Institution: Ulster University
Unit of Assessment: 3
1. Unit context and structure, research and impact strategy

Overview

This is a joint submission from the Biomedical Sciences Research Institute (BMSRI) and the Institute of Nursing and Health Research (INHR), both part of the Faculty of Life and Health Sciences at Ulster University (UU). Research from the BMSRI and the INHR, which starts at the cellular level through to whole human and population levels, exemplifies the faculty's overarching aim to focus on the inter-disciplinary theme: *Lifelong Health and Wellbeing*.

Building on our success in the REF2014, both institutes have continued to create a vibrant culture and environment that nurtures, supports and rewards our researchers during this REF period. We support all staff, including early career researchers, enabling them to maximise their contribution to the health and wellbeing of people in Northern Ireland (NI), the United Kingdom (UK) and internationally. In this REF period we have made significant improvements on key performance indicators (see Table 1), including the number and quality of our outputs, research income from competitive sources, successful graduation of doctoral students, and significant collaboration with industry, Health and Social Care Trusts (HSCTs) and international Centres of Excellence. The number of researchers has increased by 32%, reflecting our commitment and success in recruiting new talent and developing our own.

Table 1 *Improvement in Key Performance Indicators from REF 2014*

	2014	**2021**	**% increase**
Number of researchers	106.25FTE	140.08FTE	+32%
Research Income (spent)	£29,267,074	£50,107,386	+71%
Successful PhD Completions	176.5FTE	222.23FTE	+26%

Key new developments for our Unit are:

- Within the REF period the **School of Medicine** was established and we are working to recruit staff into key academic, clinical and research positions that will significantly strengthen our research capabilities. In addition, the **£28.55M capital investment fund** to develop a new purpose-built Medical School has been approved.
- We have contributed significantly to the successful **Belfast Region City and Derry/Londonderry and Strabane City Region Deals** (£850M and £250M investment packages). With the Medical School, these developments will greatly complement and expand our research capabilities in the broad themes of clinical and experimental medicine, global health, mental health, primary care and public health, and medical and health education.
- We have received significant funding from the UKRI-Global Challenge Research Fund (GCRF) for the SAFEWATER project (£4.9M original award and £836,675 in a subsequent grant) to develop low-cost and sustainable technologies for safe drinking water and to test related health impacts in rural communities in Mexico, Colombia and Brazil (**Dooley, McNulty, Ternan, Price)**.
- The Faculty has launched a new Institute of Mental Health Sciences (IMHS), led by **Tully**, with university strategic funding support. The interdisciplinary research ranges from genetic profiling of university students' mental health issues (**Bjourson, Irwin R, Walsh, Murray**), patient care for mental health issues and depression (**Sinclair, Kernohan, McIlfatrick, Martin),** to dementia research (**McClean P**, **Ryan**, **McCauley**, **Price**).
- Funding agreement from the Department of Health in NI (£1.7M to Ulster and £1.7M to Queen's University of Belfast) to establish an Academic Paediatric Cardiology Department with leadership from the Schools of Biomedical Science, Medicine and Nursing, with cross-

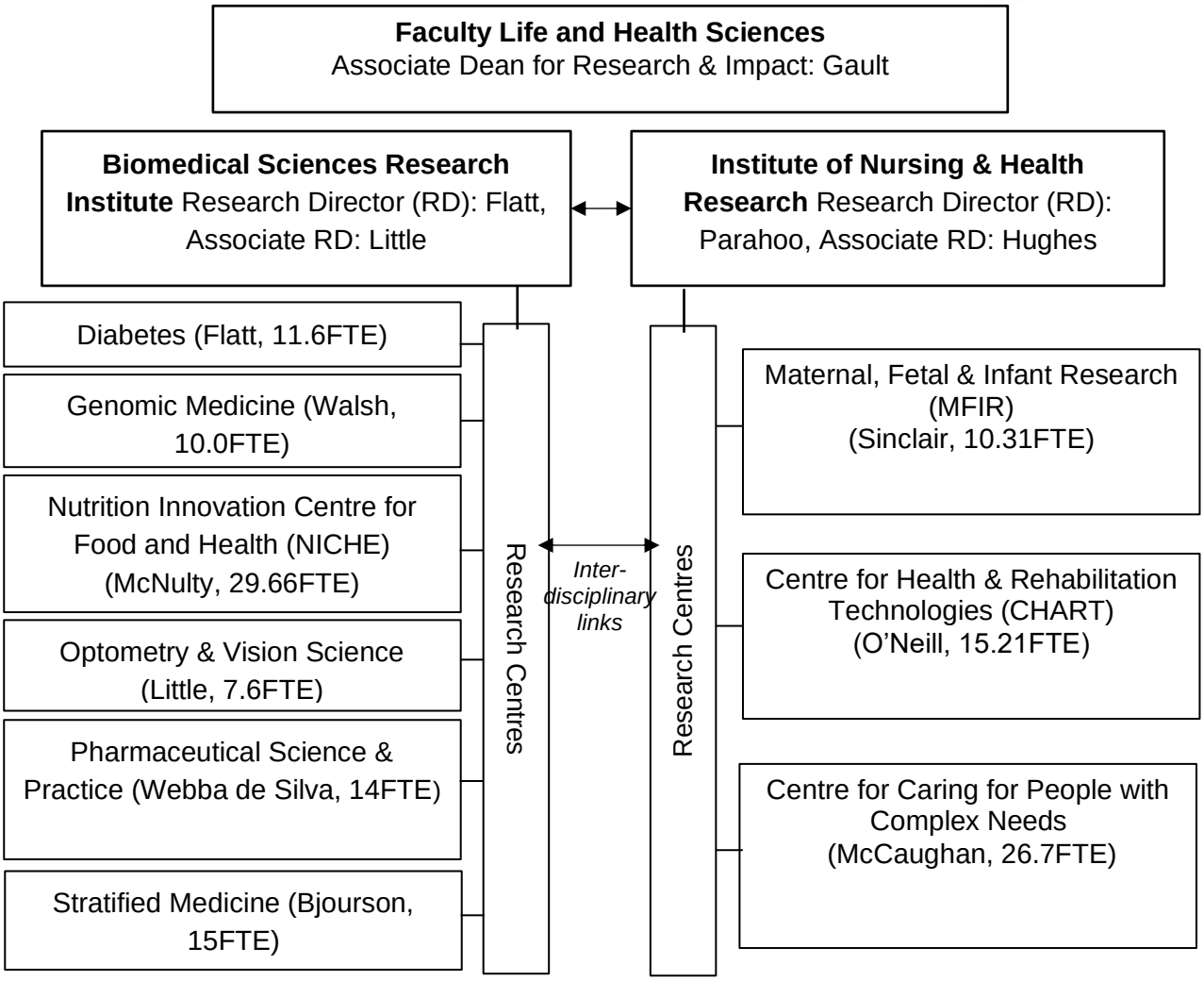
faculty partnership with the Faculty of Computing, Engineering and the Built Environment and QUB.

- We are key partners in setting up an Administrative Data Research Centre (ADRC), with over £2.238,374 from the UKRI Economic and Social Research Council (ESRC) and £375,000 from the NI Health and Social Care Research & Development office (HSC R&D (**Dolk**, **Loane**). This multi-stakeholder and interdisciplinary partnership also involves the NI Statistics and Research Agency and researchers from schools of psychology, environmental sciences, architecture and the built environment.
- Our organisational structure was strengthened with the appointment of a faculty associate dean for research and impact (**Gault**) and two associate research directors (**Little** for BMSRI and **Hughes** for INHR).

Our nine impact case studies (ICS) accompanying this submission highlight the vitality and vibrancy of our research environment and the range of innovative, interdisciplinary, collaborative and needs-responsive projects that we undertake. Our researchers are sought out as expert advisors and consultants to inform health policy and practice nationally and internationally, and we are widely represented on key research panels, committees and boards (see Section 4). Our high-quality, peer reviewed outputs and ability to attract significant funding from competitive sources highlight the sustainability of what we do, underlined by our responsiveness to the current changing landscape of the health and wellbeing needs of our target populations. This is underpinned by robust research governance frameworks. Our unit is working towards an open research environment, as early adopters of the PURE open access and research data management system and we have established a digitisation working group to reform and centralise how research data is stored and accessed.

In March 2020, the global COVID-19 pandemic triggered a temporary cessation of lab-based research across the university. Academics from both institutes continued to work during this time, and were an integral part of the Northern Ireland COVID-19 task force. We have significantly contributed to establishing and ramping up SARS-Cov-2 viral and seroprevalence testing through the NI COVID-19 Testing Scientific Advisory Consortium reporting to the Chief Medical Officer and NI Health Minister (**Bjourson, Walsh, Gibson, Singh-Rai, Irwin R**). **Moore** was appointed UK government advisor to the UK Rapid test consortium on COVID-19 and leads the *"Pandemic Study"* investigating the presence of antibodies for SARS-CoV-2 coronavirus. Additionally, researchers from UU led by **Walsh** have played a significant role in Contact Tracing data analysis, working directly with clinical leads at NI's Public Health Agency. **Ray** has contributed to NICE guidance on Vitamin D and COVID-19. Thanks to our stable and sustainable infrastructure we were well-placed to prioritise urgent laboratory-based and clinical research post-lockdown at the end of June 2020 and safely phased-in researchers returning to work. Researchers have published outputs on COVID-19 (**Martin, McFadden, Tully**) and been successful in securing research funding investigating the long-term effects of the pandemic, including the impact of self-isolation on mental health (**Tully, Murray**), and the effect of social restrictions on people with learning disabilities, their families and those supporting them (UKRI-MRC, **Taggart**).

The structure of our Institutes is as follows:



A. BIOMEDICAL SCIENCES RESEARCH INSTITUTE (BMSRI)

Our **Research Strategy** focusses on preventing and treating degenerative diseases through the lifecycle including those that affect an increasingly ageing population. Our research goes from the cellular level right through to human clinical trials leading to patient benefits and clinical benefits, as well as commercial and wider societal benefits. We have built on our successes in previous RAEs/REF, and continue to develop research capacity through training, supporting and mentoring researchers. Our research is embedded into teaching, and our academics deliver high calibre professionally-focused courses across biomedical sciences, pharmacy, optometry, personalised medicine, dietetics and human/food nutrition.

Key developments and achievements since REF 2014:

- Significant increase (47%) in research grant income from diverse and prestigious sources, from £20.5M in the last REF to £30.2M.
- We have published over 1600 peer reviewed articles, 450+ conference abstracts, six books and 60 book chapters.
- Development of a centre for personalised medicine: clinical decision making and patient safety (CPM) through £3.64M Interreg Europe funding in 2017. This interdisciplinary project links 13 partner organizations from academic, clinical and commercial environments in Ireland, NI and Scotland. As part of this a randomised controlled trial (led by **Bjourson)** to test the effectiveness of a guided web-based trans-diagnostic intervention in treating student depression and anxiety was funded (£619,000) by the HSC Public Health Agency (PHA)-Interreg Cross-border Healthcare Intervention Trials in Ireland Network (CHITIN).

- We have undertaken large-scale clinical trials through our human intervention studies unit. These include utilising our major ageing cohort study (TUDA) investigating nutritional, genetic and lifestyle factors for disease risk in older people across Ireland and NI (£613,000) and investigating bariatric surgery outcomes (£604,290). We have supported a foreign direct investment (FDI) company (Genuity Science, ROI, USA).
- A collaboration between the Centre for Stratified Medicine and Genuity Science (formerly Genomics Medicine Ireland), recruited patients across NI as part of an all-Ireland initiative to sequence the genomes of up to 10% of the Irish population (>£2M).
- We acquired the equipment and capabilities from the MRC Elsie Widdowson Unit Cambridge to establish the Nutrition and Vascular Studies Platform (**McNulty, Ward, Hughes, Ray**). We established the NI Complex Disease Bioresource (£120,000), increasing our region's capacity to store clinical biological samples and data appropriately, allowing ready access for clinicians, academics and industry partners.
- The units' intellectual property (IP) portfolio has grown significantly, BMSRI's IP alone makes up almost 30% of Ulster's entire IP portfolio. IP comes from research within diabetes, genomic medicine, human nutrition, stratified medicine and pharmacy. Since 2014, we have filed 108 invention disclosures through Innovation Ulster Ltd (IUL), helped by the development of a centre for personalized medicine at Ulster's Centre for Translational Research and Innovation Centre (C-TRIC). We have three new spin-out companies: Jenarron Therapeutics, Carritech and Sonotarg, 86 patents filed and 49 patents granted.
- An Industrial PhD Academy was created with Randox Laboratories (**Moore**) to support PhD candidates in the life sciences sector (£5M). This also lets us engage closely with industry for technology transfer and access to academic expertise.
- Lead important research activity to combat the COVID-19 pandemic, with significant grant income recently awarded from UKRI, Science Foundation Ireland, the Department for the Economy and Public Health Agency (>£1M, **McGilligan, Bjourson, Walsh, Gibson, Singh-Rai, Murray, Dooley**).

In this REF period, we have transferred knowledge and skills into useful products for patient benefit, helping to drive economic growth regionally, nationally and internationally. Since 2014, we have undertaken seven knowledge transfer partnership (KTP) grants (£894,249), all rated outstanding by Innovate UK, and 16 Invest NI proof of concept (PoC) projects (£1.09M). We have provided significant industrial consultancy (£820,572). We are the leading university on the island of Ireland for 'Fusion' (Inter-trade Ireland knowledge exchange projects) (>£150,000). IUL has also supported 15 BMSRI Proof of Principle (PoP) projects (>£100,000). These achievements have been underpinned by our core facility units (CFUs), which provide the infrastructure that allows us to use and reinvest in our specialist research equipment and allows these resources to be accessed for external contract research. Since REF2014, the CFUs have generated £8.48M in consultancy and directly supported research-funded projects. C-TRIC's innovative bio-entrepreneur programme provides mentoring and business incubation. We have completed licensing agreements with Sanofi Aventis, Randox, Almac, Avellino USA, SiSaf, Nestec, Domain Therapeutics and DSM, creating significant license income on our IP. We have also increased consultancy income and mentorships schemes for small enterprises in C-TRIC and our Nutrition Innovation Centre for Food and Health (NICHE). Our commercial approach extends beyond simply securing IP rights (IPR); we address expectations of potential business partners and/or venture capital investors by taking research to the stage where we can facilitate in-licensing and/or co-development possibilities. For example, we successfully licensed our technology that uses riboflavin (vitamin B2) to lower blood pressure in people with a common polymorphism (genetic factor) which predisposes to high homocysteine, a risk factor for heart disease to DSM Nutrition for an upfront fee of €100,000 with further milestone payments and royalties to follow when this technology reaches the marketplace. Another technology, an anti-NLRP3 immunotherapy for inflammatory eye disease has secured first phase sponsorship of 150,000 USD (rising to over 850,000 USD if option for next phase exercised) from Santen Inc (US). Santen will use it in glaucoma in exchange for an option to exclusively license the antibody for glaucoma once the sponsored work packages are complete. Along with IUL, we talk regularly (at the non-confidential level) with potential licensing partners to maximise the possibilities of securing business opportunity agreements at an appropriate stage of development.

Future plans

The Belfast Region City Deal (an investment package of over £850M) will enable the creation of the biomolecular sciences innovation group and the 'Living Lab' (part of the £42.9M Centre for Digital Healthcare Technology) which will facilitate major advances in eye research and cardiology, with plans to encompass other diseases. The project will establish new innovation pathways, linking researchers and businesses to patients and clinicians in a real-life clinical setting. It will provide clustered businesses, including FDI and spin-outs, grow-on space, supported by tailored, enabling 'soft' infrastructures.

In 2019, the Derry and Strabane City Deal initiative was awarded £105M which includes £22M funding to establish the Transformation for Healthcare Research, Innovation and Value Based Ecosystem (THRIVE). This will allow the development of two major research facilities to house personalised medicine and clinical trials units. This initiative is based on a partnership between academia, clinicians and the community and includes an expansion of the existing C-TRIC facility (now operating over-capacity) on the Altnagelvin Hospital site (the Western HSCT), and a new health research facility aligned to the School of Medicine on the Magee site due to open in 2021.

Over the next five years the personalised medicine centre will be significantly developed as we consolidate our ongoing successes in growing infrastructure. In addition, Genuity Science has established a facility in C-TRIC, and this will be a key feature of future contract research expansion as part of an initiative by this company to significantly invest in local job creation over the next five years.

A similar multi-million growth City Deal for the Coleraine area is being explored and **Gault/Gill/Flatt** are leading discussions for an infrastructural funding package. Current plans include a centre for drug discovery, formulation and delivery which builds on our research strengths in preclinical studies in pharmacy and nutrition and will add weight to our ambition to establish a veterinary school in the region.

These developments fit with our strategy to engage significantly in technology transfer and work closely with industry. We already have major industrial grants, several start-up companies and patents. These large-scale infrastructure grants will enable us to enhance our high-profile research in disease development, to improve patient care and outcomes, and will underpin our sustainability during the next REF period.

BMSRI research centres

Our institute is organised into six research centres, with strong collaborative links with one another, and across the wider university. Our research strategy is implemented by each centre's lead researcher in conjunction with the institute's research director and associate director.

Diabetes (Leader **Flatt**, 11.6FTE)**:** The centre continues to conduct innovative basic and translational research into understanding and treating metabolic disease and complications. The centre has generated valuable IP and funding, resulting in significant commercial exploitation and international impact. Our commercially relevant research has been supported by Diabetes UK, European Foundation for the Study of Diabetes (EFSD) and 8 individual PoC grants from Invest NI, which also provide experienced commercial mentors. Our research is divided into six areas that have generated 10 invention disclosures with 7 GB IP filings and 18 granted patents: (1) *Anti-diabetic and anti-obesity effects of structurally modified brain-gut peptides.* We have developed commercially viable enzyme-resistant, long-acting analogues of several brain-gut peptides to treat diabetes, obesity and metabolic disease. (GB13700347.1; GB1407532.9; GB1521442.2 and GB1806825.4), and more recently other enzyme resistant agonist peptides and oxytocin-vasopressin analogues (**Flatt, Gault, Irwin, Moffett, O'Harte**). This work has informed industrial development of new peptide-based antidiabetic compounds and exchanges are ongoing with Lilly, Novo, Sanofi, Zealand and others. (2) *Discovery, targets and action of antidiabetic drugs*. Research into novel peptide and lipid activated G-Protein coupled receptors (GPCRs) granted us a patent for GPR84 as a new therapeutic target (GB.1513543.7) plus strong partnership with industry (GreenLight Medicines Ltd (**McKillop, Flatt, Gault**). A multi-centre collaboration filed an invention

disclosure for marine-sourced peptides with strong translational potential (MaraBioactive; with Limerick, Cork and Galway-Mayo) (**O'Harte**). Research into new insulin-releasing agents from frog skin secretions, spider venom and plant sources initiated academic collaboration and industry testing, and ultimately to a patent filing (GB1401673.7) (**Abdel-Wahab, Flatt, Gault, Hannon-Fletcher, Irwin N, McClean S**). (3) *Actions of non-classical islet peptides* has uncovered significant drug effects on islet alpha-beta cell transdifferentiation. (2 patents filed; **Flatt, Gault, Irwin N, Moffett, Thomas**). (4) *Islet cell signal transduction, paracrine interactions and diabetes cell therapy*, led by recent high-profile international appointments to the institute (**Berggren, Rorsman, Tarasov)**. State-of-the-art research in this area has revolutionised understanding of human islet function and offers considerable therapeutic advances. (5) *The role gut hormones in detrimental effects of obesity-diabetes on female reproductive health*. This has delineated mechanisms behind dramatic improvements in fertility following bariatric surgeries, led to Diabetes UK funding (£444,696) and new peptide drug therapies (**Moffett, Flatt**). (6) *The effects of brain-gut peptides on bone fragility, behaviour and neurodegeneration in diabetes and Alzheimer's disease*. Interest from industry coupled with granted patents and ongoing phase 3 clinical trials, suggest promise for new therapeutic approaches (UK1521442.2; GB0717388.3; GB17166896.5; **Irwin N, Flatt, Gault**).

Genomic medicine (Leader **Walsh**, 10.0FTE): This centre has an excellent track record of fundamental and applied research in genetics and epigenetics, and a growing emphasis on interdisciplinary projects. Work is divided into five major areas: (1) *Imprinted childhood syndromes*. Our UKRI-MRC-funded (£378,637) investigation into mechanisms underlying these syndromes allowed us to develop cell-line models plus a novel software platform CandiMeth for cloud-based epigenetics analysis (**Walsh, Irwin R**). A long-standing collaboration led to the appointment of **Xu**, a world-leading expert supported by a Royal Society Newton Exchange, to strengthen our fundamental and translational epigenetics and CRISPR/Stem cell technologies. (2) *Epigenetics in brain health and disease*. This vibrant area of translational work has led to three UKRI or EU-funded novel human trials. The EpiFASSTT project (UKRI-ESRC/BBSRC £400,337; **Walsh, Lees-Murdock, McNulty, Pentieva**) in partnership with NICHE (see below) examined the intergenerational changes as a result of folic acid intervention in pregnancy; this award led to a subsequent grant for the EpiBrain project (details below). The SPIT trials in partnership with Stratified Medicine (EU/CHITIN £619,295) have recruited nearly 2000 adolescents to study prognostic epigenetic markers for mental health and depression, accompanied by significant patent filings (**Irwin R, Walsh, Murray, Bjourson,** O'Neill) and further UKRI-MRC funding (Future Minds: **Walsh, Murray,** O'Neill, McLafferty, Mulvenna, Bond, Ennis). (3) *Novel markers of cardiovascular disease (CVD)*. Several projects (**Lees-Murdock, Ward, McKenna D, Magee, Moore, Nesbit, McLaughlin**) received substantial NI Chest, Heart and Stroke Association (NICHSA) funding (>£600,000) and identified novel biological measures (microRNAs, methylation, eye vasculature alterations) with diagnostic and prognostic value in CVD. We secured funding (£100,000) for epigenomic analysis of CVD risk in a Middle-Eastern population cohort (**Walsh, Davison**). (4) *Personalised genetic treatments for eye disease* were developed after the successful demonstration of *in vitro* gene editing for corneal dystrophy (**Moore, Nesbit**). This prompted a collaboration and significant investment from Avellino Labs USA (>£391,000), and led to the development of small peptide-based treatments (**Cobice**). (5) *Molecular, pharmacological and cellular therapies* being developed for glaucoma and anterior segment ocular disease have attracted (**Willoughby**) substantial charity funding (Fight for Sight, £353,000). Novel sequence-based diagnostics (**Conway, Walsh, McKenna D**) and potential therapeutics for cancer, particularly for prostate cancer (**McKenna D**), are being developed in collaboration with Almac and clinical colleagues at Altnagelvin Hospital. We attracted significant industry buy-in for advanced nano-scale microscopy techniques (**O'Hagan, Cobice**) to examine ultrastructures (e.g. Hughes Ltd, Randox £223,633).

Human nutrition and dietetics (Leader **McNulty**, 29.66FTE): The Nutrition Innovation Centre for Food and Health (NICHE) has been an EU Centre of Excellence since 1996 and is the leading centre for applied and molecular nutrition research in Ireland and one of the largest in the UK. Research focuses on understanding diet-related health issues through the lifecycle, achieving impacts to facilitate food and health policy aimed at disease prevention, and driving related innovations. NICHE comprises nine sub-groupings: (1) *folate and B vitamins;* (2) *vitamin D;* (3) *nutrition and immunology;* (4) *microbiology and the gut microbiome;* (5) *phytochemicals;* (6) *marine*

bioactives; (7) *nutrition toxicology and child development;* (8) *obesity, energy and food choice;* (9) *agri-food and consumer innovation*. Staff collaborate with researchers in BMSRI, other Ulster faculties and academic, health and industry partners nationally and internationally. Researchers in NICHE (**Dooley, McNulty, Ternan, Price**) form part of the interdisciplinary SAFEWATER project (>£5.7M, UKRI-GCRF). This interdisciplinary research is developing low-cost, sustainable technologies for safe drinking water in rural communities in Mexico and Colombia, improving overall health and quality of life for low-middle income countries, sustainably and equitably. **Strain, McSorley, Mulhern, Yeates** are long-standing partners in the internationally acclaimed US NIH-funded *Seychelles Child Development Study*, with University of Rochester (USA), and Lund University, Sweden investigating how diet modulates the effects of mercury exposure from fish consumption during pregnancy and child development (£1,227,449 in this REF period). This research continues to inform global policy on the safe consumption of fish during pregnancy (**ICS-3**).

The EpiBrain project with Genomic Medicine (**McNulty, Walsh, Pentieva, Ward, Irwin**) and partners in Vancouver and Spain, funded by UKRI-BBSRC-JPI (£266,880), is addressing epigenetic mechanisms underpinning the effects of folic acid and related B vitamins on brain health in early and late life. The results are anticipated to provide scientific substantiation to support nutritional strategies for sustaining better brain health through the lifespan and will thus build on our existing impacts for the health and food sectors in this research area (**ICS-1**). The DERIVE project (**Ward, McNulty, Strain, Pentieva, Hughes, McAnena**), also funded by UKRI-BBSRC-JPI (£207,521), developed accessible biomarkers of riboflavin in adult cohorts to address health effects of this under-investigated B vitamin. This project builds on our discovery that riboflavin supplementation can significantly lower blood pressure in patients with a gene-variant folate metabolism, independently of routine antihypertensive drugs (funding of >£847,000 from DSM Nutritional Products AG). We were granted a patent (International Patent Application PCT/EP2008/001437) and agreed a license agreement with DSM Nutritional Products (see **ICS-6** for health and commercial impacts). The £5M Trinity-Ulster University-Dept of Agriculture (TUDA) study (**McNulty, Strain, Ward, Hoey, Hughes**) has investigated 5,186 older Irish adults from Ireland and NI (£631,094 awarded during this REF period), providing a large biobank and comprehensive data on a range of clinical variables, nutrient biomarkers, inflammatory markers, socioeconomic factors in relation to health and disease outcomes, including cardiovascular disease, osteoporosis and dementia. The TUDA resource is one of the largest, most comprehensively characterised cohorts in ageing research internationally and provides a platform for researchers to better understand the nutritional needs required for a better quality of life in older age. The research has recently been extended to involve an in-depth investigation of genetic factors in the ageing process through funding from Genomics Medicine Ireland (£608,339) involving whole-genome sequencing of the TUDA cohort, thus greatly enriching the TUDA resource and opening up new avenues for investigation. Other projects building on the TUDA study and enabling follow-up of the original cohort include VALID, funded by UKRI-BBSRC-JPI (£182,926) with partners in Italy and Dublin (**McNulty, Gill, Strain, Ward**), which validated novel biomarkers of polyphenols from foods and determined their potential role in preserving cognitive heath in ageing.

Our research on Vitamin D in elite Paralympic and able-bodied athletes, has directly influenced Sport Ireland's vitamin D supplementation policy (**Magee, Pourshahidi, McSorley**) (**ICS-2**). Close collaboration with local food industry (Dunbia, NI) and funding from the Technology Strategy Board (£240,000) (**Price, Pourshahidi, Sittlington, Strain**) has resulted in the enhancement of nutritional content (including n-3) of beef products for consumers. Cutting-edge research in food microbiology and the gut microbiome in conjunction with APC Ireland, Teagasc, Ireland and Rochester, USA has generated short and long-term projects supported via CAST awards, KTP projects and consultancy with commercial partners (**Dooley, Ternan, Gill, Allsopp, Strain, McSorley, Mulhern, Yeates**). Multi-centre collaborative research identified numerous marine derived bioactive functional food ingredients with potential health benefits (**Allsopp, McSorley, Strain, Gill, Magee**). **Price** leads the NI aspects of a US-Ireland R&D partnership programme, which documents changes in ingestive behaviour following gastric bypass surgery. We have also established NI's first ileostomate cohort (**Gill, Pourshahidi**), to explore key patient issues relating to nutritional status, mental health and quality of life (QoL). This work seeded a collaboration with the Nanotechnology and Integrated BioEngineeing Centre at Ulster (**Davis**) that optimised and validated wearable technologies to

improve QoL. The sustainable, long-term health benefits of increased activity were highlighted in a trial in school children, the 'Walking in Schools Trial', the WISH study (£592,077), funded by the Cross-Border Healthcare Intervention trial in Ireland Network (CHITIN) (**Gallagher**). We helped embed good nutrition practices into health systems thanks to research and consulting that arose from our strong links with the Cambridge-based award-winning NNEdPro Global Centre for Nutrition and Health (**Ray**).

Optometry and Vision Science (Leader **Little**, 7.6FTE): Our research, supported by grants from the National Institute for Health Research (NIHR), UKRI-ESRC, Fight for Sight, Macular Society, College of Optometrists, Action Medical Research and industry partners, focuses on translational clinical interdisciplinary research of direct benefit to patients. This work uses cutting-edge equipment (both customised and commercially available) maintained through industry partnerships and consultancy (£600,000). Our research comprises four main areas; with significant impact of the first two areas described in impact case studies **ICS-4** and **ICS-5**: (1) *Refractive Development and Myopia.* The NI Childhood errors of refraction (NICER) study is a large longitudinal population-based analysis of the distribution and determinants of childhood refractive error in the UK (**Saunders, McCullough, McClelland, Breslin, Richardson**). Supported by the College of Optometrists (>£400,000), this has delivered ground-breaking outputs profiling modern refractive profiles and risks for myopia (short-sight). In collaboration with QUB, we are investigating prescribing patterns for childhood myopia (UKRI-ESRC £199,901). We are working with international industrial partners (Hoya Vision Care, Essilor International, Oculus) and policy institutes (International Myopia Institute) to utilise our data to improve optical devices and instrumentation. We are conducting two ground-breaking multi-centre clinical trials of low-dose atropine eye drops to slow the progression of myopia in children (CHAMP £229,153, Nevakar) and CHAMP-UK, >£1.3M, NIHR). The group has also employed objective measures of activity, sleep and circadian rhythm to determine risk factors for myopia and investigate novel methods for monitoring eye growth and predicting future myopia. (2) *Visual Deficits of Children with Developmental Disabilities.* Focusing on Down syndrome, cerebral palsy and autism spectrum disorders, we have pioneered objective techniques including photorefraction, advanced imaging, electrodiagnostic and dynamic retinoscopy (which led to the commercial development of the UC-CUBE) to better identify and manage visual disorders in these vulnerable populations (**Saunders, Little, McClelland, McCullough**) with funding from HSC R&D office, SeeAbility and Action Medical Research (£193,216). We have translated our research through the Ulster Vision resources website, which curates research-based support tools for professionals, parents and lay-people. These tools have been accessed by over 161,000 users across 75 countries from 2014 to-date. (3) *Basic and Clinical Psychophysics. O*ur research has identified the necessity to re-design tools for the assessment of visual acuity. This has led to the commercial development of the Moorfields Acuity Chart (MAC) which employs high-pass filtered letters and is now being used as a preferred end-point measure in clinical trials (**Anderson, Mulholland,** NIHR and Fight for Sight >£63,418). This team is also at the forefront of novel perimetric stimulus design, including the commercial development of stimuli that track the spatial and temporal summation changes they previously identified in early glaucoma (Macular Society; £99,333). **Beirne** has established novel macular densiometry measures to investigate the disease progress of age-related macular degeneration (AMD) and collaborated with **Callan B** in pharmaceutical science to investigate novel drug delivery routes for anti-VEGF treatment for wet AMD (Macular Society and Eleanor Peel Trust; £138,294). (4) *Application of Novel Ophthalmic Imaging.* We have helped pioneer the development of bespoke narrow angle Heidelberg Retinal Angiograph to image photoreceptors in vivo without requiring adaptive optics technology (**Anderson, Mulholland**). We are collaborating with Moorfields Eye Hospital, London, to investigate using Binocular Optical Coherence Tomography (OCT) for ocular biometry, psychophysics and cataract assessment (**Little, Anderson, Mulholland**, College of Optometrists; £57,744). We have been the first to characterise cataract development in the lens of individuals with Down syndrome (DS) (**Little, Saunders, Richardson**) using in vivo high-resolution slit-lamp photography and anterior segment OCT imaging. We established the presence of significant, non-age-related changes in the DS lens, which could be an early diagnostic biomarker for Alzheimer's disease.

Pharmaceutical Science and Practice (Leader **Webba da Silva**, 14FTE): The centre's agenda-setting research spans laboratory-based investigations into synthesis and formulation design,

through to pharmacy practice-based work into specialised services and medicines management. We focus on developing and characterising responsive drug delivery systems that address clinical needs. The centre has pioneered ultrasonic- and photodynamic-driven therapeutic delivery systems that are minimally invasive. Our work has focused on three main discoveries: (1) *Microbubbles that respond to ultrasound can be used as a combined sonodynamic therapy and chemotherapy treatment,* giving exciting pre-clinical results in several solid tumour types including cancers of the pancreas, prostate and breast (**Callan J, McHale**). This research, funded by major cancer charities, the Royal Society and Invest NI (>£665,000), generated 5 patents (PCT/GB2016/053682; GB.1908352; GB.1708663.8; GB.1819853.1; GB. 2004629.8), and a spin-out company SonoTarg Ltd to commercialise the technology; (2) *Nanoparticles that can generate oxygen in response to changes in pH* (StimOx), have found applications in oncology, wound management and tissue regeneration (**Callan J, McHale**). This research, funded by several sources (>£286,000), is also moving forward for exploitation (PCT/GB2018/051481); (3) *Our sensitizer-peptide conjugate (KLAS-PDT) for photodynamic therapy* has shown impressive pre-clinical results in treating metastatic melanoma (INI funding £112,367; PCT/EP2018/066982 (**Callan J, Callan B**). The centre has also successfully developed four technology-based delivery systems: transdermal microneedles to deliver esketamine and related compounds to the brain for treating resistant depression (**Courtenay**); bioglass nanoparticles that target osteoblast and osteoclast cells to deliver antimicrobials, and biopharmaceuticals (**Lowry**); shear-sensitive hydrogel platforms to deliver anaesthetics, antimicrobial and peptide-based drugs (**McCarron, Hawthorne, Tambuwala**); and smart systems that deliver bioactives to the eye, lungs, digestive tract, and skin (**Callan B, Hawthorne, Lowry, McCarron, Tambuwala**). Our basic research led us to discover the chemical and physical principles that govern nucleic acid folding, structure and dynamics for genomic architectures known as DNA G-quadruplexes, which are important drug targets (**Webba da Silva**). Research in biosurfactants (**Banat**) supported by Unilever and part of an EU-FP7 project "Biosurfing" (€4.5M) has led to discoveries of immunomodulating and wound healing effects of microbial biosurfactants. Biosurfactants were also used for bioremediation, bioaugmentation and biorestoration of the natural environment as part of the EU-FP7 "Kill.Spill" project (€8.9M). We developed new ways to monitor and extract antibiotics from the environment (**Coleman**). A pioneering approach to topical delivery of antibiotics to the wound bed has been evaluated in an MHRA approved randomised trial and is being commercialised through a university spin-out company (Jenarron Therapeutics Ltd) (**McCarron**). The company is pursuing a Paediatric Use Medicines Authorisation (PUMA) with the EMA, and the technology is protected by patents (US 9,272,038, EP 2203192, PCT/EP2018/083164). Finally, the centre has significant achievements in pharmacy practice research. We have developed quantitative targets for rationalizing population antibiotic use and controlling resistance (**Aldeyab**) which are being extended to the Middle East. Research has also led to new policies for optimising workflow and the impact of medicines management on pharmaceutical care in the hospital environment (**Burnett, McCarron**).

Stratified Medicine (Leader **Bjourson**, 15FTE): The NI Centre for Stratified Medicine is based on the Altnagelvin Hospital site. This interdisciplinary team comprises molecular biologists, bioinformaticians and clinicians from HSCTs, all focusing on biomarker discovery and translation to clinical and commercial utility. The team have contributed to the development of innovative bispecific antibody drugs to treat inflammatory and cardiovascular disease (**McGilligan**, WO/2020/053446) and a novel SARS-Cov-2 drug treatment (**McGilligan** Patent GB2003703.2). The centre has recruited to trials >3500 patients with whole genome sequencing (out of 7000 to date) and has compiled wide ranging data on sub-cohorts. Research based on this large body of data allowed the team to develop therapeutic interventions for degenerative diseases of ageing that have shared genetic or environmental determinants. This research provides the basis for personalised medicine and has resulted in 32 IP filings in disease teams led by the following researchers: (1) *cardiovascular disease* (**McGilligan, Rai, Watterson, McDowell**); (2) *diabetes* (**Kelly, McClean P**); (3) *motor neuron disease/ALS* (**Duguez, Duddy**); (4) *rheumatoid arthritis* (**Gibson, Bjourson**); (5) *mental health* (**Murray, Bjourson**); (6) *Alzheimer's Disease* (**McClean P**); (7) *paediatric oncology* (**Matchett**); (8) *multiple myeloma* (**Bjourson**). Each team's multi-omic and clinical data are consolidated into a multimorbidity data set, which is then analysed for disease subclasses by the Bioinformatics and Systems Medicine team (**Bjourson, Atkinson, Duddy, Shukla, Watterson, Zhang**) using our in-house artificial intelligence and bioinformatics expertise. In 2017 a multidisciplinary centre for

personalized medicine, clinical decision making, and patient safety was added to our capabilities, funded with a £3.64M EU Interreg award and involving 16 clinical and commercial partners. We have also added six new groups led by academic and NHS partners: neuromuscular disease (**Duguez**); NI paediatric oncology research network supported by £415,362 from the Little Princess Trust (**Matchett**); brain, supported by £619,295 EU SEUPB/CHITIN (**Murray, McClean P**); orthopaedic and rheumatic health (**Gibson, Bjourson**); vascular medicine (**McGilligan, Peace**); and personalised medicine data analytics **(Watterson, Shukla, Duddy, Zhang**). We are researching the genomic basis of specific diseases by recruiting up to 2000 patients with multiple sclerosis, inflammatory bowel disease, diabetes, depression, ankylosing spondylitis, and other disease areas over next 2-3 years. We are also leading the establishment of a Community Research and Innovation Company (CRAIC) aligned with a new centre for Health Research Institute and Transformation for Healthcare Research, Innovation and Value Based Ecosystem (THRIVE). **Bjourson** is the UU lead on the NI COVID-19 testing scientific advisory consortium. The centre's staff have partnered with the WHSCT Laboratories to undertake virus and antibody testing at the request of the Chief Medical Officer. Funds we raised (£112,000) to purchase high-throughput robotics for SARS-Cov-2 RT-PCR testing allowed us to contribute to the UK Government/NI SARS-Cov-2 RT-PCR (Pillar 1) serology testing (**Gibson**) and track and tracing efforts. Our researchers (**Murray**, **Bjourson**) also ran a UU-QUB joint student seroprevalence study. Along with C-TRIC partners our researchers (**Bjourson, Gibson, Rai**) have established a COVID-19 testing site for essential workers including NHS staff.

B. INSTITUTE OF NURSING AND HEALTH RESEARCH (INHR)

Our **Research Strategy** embraces the "interdisciplinary theme of creating healthy communities". Hence our vision is to "*engage in cutting edge research that is internationally excellent in order to provide answers and solutions to some of the key health problems and thereby enhance the health and well-being of people in Northern Ireland and beyond*". The INHR, created in 2005, has grown significantly in terms of stature and its contribution to health and wellbeing. We have sustained and enhanced our world-leading position in nursing, midwifery, and public health research. On the island of Ireland, we remain the largest research institute in nursing, midwifery and allied health. Our researchers directly contribute to our internationally renowned nursing education and high-quality training of allied health professionals including physiotherapy, radiography, podiatry and occupational therapy**.** Our performance since the last REF shows consistent progress towards our objectives of building on our research strengths in the following core areas: maternal and infant health, complex health needs and rehabilitation technologies. Our reputation is evidenced by our consistent and continued success in acquiring large research grants. Overall, our research income has increased 36% (from £14.6M to £19.9M) since the last REF.

Key developments and achievements since REF 2014:
An important strength of the INHR is its interdisciplinary research involving disciplines such as engineering, computing, epidemiology, psychology, social policy, biomedical sciences and social work. In particular, there has been a distinct upward trend, in this REF period, of collaborative projects with researchers in computing. This bodes well for research in the COVID-19 and post-COVID-19 era when online interventions will be crucial to the delivery of health and social services. Another key strategic development has been the move from descriptive research towards the development and testing of healthcare interventions. In this REF period, we were successful in securing funding for 14 interventions. Our strategies to enhance health and well-being also includes undertaking systematic reviews to underpin policy and practice. Our output in this REF comprises over 30 systematic reviews (including 7 Cochrane reviews), in a range of areas including interventions for low back pain, health benefits of exercise, pressure ulcers, workplace bullying, online support groups for women with breast cancer and interventions for turning breech babies.

Our research has tangible impact for patients and practitioners. Our work on person-centred care has provided methodologies, models and tools that healthcare practitioners use worldwide. We continue to work closely with clinicians in the NHS Trusts in NI. This includes maintaining and creating joint appointments (**Boomer**, **Cundell**, **Coates**, **Gillen**, **Semple**). We support staff and post-graduate researchers (PGRs) to engage in impact activities from the development of their research

proposals to disseminating and implementing the findings (see Research Centres and **ICS-7, ICS-8** and **ICS-9**).

The INHR has well-organised and supportive (formal and informal) structures designed to maximise efficiency in the use of resources and to be as inclusive as possible in terms of the development of research capacity. Our research objectives are strategically operationalized and delivered via three research centres, each led by an expert in their selected field. The director of the INHR (**Parahoo**), the associate director (**Hughes**), and centre leads (**Sinclair, O'Neill, McCaughan**) develop and implement the vision and the strategic objectives at unit level through bi-monthly research meetings. All staff in the Schools of Nursing and Health Sciences, are affiliated with one of the centres and can take part in the activities of other centres, where appropriate. Each centre is open to researchers in other disciplines and professions and postgraduate research students. Clinicians are also encouraged to get involved in these centres. Each centre organises workshops, lectures and other training and disseminating activities and these are shared across the INHR. Each centre is allocated funding to support the dissemination of findings and the development of research capacity with the help of internal and external experts, with particular emphasis on the development of early career researchers.

In this REF period, we have published over 1000 peer reviewed articles, 320+ conference abstracts, 2 books and 67 book chapters. Our reputation on the global stage is evidenced by our success in attracting collaboration with international experts in areas such as congenital anomalies and cancer. As such our research has global reach and impact. For example, our work related to the Zika epidemic on the prevalence and clinical profile of microcephaly (**Dolk**) was reported in the British Medical Journal in November 2017 and has been downloaded over 13,723 times. This project was conducted in collaboration with experts from Brazil and Argentina. The project on quality of life in men living with advanced and localised prostate cancer in the UK (**McCaughan**) involved researchers from centres of excellence in Leeds, Sheffield, Edinburgh, Newcastle, Southampton and others and was published in Lancet Oncology. **McCaughan**'s and **Parahoo**'s work on sexual well-being of men with prostate cancer and their partners, funded by Prostate Cancer UK, produced three online resources. Prostate Cancer UK is rolling out these resources to NHS Health Trusts across the UK.

Future plans

The 2021 opening of our new 75,000m^2 Belfast Campus extension (£365M+ investment), the City Deals for Belfast (£850M investment package) and Derry & Strabane (£250M investment package) regions, the development of the Belfast 'Living Lab' and establishment of both a Clinical Trials Unit and Medical School at our Magee Campus in Derry will enable us to build substantially on existing achievements. At Magee, we will align with NHS strategy to develop multi-disciplinary research teams by strengthening existing collaborations in personalised medicine, biomedical science and cognitive analytics. At Belfast, we will further build postgraduate research provision, enjoy closer contact with the major hospitals and, being closer to business, seize the opportunity to develop innovative ideas and exploit global connections. We will focus on the effects of COVID-19 on mental health and lifestyles. We will expand our research on maternal and child health in Myanmar to Thailand and neighbouring countries. The establishment of an Academic Paediatric Cardiology department (£3.4M Ulster/QUB, Department of Health NI) will allow expansion of our maternal, fetal and infant research. Work on exercise and mental health will be strengthened to include the effects of exercise on other conditions such as cancer, heart disease and diabetes.

INHR research centres

Maternal, fetal and infant research (MFIR) (Leader: **Sinclair,** 10.31FTE)

Research in MFIR focuses on antenatal, intranatal and perinatal maternity care within both a global public health and clinical research framework. The outputs from the OptiBirth, EUROlinkCAT, EUROmediCAT and CONCEPTION research programmes demonstrate the technological and epidemiological mastery of the team and their potential and actual contribution to global policy at WHO and EU level (see **ICS-9**). The centre's research is organised into two inter-related themes: (1)

Midwifery. Our research aims to optimize women's birth experience and reduce maternal and infant mortality and morbidity whilst promoting interventions to enhance their mental health and wellbeing (Optibirth FP7 (€2,999,546)). We have a track record in exploring the theoretical, behavioural and cultural factors influencing breastfeeding behaviour. Our work led to new research on marginalised mothers with chronic health conditions such as epilepsy who fear their medications will transfer into their breastmilk, mothers with postnatal depression and those who suffer birth trauma. Ulster pump-primed three preliminary studies that resulted in £1,761,027 funding from the ESRC (Global Challenge Fund) to explore contextual education as a catalyst for improved maternal health in Myanmar (**Kernohan**, **Sinclair, Dornan** and international colleagues). We contributed to the development of an intervention designed to increase rates of vaginal birth after caesarean section, based on our findings from a cluster randomised trial in 15 maternity units across Ireland, Germany and Italy. **Liddle, Hughes, Gillen** and **Sinclair** studied the management of low back pain with funding from the Physiotherapy Research Foundation (£49,647). We founded the Doctoral Midwifery Research Society (funded by the HSC R&D) to promote excellence in midwifery research and maximise the use of social media to share knowledge and experience across professional, academic, cultural and geographical boundaries. (2) *Perinatal Epidemiology.* This research provides independent, scientific evidence on the safety of medications for chronic disease in early pregnancy which enables informed decision-making around medication use by women of child-bearing age and their health care providers. Since the early 2000s, researchers from the INHR have built research programmes, EUROCAT and EUROmediCAT, around surveillance of congenital anomalies, with successive EU-funding (**Dolk, Loane, Given**). We led the EUROmediCAT consortium from 2011-2019 until the consortium joined the multi-national Innovative Medicines Initiative (IMI) to further investigate maternal disease, maternal medication exposures during pregnancy and neurodevelopmental outcomes (€1.2M to UU, 2019-2024). We also lead the EMA-funded EUROmediSAFE consortium and are a partner in the H2020 funded Europe-wide EUROlinkCAT project investigating the mortality, morbidity and educational outcomes for children born with congenital anomalies (£1.14M to UU, 2017-2021). We are also a major partner in H2020 funded ZikaPLAN and we have set up the Global Birth Defects initiative (led by **Dolk**) to provide resources including an app, for birth defects surveillance in low resource environments.

Caring for people with complex needs (Leader: **McCaughan,** 26.7FTE)
Research undertaken in this centre helps to inform and test new models of care and interventions to enhance the health and well-being of people with complex needs at every stage of their life. We are heavily involved in knowledge transfer activities with funding mainly from the HSC R&D (**Brown**, **Boomer**, **Kernohan**, **McCance**, **McCaughan**, **Moore**, **Ryan**). The centre has five strands: (1) *Intellectual and neuro-developmental disabilities.* Our interdisciplinary, applied research (with colleagues in education and psychology) focuses on improving the health and quality of life of people with disabilities and their family carers, throughout their lives. **Barr** developed, tested and implemented a hospital passport as a communication aid for people with intellectual disabilities to access hospitals across Ireland (£71,000 from the Health Services Executive (Ireland)). The passport was cited as best practice in the NI RQIA guidelines on caring for people with learning disabilities. **Taggart** and **Titterington** are conducting a cluster randomisation trial developing and testing an intervention to enhance working memory and language skills in 4–5-year-old children, with funding from the HSC R&D (>£190,000). **Taggart** is conducting a feasibility study on the clinical and cost-effectiveness of the MATILDA intervention to support older adults with learning disabilities to improve their health, wellbeing and social networks (£551,903 NIHR). **Coates** and **Taggart** are exploring why adults with a learning disability and acute coronary syndrome decline to attend services. (2) *Person-centred practice and education.* Researchers in this area led by **McCance** and colleagues (**Brown**, **Boomer**, **Melby**) have achieved global recognition for developing person-centred practice through participatory research. In collaboration with computer scientists, we have developed and tested an app for implementing and measuring person-centred practice in clinical areas, with funding from the HSC R&D (£72,391). It has been tested across multiple sites in NI, Scotland and Australia. We also conducted a recording care project (**McCance**, **Brown**, **Curran**) (£80,000 Department of Health, Ireland). We are testing a person-centred cancer care approach (**McCance**, **Brown**) (£102,000 from Macmillan Cancer Support and the HSC R&D) and are exploring how useful a core set of person-centred Key Performance Indicators are in a community context (**McCance**, **Brown**) (>£40,000, the Burdett Trust). We have collaborative partners from the UK,

Ireland, Netherlands, Austria, Norway, Switzerland and Australia. Work from this strand is highlighted in **ICS-8**. (3) *Older people and their carers.* Research focuses on enhancing the quality of life of older people in nursing and care homes and their families. The research team (**Ryan, Laird, McCauley, Moore),** has attracted funding from the HSC R&D totalling >£500,000 for four projects to develop, implement and test a reminiscence app for people living with dementia. Our findings informed a play: 'The Songbirds' which has been seen by over 2000 people, and which has shown demonstrable improvement in attitudes towards dementia and understanding of the impact of reminiscence in dementia care (see **ICS-7**). Other key achievements include funding totalling over £1.1M for a number of projects to develop resources and enhance our understanding about how best to facilitate a positive transition to life in a care home (**Ryan, Moore**). Our research has significantly influenced national and international policy and practice, underpinned by our engagement with the international 'My Home Life' network (Norway, Germany, Australia, USA, Japan). (4) *Cancer care.* This strand focusses on psychosocial aspects of cancer. As part of the Movember Foundation's global prostate cancer research programme, **McCaughan** and **Parahoo** were funded by Prostate Cancer UK (£400,000) to develop and test support resources to maximise sexual wellbeing for men (and their partners) following a diagnosis of prostate cancer. We work with partners in Australia, New Zealand, USA, Canada and the UK. We have developed and tested three online resources for health professionals, patients and their partners which are being rolled out to health trusts throughout the UK by Prostate Cancer UK and being adapted for use in New Zealand and the Republic of Ireland. We have carried out a number of studies exploring the psychosocial aspects of oral cancer (**Semple, McCaughan**) and are developing an intervention for patients with oral cancer, before and after surgery (**Semple**, **Parahoo**). (5) *Palliative care.* Our research seeks to improve the care experience of those with life limiting conditions and their families and enhance the public perception of and engagement with palliative care services. **McIlfatrick** played a leading role in the all-Ireland Institute of Hospice and Palliative Care (AIIHPC) and also in establishing the palliative care research network, securing €1.5M from the Health Research Board (Ireland). We evaluated the costs and effectiveness of UK palliative care day services, including the impact on patients and family carers (**Kernohan, McIlfatrick, Hasson**), with funding from Marie Curie (£275,231). We have investigated the management of constipation for people with advanced cancer (**McIlfatrick**, **Hasson**, **Slater, Beck**) (£166,601, Marie Curie), and evaluated out of hours palliative care services (**McIlfatrick**, **Hasson**, **Slater**) (£147,741, Marie Curie). We collaborate with colleagues nationally and internationally, at Chiba University, Japan, the European Association of Palliative Care, University of Lausanne (Switzerland), Trinity College (Ireland), University College Dublin (Ireland), the Centre for Palliative Care (Czech Republic), and AIIHPC.

The Centre for Health and Rehabilitation Technologies Research (CHART) (Leader **O'Neill,** 15.21FTE). Research in CHART is organised under three themes: (1) *Technology for enablement.* Our researchers robustly test interventions embedded in allied health professional practice, such as mirror therapy for stroke rehabilitation. We also work across disciplines to develop interventions such as smart bandages in diabetes, and digital platforms for self-management of long-term conditions (stroke, respiratory conditions and musculoskeletal pain). We focus on technology to enable upper limbs following stroke, with £677,212 awarded for feasibility and main testing of mirror box therapy in acute stroke (**Porter, Stinson**); and almost €1M for the pre-commercial development of a virtual reality rehabilitation platform in the home setting following stroke (**McDonough, Pedlow**). **Martin** and **Ryan** are developing and testing a model for technology enriched supported housing (£385,490 HSC R&D). (2) *Physical activity for health and rehabilitation.* Research focuses on promoting physical activity and exercise in clinical populations and older adults. The group has published several key systematic reviews and randomised controlled trials on the effects of walking on long-term conditions and in older adults. These have informed clinical guidelines (NICE low back pain 2018) and been funded by charities (NICHSA), NIHR (Walk with me), and Horizon2020 (SitLess trial). Research into walking interventions in those with mental health illness has begun (CHITIN £313,240 **McDonough**, **Tully**). (3) *Healthcare practice and education.* Our multidisciplinary, internationally renowned research aims to enhance clinical skills development across allied health professionals and the healthcare sciences. **Breen's** work focusing on skills needed to interpret electrocardiograms (ECGs) has been used to inform national guidelines and develop an ECG interpretation app with over 50,000 users internationally. We helped develop an online independent phonetic transcription practice tool for speech and language therapy students (**Titterington)**.

Hughes and **McFadden** are investigating the educational standards of therapeutic radiography training across Europe (£116,084 ERASMUS). This research involves collaboration with researchers in Malta, Portugal and Poland and the results will contribute to guidelines regulating education across Europe. **Hughes** and **McFadden** have also developed a digital training platform for interpreting radiographic images of the chest, which improved the performance of reporting radiographers in diagnosing pathologies. This platform has the potential to reduce time delays to patient care and improve patient outcomes.

The work carried out in these Centres demonstrate sustainability, in terms of our ability to consistently acquire significant and substantial funding for research and our critical mass of experienced and early career researchers. Vitality is shown by the strength, energy and productivity of our researchers.

2. People

Ulster's staffing strategy, as set out in REF5a, is implemented by the faculty's associate dean for research and impact (**Gault**) a newly created post in this REF period. The research directors of each institute in the unit are responsible for putting into operation and monitoring the strategy along with associate research directors and senior researchers. Together, the senior team ensures that staff are provided with leadership, vision, training, resources, equipment and space to continue to build on the unit's thriving research culture and achievements. Within the institutes, research centres provide individual researchers with a structure and forum to work together, have a sense of belonging and support one another whilst maintaining their own specialism. Interdisciplinary research is encouraged through ringfenced PhD project funding and is a requirement in internal funding opportunities. Centres set their own agenda, develop their own networks of national, international and interdisciplinary collaborators and work together to produce high quality output and impact. Each centre's leader and senior researchers provide leadership, support, training and mentorship to early career researchers (ECRs). Centre leads are recruited from a pool of researchers with significant publication, major grants acquisition profiles and leadership experience. Recruitment is through a competitive process for fixed term tenure, to allow for succession planning.

Our staff have **100% completion rate** for research integrity training. We pursue an active policy to recruit, retain and reward the very best people. Experienced researchers (professors, readers) provide focussed mentoring support to academic and research staff within their faculty, which benefits everyone's research performance and achievements. **Moore, Hannon-Fletcher, Lees-Murdock** and **Porter-Armstrong** are designated Athena Swan champions.

Staff numbers	Gender (M:F)	Age range	Lecturers	Senior Lecturers	Readers	Professors	Research Assoc/ Fellows
150 (140.08FTE)	63:87	25 - 70yrs	62	27	7	43	11

We have a good demographic balance across our staff and have made sure that our key research areas can continue uninterrupted with strategic succession planning. As part of this strategy since REF 2014 we appointed **Tully** (professor) to lead the development of mental health research; **Semple** (reader, a joint appointee with the Belfast HSCT) to develop critical research in head and neck cancer; **Dornan** (lecturer) to add to strengths in maternal health research; **Beck** and **McCauley** (lecturers) to add to our critical mass of researchers in palliative care and dementia research respectively; **Bleakley** (senior lecturer), **Blackburn,** and **Marley** (lecturers) to increase physical activity research; **Courtenay** (lecturer) to add to our drug delivery research expertise; **Berggren, Rorsman** (professors), **Tarasov** (senior lecturer) and **Moffett** (lecturer) to add expertise in cellular metabolism for diabetes research; **Mulholland** (lecturer, with appointment at Moorfields Eye Hospital) to add computational and ocular imaging expertise for vision science research; **Willoughby, Xu** (professors) and **Irwin R** and **Matchett** (lecturers) to strengthen genomic and stratified medicine, and **Ray** (professor) to establish a new vascular laboratory within NICHE.

Ulster has well-established policies for recruiting staff. All staff involved in recruiting are provided with training and all interview panel members must undertake interview training. Mentors and 'buddies' are identified as soon as an appointment is made. All staff have access to online training modules including 'researcher induction'. All the schools in this submission undertake annual developmental appraisal review to agree key responsibilities, key performance indicators (KPIs), and support any development needs. A professorial appraisal scheme also gives professors the opportunity to set yearly objectives and identify support needs. Their progression to the next level of salary scale level depends on meeting these agreed objectives.

The training, development and well-being of research staff are core to our staffing strategy. At university level, three new exciting programmes developed in this REF period (RIGOUR, SOARING and Impact development series see REF5a) have been well-received by researchers in this UoA. We have also implemented a popular research mentoring programme, linking academics from different UoAs and broadening perspectives across disciplines. The majority of our researchers (71%) have participated in these training and support programmes. At faculty level, the associate dean (research and impact) organizes workshops for all levels of staff to foster interdisciplinary collaboration and address issues related to the achievement of faculty KPIs. These include research strategy funding workshops and research sandpits. At unit level, each institute organises discipline-relevant training workshops. An annual PhD away day provides a forum to foster collegiality and showcase PhD research topics across sub-groups as well as a career session between PhD researchers and senior staff. The university-wide sabbatical leave policy to enables staff development and a number of staff have successfully availed of sabbatical leave (**Nesbit, Ward and McKenna H**).

An **impact programme** has been developed across the university and is delivered by Ulster staff with experience in impact and by external consultants (see REF5a). Staff in BMSRI and INHR are supported and facilitated to attend these workshops. Both centrally and at unit level, funds are provided to support the development of case studies, especially for collecting evidence of impact. Ulster has appointed two impact officers to support staff in developing impact case studies. Both the BMSRI and the INHR have designated experienced staff (**Little, McCance**) to lead the development of ICSs and support the ICSs' authors.

Early career researchers can access all training and development programmes offered on different campuses, often online. Workshops are repeated or recorded to allow all researchers to access them. ECRs are allocated appropriate start-up funding to help them to become independent researchers, e.g. ringfenced PhD researcher funding (£70K) and equipment support. Research centres have set up manuscript review panels to advise staff, in particular ECRs, how to produce high quality papers for publication, and a review panel to advise on research proposals. We have strategically supported 12 members of staff in INHR, during this REF period, to develop their research and complete their PhD studies.

Another key part of our staffing strategy is to support staff on **fixed-term contracts, including post-doctoral researchers**. All fixed-term posts must be justified prior to recruitment. We support a policy of redeployment and opportunities for developing new skills to enable fixed-term staff to apply for a wider range of jobs internally. Bridging funding arrangements are in place, on a case-by-case basis, when there are reasonable expectations that external funding may continue. UU has developed a support programme and series of workshops to help broaden the awareness of employment prospects for researchers not just within their own discipline but in other fields as well (see REF5a). The workshops cover topics from getting an interview with industry to creating a high-quality CV and provide opportunities to meet potential employers. Research contract staff can also undertake leadership and management courses, and/or become associate fellow of the higher education academy. The rationale for these options is to increase employability in jobs requiring management or teaching skills.

Rewarding staff is central to our staffing strategy. Workshops are organized for academic and research staff to encourage promotion applications. In this REF period, 35 staff were promoted: 19 to Professor/higher Professorial grade, 1 to Reader, 15 to Senior Lecturer. BMSRI and INHR have

an impressive track record in staff being awarded the annual University Senior Distinguished or Distinguished Research award prize **(McNulty 2015, Gill 2015, McKenna D 2017, Irwin N 2018)** and early career researcher awards **(Matchett 2019)**.

We are committed to implementing UU's **equality and diversity** policies relating to equal pay, bullying and harassment, transgender staff and students, disability and physical access and egress for disabled people (see REF5a), and the majority of our staff have attended the university's unconscious bias workshops. UU is also committed to the principles of the Athena Swan charter. The school of nursing was awarded the **silver award** in 2018, while the school of health sciences and BMSRI have held **bronze awards** since 2016 and 2017 respectively. As part of UU's Athena SWAN action plan (2017-2021), a returning carers' scheme was established to support all academic and research staff on return from extended leave for reasons connected to caring; and four of our researchers have been awarded this funding. Five of our female staff received funding to undertake the Aurora leadership programme, empowering women to pursue strategic leadership roles. We aim to foster a flourishing culture, enabling both staff and students to achieve their potential, whilst taking cognisance of gender and diversity related issues and contributing to a healthy, and equal society. We have an ethos of shared governance, values and behaviours based on inclusiveness, integrity, and professionalism. We recognize that staff individual circumstances should be taken into account when planning workloads and as such encourage flexible working where possible. This approach involves looking favourably on requests to work on a part-time basis. Even prior to the COVID-19 pandemic, as a multi-campus university, we were early adopters of using remote/online platforms for meetings to aid flexible working practices.

Our researchers value the expertise, support and contribution of clinical staff to our research enterprise. They, in turn, appreciate the valuable contribution we can make by producing evidence for policy and practice. We also have productive and collaborative working relationships with industry. To this end, we have developed procedures to facilitate staff integrating into each other's setting, and two staff have been strategically seconded to industry partners **(Gibson, Dowey)**. We also have a number of joint appointments with HSCTs across NI. **Coates** is one of seven Florence Nightingale Foundation professors in nursing research in the UK. She has a clinical role in Altnagelvin Hospital developing personalized care for people with dementia. **Cundell** is a joint appointee with the Belfast HSCT to develop policy and practice in podiatry. **McAloon** is seconded to the NI Practice and Education Council for nursing and midwifery. We host 47 visiting professors in our research centres with a breadth of expertise from prominent public and professional bodies (e.g. Van Woerden (Head of Public Health Agency in NI), Verhagen (National Institute for Public Health, Netherlands), Tormey (Consultant Chemical Pathologist, Ireland)), prestigious academic appointments (e.g. Bergman (Karolinska Institute, Sweden), Del Rio (University of Parma, Italy), Dumonceaux and Hassiotis (UCL, London) and Wilson (University of Technology, Sydney, Australia)), high-profile NHS clinicians (e.g. McArdle (Chief Nursing Offer, NI), Kilmartin (NHS England), McConnell (NHS Scotland), Peace and Armstrong (WHSCT)), and experts from industry including Carr (Merck), Crockard (Randox), Meijer and O'Brien (Nestle).

Research Students

Together, the two institutes have a large and vibrant community of postgraduate research students. We promote a culture based on collegiality and sharing knowledge which engenders a sense of belonging to their learning environment. In this REF period, postgraduate research experience surveys report a high degree of satisfaction, with year-on-year positive progress. In 2019, the overall satisfaction rate for BMSRI and the INHR (combined) was 85.8%, higher than UU overall (85.2%) and the UK average (82.4%). All postgraduate researchers are members of a research centre and actively participate and have opportunity to lead in activities. In this REF period, **257 students (155 female, 102 male**), successfully completed PhDs (full-time, part-time and published works); an increase of **36% since REF 2014 (26% FTE)**. We have a vibrant mix of researchers, with 30% international students.

Each year a number of studentships and fellowships are available to applicants. The NI Department of the Economy (DfE) funds a significant number of studentships (equivalent to UKRI awards). These are open to UK residents, with 10% open to international students. International applicants can

compete for Vice-Chancellor Research Studentships (VCRS) funded by UU. In this period 124 DfE and 36 VCRS were funded. Studentships are also funded through industry (e.g. Randox), HSC R&D doctoral fellowships and charities including Prostate Cancer UK, Diabetes UK, Cystic Fibrosis. We have 40 self-funded PhD researchers. Students with DfE and VCRS studentships are also allocated £900 annually for research expenses, including conference presentation. Students are encouraged to apply for external supporting funding, and research centres and supervisors provide mentorship for this. Additionally, students can be supported to attend conferences and workshops on a case-by-case basis from our Unit's Research Strategy budgets. Currently, 225 students (83%FT, 17%PT) are undertaking doctoral studies.

The university-wide doctoral college (see REF5a) set up in this REF period, provides a suite of training modules designed to help students learn to be better researchers, manage their projects, apply for ethical approval, write peer-reviewed papers, present their work to different types of audiences and engage in impact activities. One of our researchers, **Gallagher**, is seconded as head of the doctoral college. Our institutes also have local inductions, discipline-related training and subject-specific handbooks to give researchers detailed information about their PhD journey. At faculty level, the associate dean (research & impact) is responsible for implementing and monitoring the university's policies and targets related to PhD training. Each institute has a postgraduate tutor (**McSorley** for BMSRI; **Brown** for INHR), responsible for the day-to-day management and support for PhD researchers. Students are formally assessed at 100 days, nine months and in their final year. Postgraduate tutors and centre leads organise and support these assessments. Our high (78%) PhD completion rate within 5 year-timeframe reflects the success of our approach.

All PhD proposals are reviewed by the institutes' postgraduate tutor and the research director to ensure they align with the institutes' strategic priorities. We strategically allocate fully funded PhD studentships as an institutional commitment in external grant applications. All postgraduate research students have a supervisory team. Interdisciplinary supervision, often involving collaborators from industry and HSCTs, is encouraged. The doctoral college provides access to PhD Manager, an electronic platform for recording meetings and progress. Research directors are responsible for providing an environment and the resources (computers, desks, laboratory equipment) necessary for learning. Apart from space in their respective institutes, PhD researchers can access 'hubs' on all university campuses where they can meet with students from other disciplines.

We support and encourage PhD researchers to publish their work and present at conferences. Our PhD researchers are regular recipients of Best Presenter awards and have secured funding to present at international conferences. Writing workshops are organised in each unit, run by experienced researchers and invited external experts, often journal editors. Students are also encouraged to take part in external and internal competitions such as the 'three-minute thesis' presentation (**McSorley** PhD researcher **Feehan** finalist) and the PhD researcher awards. One of our PhD graduates (**Caffrey**) was selected from across Europe as the overall winner of the DSM Science & Technology 'Bright Science Award for Best PhD Project' as presented at the Federation of European Nutrition Societies (FENS) Conference, Dublin (2019). **Moore** was awarded PhD Supervisor of the Year 2020 (Times Higher; 2020).

3. Income, infrastructure and facilities

Income: BMSRI and INHR combined external research grant income **spend** in the REF period is **£50.1M** compared with £29.3M in the 2014 REF, a significant increase of over 71%. There has also been an increase in larger grants from prestigious sources such as UKRI-BBSRC, UKRI-MRC, UKRI-ESRC, NIHR, TSB, US-NIH, EU H2020, major charities and industry. Research awards in the current REF period total **£62.7M**. Professorial annual appraisal sets research targets for experienced staff. Early career researchers are supported, mentored and encouraged to pursue research funding. The department of research and impact sends out weekly reports on funding opportunities.

Major interdisciplinary projects involving our researchers include the SAFEWATER project funded by the UKRI-GCRF and involving NI, Mexico, Brazil and Columbia (**Dooley** and **McNulty** >£5.7M). The Institute of Mental Health (IMHS) is another example and integrates expertise in mental health with other disciplines. Our early career researchers have brought in significant research income, with the award of Diabetes UK RD Lawrence Fellowship to **Moffett** (£444,696) and a Little Princess Trust fellowship to **Matchett** (£415,362). Since 2014, substantial funds have been awarded to strengthen stratified medicine (£16.6M) and NICHE (£14.8M) from a number of sources including UKRI, US National Institutes for Health (NIH), the European Commission, Republic of Ireland-Northern Ireland governmental funding (health and food sectors), Genuity Science, and industry. Staff are trusted partners of several pharmacological and biomedical companies, enabling innovative postgraduate research opportunities. Spin-out company Jenarron (**McCarron**), which licences novel wound gel putty for topical drug delivery, has received significant investment and has recently partnered with Plexus Ventures to negotiate a commercial deal with an international pharmaceutical company. A further example of industry engagement is the development of a tooth-whitening product (NOVON®). This project, initially funded from a DEL-CAST studentship, resulted in a clinical trial a well-cited paper in Clinical Oral Investigations and a patent commercialized through SMT Research Ltd, which had significant economic impact in NI.

The research funding received by researchers in the unit has led to many high-quality outputs and an impressive suite of impact case studies. Our hypertension study identified Vitamin B2 (riboflavin) as a novel nutrition solution to address high blood pressure in genetically-at-risk adults (**ICS-6**), and this research area alone has attracted over £1M in external grant income. Our work on myopia (short-sightedness) has modernised guidance for myopia diagnosis and management and our data has been used to justify interventions to slow myopia development, including investment of >£1.2M by NIHR for the first UK clinical trial investigating pharmacological treatments for childhood myopia (**ICS-4**)**.** Longstanding research on the safety of medication use in early pregnancy led to EUROmediCAT, a European database for assessing medication safety in pregnancy (**ICS-9**). This body of work has attracted €40M in research funding since 2000 and highlighted the risks of the antiepileptic drug sodium valproate during pregnancy.

Facilities and Infrastructure: Research within BMSRI and INHR is supported by high quality environment and state-of-the-art facilities. The BMSRI maintains infrastructure at the following locations; the £17.5M 6,200m^2 Centre for Molecular Biosciences (CMB) and the SAAD Centre at Coleraine; the £5.3M Functional Brain Mapping facility at Magee; the £4M Wellcome Trust- Wolfson Foundation NI Clinical Research Facility (NICRF) in Belfast; The Clinical Translational Research and Innovation Centre (C-TRIC) building in Derry~Londonderry on the Altnagelvin Hospital site houses our NI Centre of Stratified Medicine (overall investment of £11.5M). The research strategy section describes the substantial investments for our core facility units (summarised below), which are maintained with new infrastructure funding, strategic funding from BMSRI and own income generation.

The centre for rehabilitation research, based on the Jordanstown campus, is a state-of-the-art facility that provides a physical focus for health and rehabilitation research in the UK. It contains 19 research/treatment rooms, including virtual reality suites, neurophysiology suites, pressure mapping suite, ultrasound scanning suite, 3D imaging laboratory, and an incontinence suite. It also houses communal rehabilitation areas, including a well-equipped gym, movement analysis laboratory and research and administration offices (15 individual research offices for academic staff and visiting scholars, an open plan research area with 30 workstations, a seminar room and a secure data storage room). These resources are available for both staff and research students and are supported by a statistician and a technician.

The INHR also pioneered the NI administrative data research centre (ADRC) with funding from the UKRI-ESRC (£2,238,374) and the HSC R&D (£580,766). This multi-disciplinary resource supports researchers in the faculty of life and health sciences (schools of nursing (**Dolk**, **Loane**), psychology, geography, computing and engineering). The INHR has established a purpose-built nursing and midwifery competence test centre, one of only three in the UK, on the Magee campus, at a cost of

>£750,000. This facility provides opportunities to advance our research in professional education. Our future plan is to take this opportunity to expand our work in pedagogic research.

Core facility units (CFUs) were established to update and replace specialist equipment, and to organise our infrastructure into a more efficient, sustainable model. We have six permanent researchers (scientific assistant/officer) for our key CFUs and a business development manager (BDM) who manages the staff and coordinates activities. The CFUs, summarised below, are supported by 23 technical staff across BMS and Pharmacy with a contract technician based at C-TRIC, a quality assurance officer, a clinical trials manager and an IT officer. Each CFU Coordinator operates with agreed business plans and CFUs retain surplus income to reinvest in staff support or new equipment. CFU resources are available to researchers and IUL promotes CFUs services to third parties in major industry and SMEs. Since REF2014 the CFUs have generated £8.48M in consultancy and directly supported research-funded projects.

Bio-Imaging (**O'Hagan**): comprising the FEI Centre for Advanced Bioimaging (FEI's European demonstration laboratory) and the Leica Centre for Tissue Engineering: optical microscopy suites with a full range of EM and STED microscopes, with capability for super resolution confocal microscopy. Exemplar industry-related projects funded by DAERA/DAFM and KTP (£518,633).

Cell Technologies (**Thomas**): provides a suite of tissue culture rooms and cell/tissue barcoded computerized -80storage (1.2M HTA sample capacity) with full traceability in alarmed freezers, patch clamp recording, fluorescence and confocal microscopes, window chamber/skin flap model for *in vivo* imaging, flow cytometers, X-ray and caesium gamma sources. Exemplar initiatives include the newly created NI Complex Disease Bioresource (£119,500 funded by HSC R&D Office). Repository feeds the UK wide Genetic Links to Anxiety and Depression (GLAD) study, conducted in collaboration with King's College London, Edinburgh University and Cardiff University.

Genomics (**Conway**): includes state-of-the-art genome analysis technologies and genome editing tools with facilities for isolation, measurement and analysis of DNA and RNA using Pyromark Q48 Pyrosequencing System (Qiagen), the LightCycler® 480 Real-Time PCR System (Roche) and the 2100 Bioanalyzer (Agilent) among others. Enables CRISPR/Cas9 gene editing to create knock-in, knock out and gene-up/down regulation models with expertise in next generation sequencing (NGS). Exemplar project with Farmlabs Diagnostics Ltd (IRL) funded through the Intertrade Ireland FUSION Programme (£27,000).

Human Interventions Studies Unit (HISU) (**Price, Sittlington**): with a residential facility for human intervention trials and a wide range of equipment for nutritional and metabolic assessment, including exercise suite with BodPod, ViScan, ergometer, treadmill, ergospirometer, accelerometers, bone densitometers, access to nutritional intake analysis software, as well as equipment for anthropometry and 24-hour ambulatory blood pressure monitoring. The unit also provides phlebotomy rooms, a gastrointestinal laboratory, a category II laboratory for blood and faecal sampling/analysis and state-of art instrumentation for a nutrient biomarker analysis. HISU is supported via grants to NICHE (totalling £6.3M in current awards), including a large grant from the US-Ireland scheme via NIH with partners in Dublin and Florida US, for an obesity project involving metabolic studies of participants at HISU's residential facility.

Mass Spectrometry (**Cobice**): This CFU is a unique purpose-built resource within Ulster which facilitates a broad range of biologically, medically and pharmaceutically relevant analysis. It has contributed to a significant number of research grants generating £0.86M per annum and has been a fundamental part of the underpinning research for the majority of BMS Impact case studies in the current REF period. We provide high-quality analytical support using a range of mass spectrometry-based techniques including high-resolution (Orbitrap®), triple quadrupoles (Qtrap and QQQ) and mass spectrometry imaging (iPMALDI-TOF/TOF-Orbitrap®) platforms. This cross-cutting technology has been key in the support of Drug and Biomarker Discovery for disease diagnosis and stratification, underpinning key areas of our research, commercial engagement and consultancy. Strong collaboration with Randox Laboratories Ltd through £5M Ulster-Randox Industrial PhD

Academy and £0.2M income from other government and industrial sources is invested back into maintaining state-of-the-art-analytical instrumentation.

Vision Science (**Richardson**): fully equipped eye clinic (400m^2) providing specialised visual function tests including measurement of characteristics of the ocular media and the retina. Eyecare services are delivered to the public on behalf of HSCTs. Resources include ocular coherence tomography, visual electrophysiology, ocular biometry, ophthalmic photographic imaging, macular densitometry, light scattering meter, wavefront ocular aberrometry, spectrophotometry, specialised lasers and instruments. The unit's development since REF2014 has been possible thanks to strong collaborations with industry and a track-record in obtaining competitive grant income (£0.33M).

Biological Behavioural Research Unit (BBRU) (**Naughton**): BMSRI has maintained the BBRU as a TRAC costed small animal research facility since REF2014 and has immediate plans to develop a GLP Tox facility with GreenLight Pharmaceuticals Ltd to assess candidate compounds for toxicity to allow them to advance to Phase I clinical trials. There is no other GLP Tox facility on the island of Ireland. This small animal unit has been equipped recently with new surgical theatre, IVIS bioluminescent/fluorescent imaging system, CLAMS metabolic system, PIXImus densitometry system, stereo microscope systems with advanced editing and computational software for precision microsurgery, including eye surgery in rodents. This high-quality facility attracts contract research with an annual turnover of >£74,000.

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

4.1 COLLABORATION: Our researchers have links with over 200 universities and research institutions internationally and have significant relationships with industrial partners such as Randox, Genuity Science, Avellino and Greenlight. These collaborations provide valuable opportunities for competitive grant submissions, interdisciplinary publications, expertise exchange, and for PhD researchers to visit other labs and learn new techniques. Through the ConcePTION (€28.6M), EUROmediCAT (**Dolk, Loane, Sinclair**) and other consortia we have links with over 22 European country partners and 88 organisations. We have several significant joint appointments with Health and Social Care services.

Exemplar Networks/MOUs: **Cobice**: Maastricht MultiModal Molecular Imaging Institute (the Netherlands); Scottish Instrumentation and Resource Centre for Advanced Mass Spectrometry, University of Edinburgh. **Courtenay**: Galway-Mayo Institute of Technology, Ireland**. Duguez**: Children's National Medical Center (Washington DC, USA). **Loane, Dolk:** ConcePTION (Novartis and University Medical Center, Utrecht). **McCarron:** Plexus Ventures LLC. **McDowell:** GlaxoSmithKline Global Stiefel Medical Team consultancy; Galderma R&D (Nice, France) consultancy. **McHale** Sonidel Ltd/Ireland; Ludwig Boltzmann Institute for Experimental and Clinical Traumatology, Vienna, Austria. **McGilligan**: Schepens Eye Research institute at Harvard Medical School, Boston USA. **Moore:** UK Industry Rapid testing Consortium. **Tully:** School of Public Health and Health Sciences, University of Massachusetts Amherst, USA; San Diego State University and Director of Active Living Research, USA; University of Southern Denmark; Centre for Public Health, Queen's University Belfast. **Walsh:** PHA COVID-19 Track/Tracing Committee, 3Dcellfit EU COST; Royal Society/Newton International Exchanges Turkey, China. **Ward:** Deputy Director of NICRF.

4.2 SUPPORTING RESEARCH COLLABORATION: Our institutes have longstanding research networks, with the University's EU office, Invest NI and close engagement with Department of Health and the five HSCTs in NI. To strengthen the life and health sciences research ecosystem in NI, we established Health Innovation Research Alliance NI (HIRANI), with partners including Public health agency, Department of Health, HSC R&D office, the Department for the Economy and Invest NI. This influential alliance, with a funding stream of £1M, ensures we are well connected with wider UK and international organisations, and encourages a more coordinated approach, targeting funding opportunities within and outside NI. In recognition of its strategic importance to our research, the BMSRI have a strategic partnership lead (**Gill**) who liaises with these networks and actively supports collaboration opportunities. Two staff have been strategically seconded to industry partners

(Gibson, Dowey). Staff are encouraged to actively seek opportunities for collaboration internationally and nationally, and this is supported by regular seed funding initiatives.

4.3 CONTRIBUTION TO RESEARCH BASE: Our work is focussed on driving forward scientific knowledge in genomics, drug discovery, diagnosis and treatment of disease and optimising clinical care for patients. Our academics are heavily engaged in journal editorial duties, and refereeing peer-reviewed publications. We serve on grant panels and occupy positions of significant influence through membership of societies and associations focussed on research, summarised below.

Grant Panel Memberships	Editor/Sub-editor roles: Journals	Editorial board memberships: Journals	National Research-focussed committees
41	15	63	42

The following highlighted examples demonstrate how our researchers have contributed to the research base in this REF period.

Exemplar Grant Panel Memberships: Atkinson: NIHR Health Technology Assessment Programme. **Bjourson**: Medical Research Council (MRC) College of Experts, (Genomics Infrastructure). **Callan J:** EPSRC Panel member, Transformative Healthcare Technologies for 2050. **Coates**: NIHR HTA Primary care call and Efficient designs panels. **Courtenay:** Member of the European Paediatric Translational Research Infrastructure (H2020). **Duddy, Duguez:** European Research Area Personalized Medicine (ERA-PerMed) joint transnational calls. **Flatt:** EFSD/Lilly European Diabetes Research committee; UKRI-MRC/BBSRC expert review panel on UK Research Partnership for Health & Disease; Chair Studentships and Member RDL Fellowships Committee of Diabetes UK. **McDonough**: Member Swedish Medical and Health Research Council Grant Evaluation Panel; Member International Science Advisory Panel for New Zealand Government National Science Challenge Ageing Well Research Awards. **McKenna H**: appointed Scientific Review Panel member, UK Dementia Research Institute; Chair of the Study Steering Committee for NIHR PHR Programme; Chair of the International Clinical Research Panel, Swedish Research Council; Member of Standing Review Board, Humanities & Social Sciences Panel of Research Grants Council, Hong Kong. **Moore:** UKRI Strength in Places Fund Assessment Panel. **Moorhead:** Public Health Wales Research funding panel. **Parahoo**: HSC R&D Research Fellowship funding panel**;** Finnish Academy of Sciences funding panel. **Strain:** Chair International Science Advisory Panel for New Zealand Government National Science Challenge High Value Nutrition Research Programme. **Ward:** HEE/NIHR ICA Programme Clinical Doctoral Research Fellowship Scheme Review Panel (England). **Walsh**: Government of Ireland Postdoctoral Fellowship Board; UKRI-ESRC College of Reviewers.

Exemplar Industry links/Directorships: Bjourson: Co-founder and Director of C-TRIC (Clinical Translational Research and Innovation Centre). **Callan J:** Founder, SonoTarg Ltd. **Cobice:** CSO, Fundacion Cientifica Felipe Fiorellino, Argentina. Novel antimicrobial Drug Discovery; CSA, South American Multi-Modal Molecular Centre of Excellence, Chile. **McCarron:** Plexus Ventures LLC; Founder and Director, Jenarron Therapeutics; Director, Swedish Pharma. **McDowell:** GlaxoSmithKline Global Stiefel Medical Team consultancy; Galderma R&D (Nice, France) consultancy. **Moore:** Director of R&D, Avellino Labs, USA, Korea and Japan. **McHale** Sonidel Ltd/Ireland; Founder and Director, SonoTarg Ltd; Ludwig Boltzmann Institute for Experimental and Clinical Traumatology, Vienna, Austria. **Tully:** Director of Active Living Research, USA.

Exemplar Research-focussed Associations and Committee memberships: Loane: President of EUROmediCAT Consortium (2017-2019). **McKenna D**: NI Pathology Network Committee; Irish Association of Cancer Research Senior Council; European Association for Cancer Research (EACR). **Coates:** Co-Chair NI Clinical Research Network: Diabetes; Diabetes UK Research Committee. **Mulholland:** NIHR Clinical Research Network National Ophthalmology Specialty committee. **Douglas:** Executive member of European Federation of Associations of Dietitians. **Gault**: European and UK Incretin Study Groups. **Saunders:** Royal College of Ophthalmologists Paediatric Committee; Vice-chair, College of Optometrists Research Committee. **Bjourson**: Cancer Research-UK (Belfast CR-UK) Centre Governance Board; NI Pathology Network Board; NI Biobank:

Steering Committee; Irish Society of Human Genetics (ISHG) Council. **Cobice**: International Mass Spectrometry Foundation.

Exemplar Post-graduate research training: McIlfatrick: President of the Board of INDEN (International Network for Doctoral Education in Nursing comprising 34 countries). **McKenna H:** Co-Founder and Member of INDEN, Member of Academia Europeae. **Sinclair:** founder and chair of Doctoral Midwifery Research Society.

In this REF period, our researchers have been invited to deliver over **200 major invited/keynote lectures** internationally. Our staff have also **organised 25 international and national conferences** in partnership with associations such as FENS, Diabetes UK, Child Vision Research.

4.4 CONTRIBUTION TO ECONOMY AND SOCIETY: As a civic university, academics at UU are encouraged and supported to work externally with profession-specific partners where their expertise and contribution to shaping the public conversation and policy in healthcare and healthcare education are recognised. Our wide-ranging impact case studies are evidence of this contribution. We have established and embedded links with NHS through C-TRIC, joint appointments with Health and Social Care Trusts, the NI Clinical Research facility, NI clinical Research Networks, NIHR, and Moorfields Eye Hospital. Most of our research is inter-disciplinary and aims to the needs of the population and the priorities of key stakeholders. Our researchers regularly engage with the community through media channels including the Irish Times and RTE Brainstorm, and actively contribute to the NI Science Festival.

Exemplar Health and Social Care Trust/Patient and Public Engagement/Charities: Joint posts with HSCTs include **Boomer**, **Coates**, **Cundell**, **Gillen**, **Semple** and **Willoughby**. **Kernohan**, **Moore**, **Ryan** and **Tully** have all taken part in KESS, organized by the NI Assembly, with the aim to promote evidence-informed policy and law-making. **Laird**: steering group member of Dementia Together NI, tasked with the development of the Dementia Knowledge and Skills Framework for NI. **McCance**, **McIfatrick**, **Coates**: members of the Central Nursing and Midwifery Advisory Group that advises the DHSSPS. **McIlfatrick**: member of Strategic Scientific Committee for All-Ireland Institute of Hospice and Palliative Care. **McKenna H**: Chair of the Patient and Client Council Research Committee (NI); Chair of Inspire Wellbeing (largest mental health, learning disability and addiction charity in Ireland); invited member of the Lancet Commission on Nursing. **Mulholland:** Principal Research optometrist Moorfields Eye Hospital. **Ryan:** Reminiscence Network NI (2015-present); Royal College of Physicians of Ireland, Policy Group on Ageing (2016-present); NI Expert Frailty Panel (2018-present). **Tully:** Scientific Advisor, Public Health Agency (NI) Regional Obesity Implementation Group. **Walsh:** Scientific advisor, PHA (NI) Contact Tracing Data Analytics and WHSCT COVID-19 molecular testing.

Exemplar government/professional regulatory appointments: Moore: Appointed UK Government Advisor to UK Rapid test consortium on COVID-19. **McKenna H**: Appointed Chair of REF2021 Subpanel 3 Pharmacy, Dentistry, Nursing, Midwifery, AHPs and Biomedical Sciences; Member of the REF2021 Interdisciplinary Research Advisory Panel; Member of the REF2021 Metrics User Group. **McNulty:** Chair of the Folic Acid Food Fortification Review Group, Food Safety Authority of Ireland. **Anderson:** Secretary of State for Transport's Honorary Medical Advisory Panel on Driving and Visual Disorders. **Hannon-Fletcher**: Member of Fitness to Practice Committee, and Educational Visitor, Health & Care Professions Council; **Little:** Educational Visitor for the General Optical Council. **McNulty, McSorley, Ward:** Member of the Public Health Nutrition Sub-Committee, Food Safety Authority of Ireland (2014-present). **Pentieva:** Panel Member on Dietetic Products, Nutrition and Allergies, European Food Safety Authority, Italy (2015-2021). **Strain:** Inaugural Chair of the Working Group on Health Claims, and Vice-Chair, Panel on Dietetic Products, Nutrition and Allergies, European Food Safety Authority, Italy (2014).

Exemplar discipline-specific professional organisations: Flatt: Royal Irish Academy Membership Committee (Science); **Gallagher:** President/Chair, Board of the European Nutrition Leadership Platform. **Gault:** Member, Executive Committee, Heads of University Centres of Biomedical Sciences (HUCBMS). **Gillen:** Chair, Royal College of Midwives Board. **Hill:** Board

Member of BDA NI; Assessor, Health and Social Care Professions Council Ireland. **Little:** Deputy-Chair of the Association of Optometrists; Chair of the European Qualifications board for the European Council of Optometry and Optics. **McClelland:** Independent Prescribing Assessment Panel Member, College of Optometrists. **McKenna H**: Appointed international RAE Reviewer for Hong Kong University; American Academy of Nursing International Fellows Panel. **McNulty:** Member of ACACM Advisory Committee, Royal Irish Academy; Invited Expert Panel Member (Folate) in the international Biomarkers of Nutrition for Development (BOND) Project coordinated by the U.S. National Institute for Health (NIH); **Moore:** Royal College of Ophthalmologists Standards Committee; Royal Irish Academy Life & Medical Sciences Committee; American-European Congress of Ophthalmic Surgery; Aniridia EU COST; Hon Fellow Faculty of Forensic and Legal Medicine, Royal College of Physicians (London). **Porter-Armstrong:** Trustee and Deputy Treasurer of the European Pressure Ulcer Advisory Panel. **O'Neill:** Chartered Society of Physiotherapy scientific panel; **Ryan**: President of the All-Ireland Gerontological Nurses Society. **Walsh:** Vice-President for External Relation, UK Genetics Society; **Webba da Silva**: Royal Irish Academy, Physical, Chemical and Mathematical Sciences Committee.

4.5 MAJOR HONOURS, AWARDS: Anderson: Life Fellowship of College of Optometrists (2015); DSc, Cardiff University (2016). **Barr, McCaughan, McIlfatrick:** Florence Nightingale Leadership Fellowships. **Curran**: Awarded Order of the British Empire (OBE) for services to education and nursing in NI (2014). **Flatt**: Steno Medal; DSc, Ulster (2018); named on Expertscape as 1st-ranking insulin researcher in UK and 9th worldwide (2019); Editor of international multi-author special editions of journal Peptides on gastrointestinal hormones. **Gault**: RD Lawrence Lecture, Diabetes UK Annual Professional Conference (2017). **Irwin N**: Named on Expertscape 'Top 30 leading insulin researchers in the UK' (2019). **Little:** Neil Charman Medal for outstanding Research, College of Optometrists UK (2016). **McKenna H, McIlfatrick**: Fellow of the RCN; American Academy of Nursing; **McKenna H**: European Academy of Nursing; Royal College of Surgeons (RCSI); Lifetime Achievement Award, Journal of Psychiatric and Mental Health Nursing. **McKenna H**, **McCance**: each voted one of 70 Most Influential Nurses since the founding of the NHS. **McNulty**: Elected as Fellow of the International Union of Nutritional Sciences (2016). **Moore:** Ophthalmology Power list double award, Inventor and Emerging Leader (2019). **Mulholland:** Imaging & Perimetry Society Heidelberg Engineering Award (2016). **Parahoo, McCance:** Royal College of Nursing Outstanding Achievement award (2016, 2019). **McIlfatrick**, **Parahoo, Ryan**: Honorary Fellows, Royal College of Surgeons (Ireland) (2014, 2017, 2019). **Saunders:** Life Fellowship of College of Optometrists (2019) **Semple, McAloon**: RCN Nurse Researcher of the year (2015, 2016). **Semple**: MBE then OBE for services to Nursing (2015, 2017). **Sinclair**: Lifetime Achievement Award by the British Journal of Midwifery for contribution to midwifery research and impact. **Strain:** Honorary Fellowship, Nutrition Society (2019); OBE for services to Nutrition research (2014). Finally, 3 staff (**Flatt, McNulty, Strain)** are Members of the Royal Irish Academy (MRIA); membership is by election and considered the highest academic honour in the sciences in Ireland.