issues arising, and agree future plans. Fellows are offered University-funded extensions to advance their research programmes before applying for follow-on funding or more senior fellowships or are offered tenure if performance is strong.

2.5 Equality, Diversity and Inclusivity

We have submitted all independent researchers. UoA4 researchers work within UoM's EDI framework (see REF5a, section 3.2). Committed to EDI principles across the entire spectrum of Protected Characteristics, UoM has clear strategies for advancing EDI, embedding inclusive practice and creating a structure that supports and includes staff and students in all aspects of University life. FBMH's EDI Committee ensures responsibility for, and awareness of, EDI commitments and objectives.

The three Schools comprising UoA4 were awarded Athena Swan silver status (2018), with the Athena SWAN assessors reporting:

> *The submission demonstrated commitment and engagement in the process from all levels….. The panel considered it to be a clear and reflective submission…it was clear how staff were communicated with throughout the process of restructuring.*

Benchmarking analysis from 2017 data showed that UoM had the narrowest mean Gender Pay Gap of the Russell Group Universities.

UoM EDI structures:

Coaching provision for UoA4 staff: PS and Academic staff actively engaged with internal coaching provision available via Staff Learning and Development. 100% of participants would recommend the coaching to colleagues. Since August 2019, 82% of FBMH participants have been women and 26% BAME.

BAME advocacy and working group: FBMH launched the flagship "Inclusive Advocacy Programme", designed to ensure that high-performing researchers from under-represented groups are supported to reach their full potential. The programme aims to increase diversity in leadership positions and promote inclusivity, both of which have been shown to increase productivity and innovation. A BAME working group is currently addressing barriers faced by BAME individuals in achieving high-level UoM roles.

Support for women: **"**Women in FBMH" provides a support network, organising events and courses promoting EDI; e.g., confidence and personal impact workshops and international women's day events attended by over 400 staff and students. FBMH Athena SWAN self-assessment teams hold regular events to promote flexible working and wellbeing which is important to women's progression in HE.

UoA4 has invested in the development of a workforce that reflects EDI. For example:

- UoA4 researchers are line-managed in three Divisions within two Schools, all of which have been headed by women;
- 50% of UoA4 promotions to Chair, Reader or Senior Lecturer were female (section 2.7);
- our workforce is enriched by employment or consultancy of people with specific Protected Characteristics;

- our environment facilitates joint working and co-authorship between lead researchers and service user/carer team members. For example, our NIHR-funded suicide prevention trials have resulted in high impact publications led by service user co-applicants (**Awenat**, *British Journal of Psychiatry, 2017*);
- we undertake structural inequalities work in specific communities; e.g., unequal access in service delivery including African Caribbean people with SMI (**Berry**, **Abel,** *Pilot and Feasibility Studies, 2016*), remote delivery of psychological interventions for people with SMI (**Bucci**, **Lewis**, **Haddock,** *Schizophrenia Bulletin, 2018*), studies in to low- and middle-income countries e.g., suicide and self-harm in Pakistan (**Husain,** *British Journal of Psychiatry, 2014*).

Our REF2021 Code of Practice (published 2019) complies with EDI legislation and provides a transparent explanation of our approach for our submission.

Staff wellbeing: In 2016, UoM set out a Wellbeing Strategy "to promote and enhance wellbeing for all staff through the development of a proactive and enabling culture," with responsibility for implementation at university, managerial, and individual levels. Actions included the launch of the Manchester Ways to Wellbeing Campaign, promoted via our "wellbeing champions" staff network, with 12 champions within FBMH. Online materials facilitate wellbeing at work. UoM provides dedicated "Wellbeing Rooms" for exercise and relaxation. UoM's wellbeing strategy during COVID-19 was led by a UoA4 mental health clinical academic (**Haddock**).

2.6 Recruitment and Promotions in UoA4

In the REF period, we have made strategic external appointments (**Hooper, Roncaroli)** and promoted established academics to provide strategic vision to drive and enhance our research delivery and/or provide research continuity.

Internal Promotions

- 11 Chairs (six female): **Berry**, **Bowen**, **Brough**, **Bucci**, **Elliott**, **Husain**, **Leroi**, **Pendleton**, **Petersen**, **Roncaroli**, **Theakston**.
- Five Readerships (three female)*:* **Mansell, Parkes**, **Pinteaux**, **Ulph, Woollams**.
- 14 Senior Lectureships (six female): **Brooks**, **Brown**, **Gigg**, **Gowen**, **Humphries**, **Lawrence**, **Lewis**, **Pobric**, **Powell**, **Pratt**, **Schiessl**, **Talmi**, **Taylor**, **Varese**.
- Two Lecturers: **Muhlert**, **Yao.**
- Four Research Fellows (two female): **Kafkas**, **Leadbitter**, **Patchwood, Storchi.**

2.7 Externally funded positions

Senior Research Awards

- NIHR Senior Investigators: **Abel***,* **Deakin, Green***,* **Haddock***,* **Lewis***,* **Shaw, Yung**.
- NIHR Research Professorships: **Bucci**

Intermediate Research Fellows:

- NIHR Clinical Trials Fellowship: **Berry**
- NIHR Advanced Fellowship: **Varese**
- Sir Henry Dale Fellowship*:* **Storchi**
- Versus Arthritis Clinical Research Training Fellowship*:* **Chew**
- Sir Henry Wellcome Fellowship*:* **Chiou**
- MRC Senior Non-Clinical Fellow*:* **Humphries**
- MRC Skills Development Fellowship: **Lea-Carnell**
- Stroke Association Postdoctoral Research Fellow: **Patchwood**

Research Fellowships:

- BBSRC Discovery Fellowship: **Rivers-Auty**
- UKRI Future Leaders Fellow: **Firth***,* **Yao**
- NIHR Doctoral Research Fellowship: **Shepherd**

- Presidential Fellowship: **Steeg**
- Dean's Fellows: **Farmer**
- Alzheimer's Society: **Hicks**, **West**
- David Sainsbury Fellowship: **Storchi**
- EPSRC Early Career Fellow: **Trujillo-Barreto**

3. Income, infrastructure and facilities

3.1 Research income

UoM is a major recipient of bioscience and biomedical funding, which cuts across UKRI, UK government, charities, international and industrial funding. Our live funding portfolio from BBSRC and Wellcome is £129m. We have consistently ranked as the first or second highest recipient of funding from the BBSRC since 2014.

During this REF period:

- UoA4 researchers have contributed to a total of £147.9m awards (Figure 4).
- 56% of total UoA4 income is cross-disciplinary, with multi-investigator awards spanning at least one other UoA.
- UoA4 researchers have contributed to £6.7m income from industrial partners

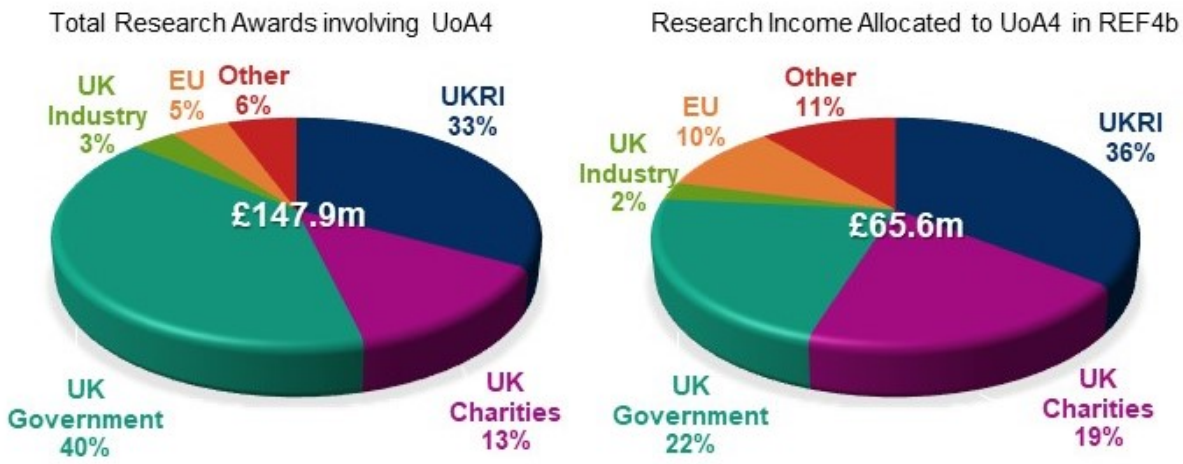

Figure 4: *Research awards and income to which UoA4 has contributed by source*

3.2. Research Support

UoM central Research Services Team (RST) is part of our wider RS&I team and comprises a group of Strategic Funding Managers (SFMs) who work across FBMH. RST is responsible for leading and developing an integrated and effective research service to maximise our ability to attract researchers and research income, undertake high-quality research, and exploit research outcomes. RST includes a specialist EU office, compliance and risk management, research governance and data protection.

UoA4's research is enabled by FBMH's RS&I (section 2.2.2), organised through the:

Research and Business Engagement (RBE) Team, comprising Research Services, Research Governance, the PGR Doctoral Academy, and Business Engagement and Strategic Funding and is responsible for developing and implementing FBMH's research and business engagement strategies.

Strategic Funding Team, which helps implement FBMH's research strategy, provides support to investigators, facilitates collaborative and multidisciplinary research and creates new research consortia and networks to respond to strategic funding opportunities.

RST's primary objective is to coordinate the development of large (>£1m) strategic grant proposals. Success during the REF period is demonstrated by the number and value of the Centres and Consortia bids listed below.

3.3 Externally funded Research

3.3.1 New Centres / Networks established in REF period:

- **Appleby**, Healthcare Quality Improvement Partnership (HQIP) The National Confidential Inquiry into Suicide and Safety in Mental Health (NCISH) 2015-2018 HQIP NCA 149, 2015-22, £2.3m;
- **Appleby**, HQIP, National Confidential Enquiry into Suicide and Homicide, 2013-15, £1.5m;
- **Bucci**, **Haddock**, Wellcome, Optimising AVATAR therapy for distressing voices: a multi-centre randomised controlled trial, 2019-23, £3.3m (total multisite award);
- Cullum (UoA3) NIHR Applied Research Collaboration - Greater Manchester (NIHR ARC-GM), total NIHR award £11.3m (with UoA4 Co-Is **Bucci, Abel, Green, Armitage**);
- **Herholz**, MRC: Dementias Platform UK MR-PET Partnership, 2016-20, £1.1m (total multisite award);
- **Hooper**, MRC: Momentum Award - Dementias, 2016-19, £1.2m (total multisite award);
- **Lambon Ralph**, **Hooper** MRC, UKDP: Integrated Dementia Research Environment, 2015-16, £6.1m.

3.3.2 Major industrial funding in REF period:

- **Armitage**, Tesco Stores Ltd, Achieving Transformational Change in Health and Wellbeing, 2016-19, £1.2m;
- **Asselin**, Hoffman LaRoche Ltd, Biomarkers for the anti-angiogenetic anti-vegf antibody Bevacizumab, 2014-16, £2.3m;
- **Deakin**, P1VITAL Ltd, Phase 1 study investigating the effects of HTL0009936 on cognition and BOLD fMRI signals in healthy elderly subjects, 2015-17, £500k;
- **Deakin**, Sunovion Pharmaceuticals Inc, Effects of SEP-363856 and Amisulpride on BOLD-FMRI Signal in Healthy Male and Female Volunteers with High or Low Schizotype Characteristics, 2013-16, £500k;
- **Lucas**, Signify Netherlands B.V., The Impact of Daytime Light Exposure on Diurnal and Circadian Rhythms in the Diurnal Rodent Rhabdomys pumillio, 2017-21, £500k;
- **Lucas**, Acucela Inc, Optimising human rod opsin for optogenetic restoration of vision, 2018-20, £500k.

3.3.3 Major international collaborative funding in REF period;

- **Abel**, European Commission, Children and adolescents with parental mental illness: understanding the 'Who' and the 'How' of targeting interventions, 2016-21, £1.4m;
- **Allan**, Leducq Foundation, Stroke-immune mediated pathways and cognitive trajectory, 2020-24, £1.4m UoM. Transatlantic Network of Excellence;
- **Appleby**, European Commission, Understanding the Determinants of Suicidal Behaviour, Serious Accidents and Violence in Young People, 2014-19, £800k;
- **Herholz**, European Commission, European Medical Information Framework, 2013-18, £900k;
- **Herholz**, European Commission, Imaging of Neuroinflammation in Neurodegenerative Diseases, 2012-18, £500k;
- Robinson (UoA3) **Husain**, GCRF, South Asia Self Harm research capability building initiative (SASHI), 2018-23, £3.1m;
- **Leroi**, European Commission, Ears, Eyes and Mind: The 'SENSE-Cog Project' to Improve Mental Wellbeing for Elderly Europeans with Sensory Impairment, 2016-20, £1.8m;

- **Lieven**, ESRC, The Centre for Language and Communicative Development, 2015-24, (£9.5m total awards; £3.3m UoM). Partners in Europe, US and Australia;
- **Lucas**, European Commission, LIGHTCAP: Light, Cognition, Attention, Perception, 2020-24, £500k.

3.3.4 Major Funding Awards (>£1m) in REF period by Research Theme

Research theme	Income in current REF period
Translational Neuroscience	£72.5m
Mental Health	£70.9m
Language and Communication	£3.7m
Vision Science	£10.0m

***Translational Neuroscience*:**

- **Baines**, Wellcome, Developmental Tuning of a Motor Network, 2020-25, total £1.8m (total multisite award);
- **Bowen**, DoH, Collaboration for Leadership in Applied Health Research and Care, 2014-19, £8.0m;
- **Bowen**, NIHR, Does Interleukin-1 Receptor Antagonist Improve Outcome Following Aneurysmal Subarachnoid Haemorrhage (aSAH), 2018-23, £2.2m;
- **Brough**, MRC, New insights into NLRP3 with inflammatory disease, 2020-25, £1.5m;
- **Burns**, ESRC, Neighbourhoods and Dementia: A Mixed Methods Study, 2014-19, £3.7m;
- **Burns**, NIHR, Older people and frailty policy research, 2019-23, total award £5.0m;
- **Lambon Ralph**, MRC, Towards a unified, computationally-implemented neural network for understanding semantic cognition and its disorders, 2011-18, £1.7m;
- **Lambon Ralph**, European Commission, Developing and delivering neurocomputational models to bridge between brain and mind, 2016-20, £1.5m.

Mental Health:

- **Abel**, NIHR HTA, WORSHIP III Women offenders repeat self-harm intervention pragmatic trial, 2018-23, £1.4m;
- **Anderson**, **Elliott**, MRC/NIHR EME, Ketamine augmentation of electroconvulsive therapy to improve outcomes in depression, 2012-15, £1.0m;
- **Armitage**, Tesco Stores Ltd, Achieving transformational change in health and wellbeing. A 3 Year Programme, 2016-19, £1.2m;
- **Berry**, **Haddock, Bucci,** NIHR PGfAR, Increased psychological therapy on inpatient wards: TULIPS study, 2017-22, total award £1.3m;
- Edge (UoA3) **Berry**, **Abel**, **Morrison**, NIHR HTA, Culturally adapting established psychological interventions for psychosis patients from BAME groups, 2019-23, £2.3m;
- **Bucci**, MRC, Active Assistance for Psychological Therapy (Actissist 2.0): digital intervention for co-producing care in psychosis, 2017-20, £1.3m;
- **Deakin**, MRC/NIHR EME, The benefits of minocycline on negative symptoms in schizophrenia: extent and mechanisms. 2011-16, £2.0m (multi-site award);
- **Deakin**, MRC, Defining the disturbance in cortical glutamate and GABA function in psychosis; its origins and consequences, 2013-18, £1.3m;
- **Husain**, NIHR, Multi-centre RCT of a group psychological intervention for post-natal depression in British mothers of South Asian origin (ROSHNI-2), 2016-20, £1.8m;
- **Green**, MRC, Communication-Centred Parent-Mediated Treatment for Autism Spectrum Disorder in South Asia (COMPASS), 2018-22, £1.9m;

- **Green**, NIHR, REACH-ASD Trial: A randomised Controlled Trial of Psycho education and Acceptance & Commitment Therapy for Parents of Children recently diagnosed with ASD, 2019-23, total award £1.2m;
- **Green**, NIHR, PACT-G The Paediatric Autism Communication Trial - Generalised, total award £1.8m;
- **Haddock**, **Gooding**, MRC / NIHR EME, Self-harm and suicidal behaviours: A psychological intervention for suicide applied to patients with psychosis: the CARMS trial, 2017-21, total award £1.4m;
- **Lewis**, EPSRC, The wearable clinic: connecting health, self and care, 2017-21, £1.2m;
- **Morrison**, NIHR i4i, Using virtual reality therapy to help people with psychosis, 2019-23, £4m (total multisite award);
- **Pratt,** DoH, Prevention of suicide behaviour in prison: enhancing access to therapy (PROSPECT) Programme, 2019-23, total award £1.6m.

Vision Science:

- **Humphries**, MRC, Networks of neural dynamics: knowledge-discovery for experimental neuroscience, 2012-19, £1.3m;
- **Lucas**, Wellcome, Daylight vision beyond cone photoreceptors, 2018-23, £1.4m;
- **Lucas**, ERCl, Melanopsin-based vision in health and disease (MeloVision), 2011-16, £2.0m.

3.4. Securing Future Funding

UoA4's principles underpinning, maintaining and increasing research funding, build on the successes in this REF period, guided by our future research strategy (section 1.3), and include:

- exploiting UoM's advanced "big data" analytics and large health informatics and software engineering department to power medical innovation in mental health, particularly digital mental health;
- further aligning our research with the healthcare needs of our population and close partners in the NHS (e.g., HInM) via securing significant external funding in a strategic partnership with the Northern Care Alliance to develop the Geoffrey Jefferson Brain Research Centre (section 1.4.1); developing, evaluating and implementing innovations that address neuroscience and mental health priorities for HInM (section 1.4.2);
- integrating our new Mental Health Manchester and translational Neuroscience strategies into the BRC renewal;
- leading and/or participating in new interdisciplinary, inter-faculty strategic initiatives particularly in digital health, AI, inequalities;
- developing our emerging funding portfolio in global health;
- maintaining a competitive stream of ECRs/potential ECRs, in particular taking advantage of our recent international partnerships with universities in Australia, Canada and China;
- supporting career aspirations of current researchers and ensuring researchers continue to have access to the very highest level of infrastructure support;
- building on industry links related to treatment of neurodegenerative disorders (e.g., Bigger (UOA1) £10.3m from Orchard Therapeutics gene therapy for Mucopolysaccharidosis).

3.5. Infrastructure and Facilities used by UoA4 researchers

UoM operates an investment strategy that enables excellence through facilitating inter-disciplinary research. Investment in buildings and facilities supports UoA4 researchers.

3.5.1 New buildings

The University is continuing to undertake a major programme of updating and building new facilities in an ambitious University Estates plan (>£1bn).

Building work completed in the REF period includes:

- *MSP's Bright Building* (£35m) MSP (Manchester Science Park) together with SMEs and larger Manchester-based companies;

- *Citylabs 1.0* (£25m) brings together and accelerates collaboration between UoA4 researchers, NHS, and industry. *Citylabs 2.0 and 3.0* under construction at MFT Oxford Road (£60m). Citylabs 2.0 will be the main UK site of UoM's strategic industry partners.

3.5.2 Refurbishment

Vaughan House: Campus listed building refurbished (£2.4m MRC) for Manchester Health Informatics Hub of the Northern England Health eResearch Centre. Promotes cutting-edge research linking e-health records with apposite research data on which many UoA4 staff collaborate.

3.6. Core Research Facilities

3.6.1. Core Laboratory Facilities (CLFs)

UoA4's researchers maximise effectiveness through accessing FBMH's CLFs (also available to Healthcare partners). FBMH's Research Technology Development Group oversees nine CLFs: Bioimaging; Biological Mass Spectrometry; Biomolecules; Electron Microscopy; Flow Cytometry; Genomic Technologies; Genome Editing; Histology; Proteomics.

CLFs have grown substantially over the review period through internal and external investment (>£15m) and staffing has increased from 33 (2014) to 49 experimental officers/technicians (2020). The researcher value is reflected in turnover (<£2m 2014, ~£3.5m 2020). Discounted rates support post-graduate student training. Cost-recovery has increased annually (currently >90%). Increased impact through investment is exemplified by Genome Editing, which historically focused on transgenic animals, but through Wellcome ISSF funding now incorporates CRISPR technology.

3.6.2. Core Imaging Facilities (CIFs)

Neuroimaging is a key methodology underpinning UoA4 research strategy. In the REF period, UoM, with RCUK and industry support, has continued to develop facilities to support pre-clinical and clinical imaging research. Researchers in UoA4 carry out >50% of the imaging activity undertaken on the University's four research-dedicated human scanners (two 3T MRI, 1.5T MRI, simultaneous PET-MR), three pre-clinical scanners (3T and 7T MRI, PET-CT) and EEG (8x64/128 channel systems in purpose-built facilities). A £6m award from Dementias Platform Initiative afforded a new simultaneous PET-MR scanner (one of only seven in the UK) installed in University-owned facilities embedded in MFT. In 2021, the 3T MR scanner at the NIHR Clinical Research Facility will undergo a major upgrade, with support from University Strategic Investment. The 3T scanner at SRFT was replaced in 2020 jointly by NCA and UoM (£2.1m), spearheading translational neuroimaging research as part of the Manchester Centre for Clinical Neurosciences at SRFT. UoA4 researchers also benefit from a state-of-the-art Virtual Reality Research Facility (VR2) (£190k UoM).

3.7 Manchester Clinical Research Facility (MCRF)

UoA4 researchers conduct many of their clinical trials in the NIHR/Wellcome Trust MCRF (£12.5m) with The Christie and MFT. MCRF supports early-phase commercial and academic clinical trials, delivering complex experimental medicine studies and driving faster translation from bench to bedside. Research studies are increasing year-on-year (688 studies in 2018/19 up 22% on 2017/18; 17% increase in Phase I/II studies).

The MRCF belongs to the recently established Mental Health theme of the NIHR Translational Research Collaborative, a national network of BRCs and CRFs which aims to facilitate UK-wide national Experimental Medicine studies. **Deakin** set up the Early Psychosis sub-theme, Ainsworth (UoA2) heads the new Informatics sub-theme.

3.8 Model Organisms Research Facility

Our Biological Services Facility (BSF) supports research in model organisms: currently, sheep, rats, mice, gerbils, zebrafish, frogs, tortoises and snails. We also have a dedicated Fly Facility. With 9,000 sqm of usable space, a turnover of £2.5m and 42 FTE staff (from 38 FTE in 2014), the BSF is one of the largest in Europe. After a £25m refurbishment 10 years ago, a further £1.4m was invested since 2014, including a new, state-of-the-art germ-free facility.

3.9 University Library

UoM's Library is a designated National Research Library, offering tailored products and services for research. The library has the most extensive digital collections of any library in the UK and is one of the largest subscribers to print and e-resource collections for biomedical sciences within the Russell Group. UoA4's researchers have seamless access to extensive discipline-specific collections, on and off campus.

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

To achieve our goals of discovery, development, and delivery of life changing interventions, UoA4 researchers adopt an interdisciplinary, collaborative approach, locally, nationally, and internationally. At the heart of UoA4's research in neuroscience and mental health is our unique relationship with NHS partners and local government. Opportunities for further integration afforded through the recent creation of the GMHSCP (Greater Manchester Health and Social Care Partnership) and HInM are key to our future research and impact strategy.

4.1 Research Collaborations, Networks, and Partnerships

4.1.1 International and National Collaborations

The negative impacts of neurodevelopmental, neurological and mental health disorders are pervasive, and to alleviate these effectively represents a global priority.

Key international projects/collaborations include:

- *Communication-Centred Parent-Mediated Treatment for Autism Spectrum Disorder in South Asia (COMPASS;* ***Green****,* UoA4 impact case) has transformed the lives of children with autism and their families and will impact health policy and practice in low resource settings globally (section 1.4.2);
- *Stroke-IMPaCT (Stroke–Immune Mediated Pathways and Cognitive Trajectories;* ***Allan****)* is a multidisciplinary international collaboration to study cognitive problems after stroke with Edinburgh, Berlin (Charite), Madrid, New York (Cornell and Columbia), Arizona, and Seattle (Washington) (section 1.4.1);
- *Orygen (****Yung****,* ***Morrison****,* ***Bucci****,* ***Berry****), a National Centre of Excellence in Youth Mental Health, Melbourne, Australia* is a world-leading research and knowledge translation organisation focusing on mental ill-health in young people. **Yung** holds a joint Professorship with Orygen. **Bucci** and **Berry** share a PhD student with University of Melbourne and we host Orygen computer scientists via the Melbourne-Manchester strategic exchange programme.
- *Suicide and self-harm* are serious global public health concerns, particularly in LAMIC (low- and middle-income countries) where >75% deaths by suicide occur. **Husain** leads a programme of research with colleagues in Canada and the Netherlands building research capacity and capability in Pakistan and India and testing scalable brief psychological interventions with adults and young people. Husain collaborates with the Pakistan parliament Sustainable Development Goals Task Force to develop policy and practice for self-harm and suicide prevention (South Asia Self Harm research capacity building Initiative: SASHI).
- *Parental depression: Learning through Play Plus* (**Husain**) is an integrated low-cost parenting intervention for depressed parents of young children, initially tested in Pakistan funded by Grand Challenges Canada and now being carried out in Kenya, Nigeria, and India. With

colleagues at the University of Toronto and Save the Children (UK), the intervention is being trialled with Rohingya refugees in Bangladesh.

69% of UoA4 researchers have produced outputs with international collaborators from 18 different countries, as shown in Figure 5.

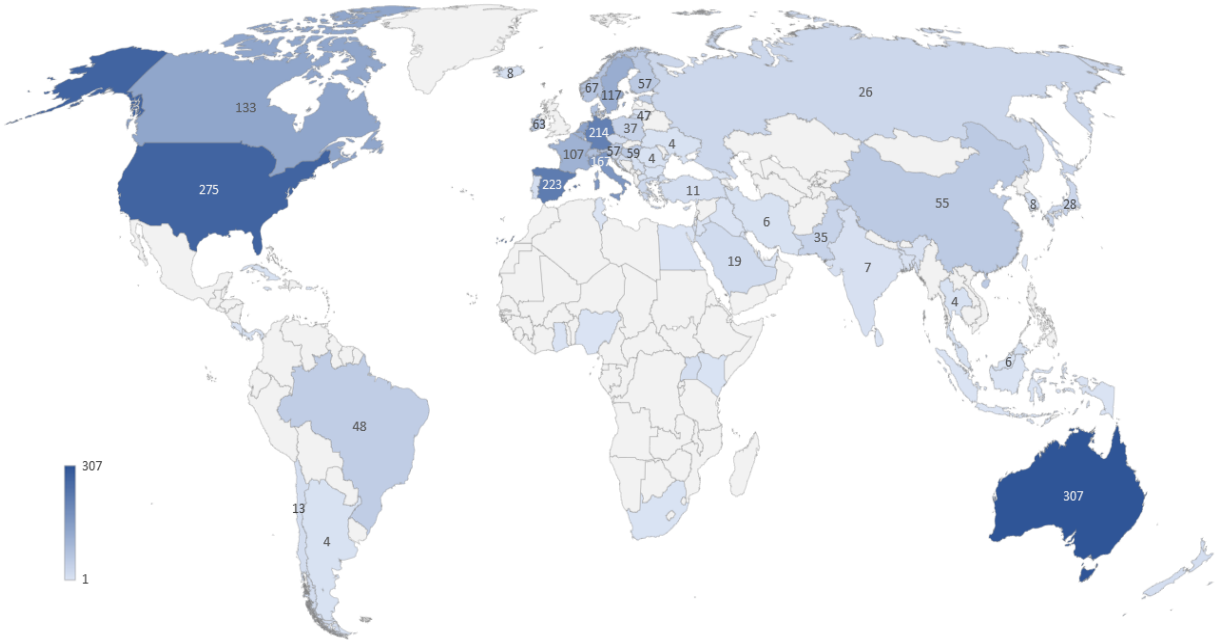

***Figure 5**: Worldwide distribution of UoA4 authored journal publications within the REF period*

Our research also involves collaboration across the UK, with many UoA4 researchers embedded within our national research network. Key projects:

- *Discovering neuroinflammatory mechanisms of and preventative approaches to stroke-related complications* with the Universities of Edinburgh and Oxford (£2.3m joint funding from MRC and Stroke Association; **Brough**, *Chemical Science*, 2020);
- *Neurorehabilitation interventions for cognitive deficits after stroke* (**Bowen**, **Patchwood**) collaborating on (i) the Clinical effectiveness of Aphasia Computer Treatment versus Usual Stimulation (CACTUS, £1.5m NIHR-HTA) RCT study with the University of Sheffield and Glasgow Caledonian University and (ii) the Study of Prisms And Therapy In Attention Loss (SPATIAL) after stroke study with the University of the West of England;
- *Discovering biological mechanisms and biomarkers of psychosis* with Cardiff University, University of Nottingham, KCL, University of Edinburgh and Queen's University of Belfast (**Deakin, Talbot, Drake,** *Schizophrenia Bulletin*, 2020). The NIHR Benemin clinical and biomarker trial of minocycline in psychosis recruited 207 patients in 2 years across 6 UK universities and 11 NHS trusts (**Deakin, Drake**, *Lancet Psychiatry* 2018);
- *ESRC International Centre for Language and Communicative Development (LuCiD)* is a research collaboration involving over 40 researchers and seven PhD students from UoM (**Theakston**, **Lieven**, **Twomey**), the University of Liverpool, and Lancaster University, supported by international colleagues.

4.1.2 Interdisciplinary Collaborations

UoA4 research is fundamentally interdisciplinary, and NMHD integrates researchers with diverse skills necessary to span the translational pathway (section 1.5). Our interdisciplinarity is evidenced by our funding portfolio: for funded research projects involving UoA4 staff (2016-2019, inclusive), 51% involve collaborations across UoM Divisions, 34% involve collaborations across UoM Schools, and 46% involve collaborations with researchers from other UoAs. We

also take advantage of UoM cross-faculty interdisciplinary institutes, such as MICRA, Thomas Ashton Institute, the new Christabel Pankhurst Institute and the Institute for Data Science & AI (section 1.6.1) particularly in developing our digital mental health programme (section 1.4.2).

4.2 Engagement with partner NHS Trusts and infrastructure

UoA4 clinical research is conducted within local NHS Trusts where many UoA4 clinical academics hold honorary contracts. Our translational research strengths depend on strong collaborative links with GMMHT (mental health) and SRFT (stroke and neurodegeneration). During the REF period, MAHSC has enhanced and enabled clinical research reported in UoA4. A step-change in UoA4's research scope followed devolution of the £6bn annual Health and Social Care budget to GM in 2016, formation of GMHSCP, and through it, HInM.

4.2.1 Greater Manchester Health and Social Care Partnership (GMHSCP)

Compared to much of England, GM has higher morbidity and lower life expectancy. Of the 22 Local Authorities in GM and Lancashire, 13 lie in the most deprived quintile nationally. The formation of GMHSCP creates opportunities to directly improve health outcomes and life expectancy. UoM works closely with GMHSCP to shape the research strategy that must underpin improving our community's health. This includes a clear direction and research framework that will characterise UoA4's research in the next REF period. It has already proved itself with initiatives including embedding our digital mental health platform technology (ClinTouch) into mental health Trusts across Manchester, formalisation of our longstanding research collaborations with SRFT on stroke and neurodegeneration via the Manchester Centre for Clinical Neurosciences, and a stepped increase in patient recruitment to NIHR Clinical Trials (31,927 in 2017/8 vs. 66,727 in 2018/9).

4.2.2 Health Innovation Manchester (HInM)

HInM was launched to provide seamless delivery of healthcare research through closer integration of GM's wider research and innovation systems. HInM enables a constant flow of targeted treatments to be sent through effective, streamlined evaluation processes, enabling adoption at pace and scale across GM. This synergy has already facilitated the impact of UoA4's research on healthcare. For example, HInM is supporting implementation of novel digital mental health solutions (**Bucci**, **Lewis**), building on the established GM Care Record to provide infrastructure for real-time, clinic-based evaluation of the next generation of digital well-being technology. Closer linkage between UoM and NHS Trusts has aligned research offices, allowing a common approach to costing, review, access and training, which combine to further optimise research effectiveness over the next 5-10 years.

4.3 Service User Collaboration, Community Involvement, and Public Engagement

Patient, public, and community involvement underpins UoA4's research ethos. We involve patients and carers in the planning, execution, and interpretation of research through active consultation and involvement in the decision-making processes. The extensive linkages of UoM with clinical contexts, formalised via GMHSCP and HInM, ensure that our research engages and involves key research users, beneficiaries and audiences. This goal is also facilitated by the Trust. The Manchester BRC has a substantial PPIE programme with dedicated project managers. Commitment of our UoA4 staff to PPIE is shown by:

- Autism@Manchester includes an "Experts by Experience" Advisory Group that ensures people with autism and their families can contribute to the formulation and design of research. The work has won a UoM award for Outstanding PPIE in Research;
- NCISH Lived Experience Advisory Panel provides the opportunity to comment on research findings and dissemination of results to service users and incorporates a direct feedback mechanism via its website;
- The Organising Support for Carers of Stroke Survivors study (OSCARSS; **Bowen**, **Patchwood**) works in partnership with stroke carers to improve their support;

- **Bucci** and **Haddock** were awarded a £50k Wellcome Public Engagement grant working with the Charity sector exploring diverse perspectives and experiences of resilience, recovery and happiness with people living in the most deprived areas across GM;
- **Varese** leads the NIHR Priority Setting Partnership on Sexual Violence, a partially crowd-funded initiative that uses PPIE to inform the future research agenda.

UoA4 staff and their students also contribute to public engagement events, including Manchester Science Week, the Big Brain Summer School, and provide school students with exposure to research via our Widening Participation Programme, with PPIE embedded as formal compulsory training in our MRC and BBSRC Doctoral Training Programmes.

4.4 Promoting Healthcare Innovation through Industry Collaborations

The Manchester Innovation Factory (MIF) was formed to drive commercialisation of UoM's innovations and intellectual property to create positive social and economic impact. Collaborating with MIF and Investor Communities, UoA4 researchers registered two spin-out companies: Bioxydyn (**Parker**), which provides state-of-the-art neuroimaging sequences, and Affigo (**Bucci**, **Lewis**), which implements digital provision of mental health monitoring and intervention technology. Affigo secured their first NHS contract in South London in 2019 and have won several awards, including **Bucci** named as a female entrepreneur as part of the Women Supporting Women Social Entrepreneurs network; Affigo technology featured on the BBC Horizons 'WhydidigoMad' programme (aired 2017; >1m viewers). UoA4 researchers have created software to facilitate research: neuroimaging analysis software (**Parker** and **McFarquhar**); digitised measures of communication outcomes after stroke (**Bowen**); and health assessment software (**Lennox**). UoA4 researchers have been granted 15 Patents and 14 Royalty Bearing Licenses.

4.5 Contribution to the Discipline

UoA4 academics contribute significantly to national and international research management, knowledge transfer, and education through research. Of staff returned:

- 77% have been invited to organise or speak at 470 national and international conferences including: Euroscience Open Forum, European Society for Cognitive and Affective Neuroscience, European Society for Cognitive Psychology, European Conference on Visual Perception, The Nobel Forum, Society of Behavioral Medicine, World Congress of Behavioural and Cognitive Therapies, Society for Mental Health Research, International Association of Forensic Mental Health, International Society for Magnetic Resonance in Medicine, International Congress of Clinical Neurophysiology, Human Brain Mapping, and World Congress of Psychiatry;
- 36% held external Professorships/NHS clinical positions, including Directorships of the Complex Trauma and Resilience, Patient Safety and Anxiety, Depression and Psychological Therapies Research Units and Functional Neurological Disorders Service;
- 20% have served on national or international grants committees including NIHR (Research for Patient Benefit, Programme Grants, Health Technology Assessment, Efficacy and Mechanism Evaluation), MRC (Neuroscience and Mental Health Board, Experimental Medicine, Methodology Research, Global Mental Health), BBSRC (Animal Disease, Health and Welfare), NC3Rs Studentship Assessment, EPSRC (Health Technology), Wellcome Trust (Intermediate Fellowships; Neuroscience External Review Group), UKRI (Global Challenges Research Fund, Future Leadership Panel);
- 39% have contributed to policy (via the Lancet, British Psychological Society, NHS, NICE, FDA, WHO), or provided external consultancy (AstraZeneca, Glaxo-Smith Kline, GE Healthcare, BBC);
- 41% have been awarded prizes and fellowships, including a Stroke Association Lectureship, an NHS Senior Clinical Lecturer Award, an EPSRC Research Fellowship, an MRC Skills Development Fellowship and an MRC New Investigator Award, two ESRC Future Research Leaders Fellowships, three NIHR Fellowships, and Fellowships of the British Psychological

Society, Academy of Social Sciences, Academy of Medical Sciences, the Royal Society for Biology and Academia Europaea;

- 45% have served on 37 professional bodies, (e.g., British Psychological Society, British Neuropsychological Society, Experimental Psychology Society, Biochemical Society, Academia Europaea) and advisory boards (e.g., NIHR, ESRC, Alzheimer's Research UK, Parkinson's UK, National Autistic Society, Royal College of Psychiatrists);
- 32% have been involved in PPIE activities, with two Making A Difference Awards for work on suicide, an Outstanding Contributions to PPIE Award to Autism@Manchester, and a GM Clinical Research Award for Public Engagement for the THINKphysical Manchester Mental Health Festival;
- 43% have outputs leading to public commentary, in broadcast media (e.g., BBC, ITV, CNN), newspapers, and online (e.g., Reddit Science Forum);
- 69% served on journal editorial boards of 90 journals, including *Scientific Reports, Neuropharmacology, Acta Pharmacologica Sinica, Journal of Biological Chemistry, Glia, Purinergic Signalling, Cell Calcium, Cell death and disease, Acta Physiologica, Journal of Cerebral Blood Flow and Metabolism, Journal of Nuclear Medicine, European Journal of Nuclear Medicine and Molecular Imaging , ASN Neuro, Neuroscience Bulletin, Dialogues in Clinical Neuroscience & Mental Health, Clinical Psychology Review, Annals of Behavioral Medicine, Health Psychology, Age and Aging, Journal of Alzheimer's Disease,* and *Neurology*, and wide coverage across the range of *Frontiers* journals.

4.6 Responsiveness to Research Priorities

The FBMH SFT promotes collaborative and multi-disciplinary working via FBMH research domains, helping to build capacity and capability in strategic priority areas. It advertises current funding opportunities of relevance to research in UoA4 via regular communications and assists in coordination of the production and submission of large-scale research funding applications. Most recently, UoA4 researchers have responded rapidly to COVID-19 research priorities (section 1.8). The agility of the research environment is highlighted by the establishment of the "COVID-19 Rapid Response Research Group", co-ordinated by the BRC, which incorporates the expertise of UoA4 researchers at multiple levels.