**Institution: Anglia Ruskin University**

**Unit of Assessment: UoA3 (Allied Health Professions, Dentistry, Nursing and Pharmacy)**

## 1. Unit context and structure, research and impact strategy

### 1.1 Overview

Allied health research at ARU has expanded considerably in scope, depth and volume, and has undergone considerable restructuring since REF2014. As shown in Figure 1 below, we have significantly **increased external research funding**, **expanded the number of research active staff**, **increased doctoral degree completions**, **recruited more early career researchers (ECRs) and senior research staff,** and supported our researchers by **substantial improvements to the research infrastructure**. We have demonstrably achieved considerable successes and surpassed many of the strategic targets set for this REF cycle.

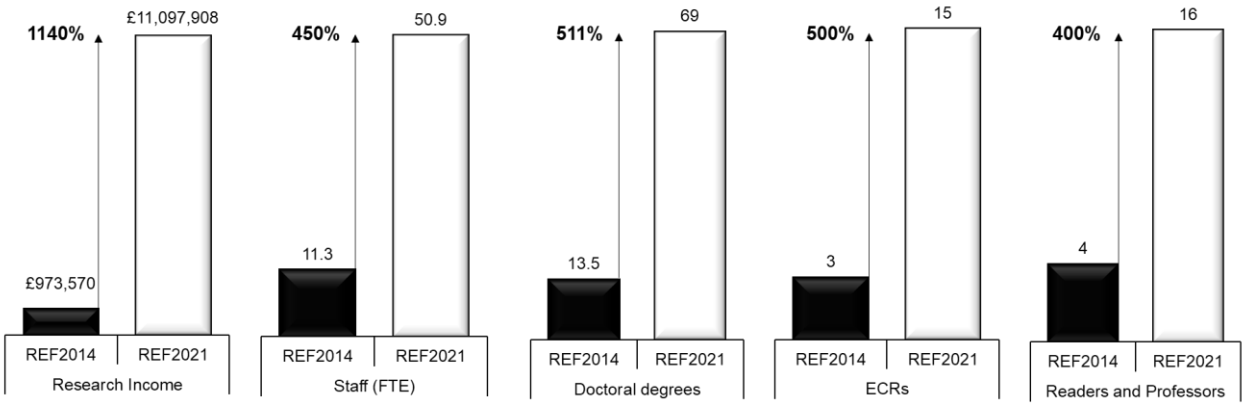


*Figure 1: Graphical representation of the significant improvements to the unit's environment metrics between submissions to REF2014 (black columns), and REF2021 (white columns).*

Our fundamental strategic goal has been to create a research environment that identifies and supports research which is **innovative** in approach and application, addresses **national and international needs**, involves key **collaborators** and embraces a variety of **disciplines**. The results are aimed to be **world-leading, novel, reproducible and translational,** with potential to **improve knowledge, practice and theory**. An essential outcome of this approach is to ensure **sustainability** and to **train the next generation of researchers** in the healthcare and biomedicine sectors.

### 1.2 How is research structured in the unit?

The submission for this unit draws on the research and innovation activities of **three Faculties:**

- Faculty of Health, Education, Medicine and Social Care (FHEMS),
- Faculty of Science and Engineering (FSE), and
- Faculty of Business and Law (FBL),

with laboratories and research spaces at both the **Cambridge and Chelmsford campuses**, drawing on the collective experience and expertise of 58 research-active staff including 5 readers and 11 professors.

The unit is composed of **four research clusters**: Vision and Eye Research Institute (VERI), Medical Technology Research Centre (MTRC), Health Research Cluster (HRC), and Biomedical & Forensic Research Group (BFRG). The clusters are strategically aligned to four of the eleven

**ARU research priority areas**: healthy ageing, sustainable health care, vision, and medical devices and technology. Whilst the research clusters form foci for researchers in specific subject areas, there is considerable collaborative work, exchange of ideas, and communication of research between the clusters (see Section 4.1). These clusters not only produce high quality research outputs, but also act to benefit and improve the student experience by providing a research-enriched curriculum. The coordination and strategic leadership within the unit are provided by Deputy Deans in each Faculty, alongside cluster leads.

**1.2.1** The **Vision and Eye Research Institute** (VERI; 11.15 FTE) was designated a Research Institute in 2018 in strategic institutional recognition of the sustained excellence of its work; it was originally established in 2009 as the Vision and Eye Research Unit (VERU). VERI is a multidisciplinary research platform comprising staff from two faculties (FHEMS and FSE) who carry out ground-breaking research in key areas of vision, eye and hearing research such as ophthalmic epidemiology, diabetic retinopathy, impact of low vision, anterior eye research, vision and handedness in sports, visual acuity and crowding in children, refractive error development, audiology and visual short-term memory. In addition to a team of three professors, two readers, two ECRs, four senior lecturers, and two research fellows, VERI also collaborates with staff from other departments at ARU including Life Sciences, Sports Sciences, Psychology, and Computing and Technology, and with researchers from prestigious laboratories/hospitals across the world, including in China, India, Italy, Nepal and Thailand. The team is further strengthened by public and private stakeholder partners from the NHS and industry.

Within this REF period, VERI has produced 210 outputs (including 26 in *The Lancet*) and secured £2,093,564 in external research funding from the following bodies: European Union, NIHR, College of Optometrists, British Society of Audiology, Wellcome Trust, British Council, Agitos Foundation, International Paralympic Committee, International Glaucoma Association and Brien Holden Vision Institute. ***Key achievements****:* (i) the first global, temporal analysis of change in the burden of blindness and vision impairment; (ii) first time demonstration of how barriers across various demographics affect the risk of diabetic sight threatening retinopathy in China, India, Nepal, and UK; and (iii) development of a new sport-specific, evidence-based classification system for athletes with vision impairment.

VERI's research has led to the development of **two impact case studies** for REF2021 (see 1.6.1).

**1.2.2** The **Medical Technology Research Centre** (MTRC; 6.0 FTE) was initiated in 2018 and aims to research and develop novel biomedical technology solutions for sectors including healthcare, pharmaceuticals, medical engineering, and medical devices. MTRC's research has focussed on drug discovery using phenotypic screening, development of polymerase chain reaction (PCR)-based diagnostics, medical devices and novel drug delivery platforms. The Centre is comprised of two professors, three ECRs and a senior lecturer. Its outputs include 55 publications and two patents, and its funding (total £4,211,154) from EU Horizon 2020, Innovate UK, the Bill and Melinda Gates Foundation, Royal Academy of Engineering, and the Newton Fund; charities such as European Society for Sexual Medicine and Peterborough Burns Unit Appeal Fund; and pharmaceutical and medical device companies such as GlaxoSmithKline, AstraZeneca, and Life Technologies. ***Key achievements****:* (i) development of four CE-marked PCR-based diagnostics kits for fungal infections; (ii) the first demonstration of a synergy between two FDA-approved drugs for treatment of Peyronie's disease; and (iii) development of disulfiram-loaded nanoparticles for treatment of lung cancer.

**1.2.3** The **Health Research Cluster** (HRC; 17.15 FTE) was established in 2017 and represents research and innovation activities in the health sector across the three Faculties. The cluster comprises sub-groups including the Circulatory Research Group, Ageing Research Group, and Global Public Health, Migration & Ethics Research Group. It includes four professors, two readers, five ECRs, six research fellows and five senior lecturers. The work of the cluster has been supported by external funding (total £4,187,308) from EU Horizon 2020, AHRC, MRC, ESRC, NIHR, the Royal College of Nursing, Institute for Healthcare Management, Dunhill

Medical Trust, Enhancing Learning and Research for Humanitarian Assistance (ELHRA), Essex Hertfordshire Air Ambulance Trust and the pharmaceutical industry (such as AstraZeneca, Takeda, Eli Lilly). It has produced 360 outputs. Partnership working has primarily been with NHS Trusts, Public Health England and Health Education England. ***Key achievements****:* (i) the first demonstration that continuous thermodilution is predictive of microvascular dysfunction in patients with myocardial infarction; (ii) the first demonstration that muscle mass measures adjusted for height only are better risk factors for incident osteoporosis in postmenopausal women; and (iii) the first study at the primary care level to investigate prevalence of mental health disorders among conflict-affected populations in the Northern Province, Sri Lanka.

The cluster's research has led to the development **one of the impact cases studies** submitted to REF2021 (see 1.6.1).

**1.2.4** The **Biomedical & Forensic Research Group** (BFRG; 16.6 FTE) was established prior to REF2014 with the aim of coordinating research activities in different aspects of biomedical and forensic sciences such as cardiovascular sciences, cancer cell biology, microbiology, genetics, molecular biology, forensic and investigative sciences. The BFRG includes two professors, one reader, five ECRs, eight senior lecturers and one research fellow. The BFRG has produced 78 outputs and one patent. In the current REF cycle, it has received funding (£605,882) from Innovate UK, British Heart Foundation, Diabetes UK, Wellcome Trust, Royal Society for Chemistry, Essex Police, Analytical Chemistry Trust Fund, Edith Florence Spencer Memorial Trust, Microbiology Society, MedAnnex Ltd and OnchoBioPharm Ltd. ***Key achievements****:* (i) the first demonstration of an inhibitory effect of an artificial sweetener on vasculogenesis; (ii) the first demonstration of fluctuations in zinc levels regulating reactive oxygen species in platelets and (iii) development of new analytical methods to detect drugs of abuse in drinks.

The group has developed **two impact case studies** in this submission (see 1.6.1).

## 1.3 Review of the strategic research goals set in REF 2014

The UoA3 submission to REF2014 was led by VERU (now VERI). VERU set the following strategic aims in REF2014, all of which have been met:

**1.3.1 Enhance VERU's reputation as a world class research centre:**
a. We have further **built on key areas identified in REF2014** for which we have an established international profile:

i. ***Ophthalmic epidemiology****: Bourne* heads the Vision Loss Expert Group (VLEG) comprising over 102 epidemiologists worldwide, which is part of the International Agency for Prevention of Blindness (IAPB) and funded by the Brien Holden Vision Institute, Fondation Théa, Gates Foundation, Lions Clubs International Foundation, Sightsavers International, Fred Hollows Foundation and the University of Heidelberg. The research, published in 57 journal articles including 13 in *The Lancet* within this REF period, has informed eyecare policies within the WHO, IAPB, Fred Hollows Foundation, UK National Eye and Hearing Survey (UKNEHS) and Vision Aid Overseas. This research was utilised by the Adviser for the Science and Technology Committee to inform the House of Commons in 2018 and forms the basis of a REF2021 impact case study (see 1.6.1).

ii. ***Visual impairment:*** research led by *Pardhan*, in collaboration with the University of Cambridge, provides breakthrough on how people with vision loss utilise hearing cues. Further research collaboration with the University of Cambridge and NHS Trusts explores associations between cortical and retinal changes in people with Down's syndrome.

iii. ***Myopia research*** led by *Allen* has continued in the unit, and we are currently one of five sites for The Childhood Atropine for Myopia Progression (CHAMP) study. CHAMP-UK is an NIHR-EME funded trial (started in 2016 and ongoing) that aims to evaluate the efficacy of low dose atropine eye drops to reduce the progression of myopia, determine the mechanism of atropine eye drops and explore the influence of other factors in the progression of myopia in children.

iv. ***Anterior eye disease research*** led by *Bourne* and *Pardhan* resulted in two PhD student completions in dry eye and corneal endothelium as well as an EU Marie Curie Fellowship.

v. ***Diabetic retinopathy*****:** responding to global initiatives through various agencies and key stakeholders in China, India, Nepal and Thailand, research by *Pardhan* has led to improved eyecare for patients with diabetic retinopathy in those countries. This work led to seven peer reviewed publications, decreased the risk of blindness in people with diabetes and formed the basis of the second impact case study in this submission (1.6.1).

vi. ***Sports Vision*****:** This is a new area that has been developed in this REF period. *Allen* and colleagues have been investigating the impact of visual function on elite athletes. Strands of this research include eye and hand dominance and their relationship to performance, working with the International Paralympic Committee to establish sport-specific evidence-based classification systems for athletes with vision impairment, and working with the England and Wales Cricket Board to investigate the visibility of the new pink cricket ball.

b. We have **increased collaboration with world-class research centres and bodies** such as the WHO, IAPB and US Global Ophthalmology Network, by expanding our visiting professoriate: *Raman* (India), *Moore* (University of Cambridge), and *Davies* (past Chairman of Public Health England) all joined VERI during the assessment period.

c. We have **developed our research infrastructure and facilities**: in December 2014 VERI moved into a purpose-built research centre (190 $m^2$) in Young Street, Cambridge, following a capital investment of £900,000 from ARU.

**1.3.2** We have **translated our research into improved patient outcomes** by disseminating findings through the newly formed infrastructure of the School of Medicine (2018) and partners throughout the region, as well as increasing our collaboration with NHS clinicians working in VERI, the WHO and 14 collaborators in China, India, Nepal and Thailand. Supported by the Anglia Ruskin Clinical Trials Unit (3.2), we initiated two NIHR-funded clinical trials – one on dry eyes, with partners from Moorfields Eye Hospital and Bedford NHS Trust (2016-2020), and the other on myopia, with partners from Queen's University Belfast, Aston University, Glasgow Caledonian University, Ulster University and Moorfields Eye Hospital (2016-ongoing).

**1.3.3** We have **responded to global initiatives through collaborations** with various national and international organizations including Sightsavers, Vision Aid Overseas, International Agency for the Prevention of Blindness (IAPB), International Paralympic Committee (IPC), Royal National Institute of Blind People (RNIB) and England and Wales Cricket Board (ECB). Our collaboration with the European Coalition for Vision led to an invited session at World Sight Day in October 2020.

**1.3.4** We have **responded to national priorities** though our close collaboration with NHS clinicians who form part of our visiting staff, to quickly identify and respond to new NHS initiatives on issues such as dry eye and the effect of environmental stress on patient compliance for glaucoma treatment.

**1.3.5** We have **engaged with industry partners** by capitalising on the expertise of previous KTPs, leading to partnerships with Bausch + Lomb (eye health products), Welch Allyn (diagnostic devices), and SPARCA (medical imaging).

**VERI** has made significant progress towards the **targets that were stated in REF2014:**

1. **Increase our research outputs in key research areas by 100%:** Within this REF period, VERI has produced 210 outputs compared to 76 in REF2014 (276% increase). Publication numbers per FTE increased from 6.7 (REF2014) to 18.8 (REF2021) (280% increase).
2. **Increase our postgraduate research student population by 50%:** VERI has hosted 16 postgraduate research students to successful completion in this REF period, compared to 13.5 students in REF2014 (19% increase).
3. **Increase our strategic partnerships (NHS and industry) by 100%:** This is evidenced by increased satellite clinics as well as new partnerships with the WHO, International Agency for the Prevention of Blindness, plus a number of international partners in Nepal, India, Thailand,

China (see 1.6.1) and Italy. Further partnerships have been developed with the International Paralympic Committee and International Blind Sports Federation for the sports vision work.
4. **Increase our research income by 10% per annum:** In this REF period, VERI was successful in securing £2,093,564 in research income, compared to £973,570 in REF2014 period (**115% increase**).
5. **Increase our research staff base by 50%:** FTE decreased marginally from 11.3 in REF2014 to 11.15 in this REF period. This was due to difficulties in staff recruitment in 2020 caused by Covid-19 and Brexit.

## 1.4 Revision of strategic research objectives during the assessment period

Strategic planning for sustainable, world-leading impactful research programmes has been at the core of the unit's development since before REF2014, and the positive feedback we received in 2014 has encouraged us to hone our strategic approach further. Our key strategic goals are **aligned with our University's Research and Innovation Strategies** (2014-18, 2018-22), addressing four of the eleven priority research areas: healthy ageing, sustainable health care, vision, and medical device & technology.

The expansion of the unit during the REF period has necessitated a reassessment of our strategic objectives, as outlined below. We have successfully implemented our new strategy through the **development and restructuring of research clusters**, through strategic investment in priority areas and staff.

Our strategy also dovetails with and enhances the teaching curricula as it provides students with a **research-driven and research-enriched curriculum**, providing opportunities for them to participate in research linked to these priorities. This is aimed at attracting and developing the next generation of research scientists.

The research and innovation strategy of the unit during the assessment period can be summarised by the following three areas:

### 1.4.1 Increase research capacity in strategic research areas:

Research capacity has been supported from investment in, and development of our research clusters, which are designed to address unmet needs in healthy ageing, sustainable health care, vision, and medical device & technology. During the REF period, two new research clusters (MTRC and HRC) were established, to support the two existing clusters (VERI and BFRG) submitted in REF2014 to UoA3 and UoA5 respectively. Research and innovation activities are led by directors in each cluster, who coordinate and support research from the members, and liaise with other teams to identify areas of mutual interest with potential for collaboration.

We have increased the external income generated and have diversified our external income sources. Our **external income has increased eleven-fold** from £973,570 (REF2014) to £11,097,908 (REF2021) (Figure 1), and includes funding from RCUK/UKRI, EU Horizon 2020, Innovate UK, NIHR, national and international charities (such as Wellcome Trust, British Heart Foundation, Diabetes UK), and commercial enterprises. The **annual average external income per FTE significantly increased** from £17,231 (REF 2014) to £31,147 (REF2021).

University funds including QR income have been targeted towards **pump-priming projects** that are most likely to lead to the generation of impactful research and improving our research capacity and **supporting ECRs**. £332,992 has been distributed to the research groups across the unit to support staff, resources and research costs.

### 1.4.2 Invest in research staff:

A key strategic goal has been the investment in dedicated research staff, including professors and readers. We have an **increased number of staff submitted** in the unit from 11.3 FTE in REF2014 to 50.9 in REF2021 (Figure 1).

**Increasing the ECR population** was a key aim for the REF period. This provided dedicated professionals to drive externally funded research projects while increasing our research capacity and vitality in a sustainable manner. The number of ECRs has increased from 3 (REF2014) to 15 (REF2021) (Figure 1). This strategy has recently been gaining momentum, and has attracted further external research income, including from RCUK/UKRI, commercial sources and charities, as detailed in Section 3.1.

**1.4.3 Increase national and international collaborations:**
Part of our mission of **"***world-leading, novel, interdisciplinary, collaborative, translational research and innovation*" is collaboration; this is particularly important in this unit because of its size and diversity. Collaborations within the unit, across the university and with external partners are always encouraged, supported at all management levels and coordinated through Deputy Deans for Research and Innovation and colleagues in the Research and Innovation Development Office (RIDO – see 3.1 and Institutional Environment Statement [IES] 1.1 and 2.1). Accordingly, several successful collaborations have been established with other universities, private sector bodies, charities, NHS Trusts and NGOs (details in Section 4.2).

**1.4.4 Grow the doctoral student community:**
Developing the next generation of scientists capable of addressing future healthcare problems remains an important part of our unit's role and mission. We have increased the number of research doctoral degrees awarded from 13.5 (REF2014) to 69 (REF2021) (Figure 1). Our support mechanisms for our doctoral students are explained in Section 2.4.

## 1.5 Strategic plans for the next five years

A recent review of the University's research and innovation strategy has led to the emergence of **three new research and innovation themes**: *health, performance and wellbeing*; *sustainable futures*, and *safe and inclusive communities*. This unit will be making significant contributions to all themes while being pivotal to the success and further development of the health, performance and wellbeing theme.

The unit's goals for the next five years are to:
**1) Continue increasing research capacity:** We will aim to support the organic growth of researcher numbers and to improve the staff profile across the unit's four clusters by ensuring that there is an appropriate balance of ECRs and senior researchers. We will support our researchers with dedicated funding, ensuring they have sufficient and appropriate time allocation for research and innovation activities, and opportunities for doctoral student supervision. We will build upon ARU's ECR charter (launched in 2019, see IES 3.9) to support our ECRs.
**2) Continue the growth of national and international collaborations:** We will aim to nurture existing collaborations and build new ones that are in alignment with research and innovation themes and our impact strategy.
**3) Consolidate the growth of doctoral student community:** We will aim to improve the completion times and student experience of our doctoral students across the four clusters within the unit while maintaining the number of completions.

## 1.6 Impact strategy

**1.6.1 For the assessment period:**
Our impact strategy builds on the positive feedback the unit received following REF2014. It prioritises the identification and development of and investment in projects that have the potential to achieve research impact at national and international level.

For the development of new research projects, identification of potential impact has been key, with impact awareness being written into project design. For ongoing research projects, the

approach has been to identify their potential impact with clear pinpointing of end-users and key stakeholders and subsequent allocation of funding and support to target specific problems. This approach has mobilised our research projects to engage with contemporary health care questions.

We have invested QR funding (total £234,296) in this unit to develop the **impact case studies** submitted in REF2021. All five of our impact case studies are embedded in the core strategic aims of our research clusters:

VERI:
**ICS1:** New Policies and Strategies Addressing the Global Burden of Eye Diseases.
**ICS2:** Reducing the Risk of Sight-threatening Diabetic Retinopathy in People of Asian Origin in the UK, Nepal, India, Thailand and China.

HRC:
**ICS4**: Developing Compassion and Compassionate Resilience in Health Care Workers and Family Carers.

BFRG:
**ICS3:** Drug-Facilitated Sexual Assault in Nepal: Enhancing Forensic Capacity and Raising Public Awareness.
**ICS5**: Reducing the Fire Risk from Emollient-Impregnated Fabrics.

The leads of the impact case studies **shared their best practice** with the rest of the institution through *Research Impact Seminars* in 2020.

For more details on our impact-focused stakeholder relationships please see Section 4.1-4.3.

**1.6.2 For the next five years:**
In collaboration with our external partners, we have identified and started to support projects that have the potential to generate impact in the future, such as development of diagnostics for sepsis, development of novel antifibrotic medicines, use of sweet taste receptor agonists in the treatment of acute respiratory distress syndrome, development of assays to detect pathogen-associated molecular patterns, investigation of antibiotic resistance genes in pathogens from bird faeces, and identification of novel biomarkers from fingerprints.

We will develop these over the next assessment period, ultimately benefiting stakeholders including the NHS, specialist companies, healthcare professionals and patients in the UK and worldwide.

## 1.7 Interdisciplinary research

Since our unit is at the intersection of technological advancements in the healthcare and biomedicine sectors, it is not surprising that the majority of the unit's research activities are interdisciplinary, ranging from engineering and pharmaceutical sciences to biomedical, medical and social sciences. Our interdisciplinary work is exemplified in our outputs as well as our collaborations (see Section 4.2).

The unit has taken the following approach to support interdisciplinary research, which **enhanced the vitality and sustainability** of the unit's research environment:

- We encourage staff and research students to actively take part in interdisciplinary projects from inception to delivery (see Section 2),
- We support staff and research students to attend and present at national and international interdisciplinary research meetings (see Section 2),
- We reinvest research funds in infrastructure and facilities to support interdisciplinary research (see Section 3).

For further details on ARU's approach to interdisciplinary research see IES 2.4.

## 1.8 Open research environment

The University is supportive of open access and has an **Open Access Fund** which funds the cost of publication in Open Access journals. The unit actively promotes open research by supporting staff to publish through gold or green open access. Throughout this REF period, a total of 60 publications in this unit have received funding totalling £104,134 from the Open Access Fund. All of our publications are deposited in the **Anglia Ruskin Research Online Repository (ARRO)**. The unit is supportive of the **Concordat on Open Research Data** and where possible makes its **research data is made publicly available** through online open access repository (Figshare). (Further details on open research: IES 2.2).

## 1.9 Reproducibility of research

Our staff and research students in this unit are encouraged to publish **experimental methods** in full detail and use **reporting checklists** such as (but not limited to) CONSORT for clinical trials, PRISMA for systematic reviews and meta-analysis, and ARRIVE for animal studies during the design and reporting of their research. Moreover, some staff have been involved in **developing international guidelines** for the reproducibility of research:

1) *Bustin* led a consortium of scientists that developed "*Minimum Information for Publication of Quantitative Real-Time PCR Experiments (MIQE)"* guidelines in 2009, which aims to guide scientists how to perform qPCR and what forms of data should be collected and published in the process. This allowed editors and reviewers of scientific journals to employ the guidelines when reviewing submitted papers that included qPCR data. The uptake of the MIQE guidelines by the publishers grew over the years including this REF submission period. An update of the guidelines for digital PCR was published in 2020.
2) *Cellek* co-authored *"Guidelines for Protein Detection and PCR"* for the *Journal of Sexual Medicine* (Elsevier) in 2018, which comprises reporting checklists for antibody-based protein detection systems as well as the MIQE Guidelines.
3) *Ilg* co-authored "*Consensus Statement on the Use of the Cavernous Nerve Injury Rodent Model to Study Postradical Prostatectomy Erectile Dysfunction*" in 2020, which aims to guide researchers in the field how to best perform experiments using the rodent cavernous nerve injury model, lays out details of the technique, and highlights possible pitfalls.
4) *Meads* co-authored guidance on conducting evidence reviews (2017) for the What Works for Wellbeing Centre, which was established by the UK Prime Minister in response to the Commission on Wellbeing & Policy in 2014, to continue the implementation of the UK Measuring National Well-being Programme 2010. The guidance was funded by ESRC and aimed at developing a common currency for measuring wellbeing outcomes.

(See also: IES, Section 4.1)

## 1.10 Research integrity

A culture of ethical research with integrity is engrained in the mindset of our researchers in this unit as ARU is a signatory to the ***Concordat to Support Research Integrity*** (IES 2.5). All research active staff in this unit have completed research **ethics and integrity training courses**; all of our research projects have been ethically approved by Faculty Research Ethics Panels and NHS Research Ethics Committees if they involve NHS patients/staff. Staff in this unit (*Allen, Cellek, Claydon, Cole, Coussons, Doherty, Formankiewicz, Gautam, Jones, Knight-Davidson, McVicar, Nisbet, Pugh, Schutte, S Walker, Waugh*) take an active role in reviewing ethics applications in their capacity as members of Faculty Research Ethics Panels. ECRs are particularly encouraged to act as panel members to support their development and training. Furthermore, *Doherty* is one of the co-authors of a *Research Ethics Tool* to aid research during

humanitarian crises, published by Enhancing Learning and Research for Humanitarian Assistance (ELHRA).

Some of the research undertaken in this unit involves **human biological material**; accordingly, such research activities are licenced by the Human Tissue Authority in both campuses. Staff in this unit are co-chair (*Cellek*) or members (*Pugh, Nisbet*) of University and Faculty Human Biological Material Committees where all research involving human biological material is reviewed.

Although we do not undertake animal research on our University premises, some of our **research involving animals** was carried out through external collaborations. All necessary Home Office regulations and/or ethics requirements were met.

## 2. People

### 2.1 Staffing and recruitment strategy

The aim of the unit's staffing strategy is **to grow and develop researchers** who have the expertise, experience and motivation to address contemporary health challenges. Our strategy is aligned with institutional strategy, and commits to "*transform lives through innovative, inclusive and entrepreneurial education and research.*"

This strategy has delivered **a significant increase in the number of staff** alongside corresponding increases in the volume, quality and impact of outputs. 50.9 FTE are included in the current submission (compared to 13.5 FTE in REF2014). We have recruited staff to strengthen our core strategic aims. This significant increase in the number of staff was a result of a key strategic recruitment initiative that took place immediately after REF2014. As a result, 60% of staff returned in REF2021 were recruited between 2014 and the 2020 census date.

The unit provides a **secure and sustainable** research environment to researchers. 19% of the staff in the unit have fixed short-term contracts; at the end of their contracts, they are given the opportunity to become permanent members of staff. The percentage of staff who are ECRs, research fellows, senior lecturers, readers and professors are 26%, 17%, 29%, 9% and 19% respectively. Furthermore, succession plans for senior staff approaching retirement are in place.

The demographic profile of the unit has improved in diversity since REF2014: 36% female in REF2014 vs 47% female in REF2021; and 14% BAME in REF2014 vs 21% BAME in REF2021 (see also 2.6).

### 2.2 Staff Development

The unit implemented the *Concordat to Support the Career Development of Researchers* (IES 3.8) by recruiting and retaining researchers with the highest potential to achieve excellence in research, and by ensuring that our researchers are equipped and supported to be adaptable and flexible in an increasingly diverse, mobile, global research environment. Accordingly, ARU retained the *European Commission HR Excellence in Research Award* in 2015, 2017 and 2019.

One key measure of success in supporting our staff has been the **promotion** of academic researchers in the REF 2021 assessment period. One staff member (*Knight-Davidson*) was promoted from research assistant to research fellow, four (*Francis, Rose, Sapkota, Wilson*) from research fellow to senior research fellow, four (*Jones, Nisbet, O'Kane, C. Walker*) from lecturer to senior lecturer, and four (*Bungay, Gautam, Pugh, S. Walker*) from senior lecturer to reader. Two staff (*Corrigan, Doherty*) were promoted from senior research fellow to senior lecturer, and one (*McVicar*) from reader to professor.

The unit utilises the **Academic Work Balance Model** (AWBM) to ensure that all staff have the opportunity to engage with research activities. All research staff are allocated an experienced **mentor** (IES 2.6, 3.1, 3.9) to provide guidance on scholarly and research activities. All staff undertake a collaborative **annual appraisal** with their line manager (IES 3.3), which incorporates an **individual research report** (IRR). The IRR outlines annual achievements, delivered objectives, reflective learnings, and future action planning. This system not only supports targeted growth in line with personalised research objectives but also enhances and streamlines planned targets in alignment with cluster and unit objectives.

Staff are further supported by **flexible** and **remote working** (IES 3.2) and investment in IT services, which facilitates communication and collaboration between colleagues working in different campuses and remotely. Career pathways for **fixed-term** and **part-time staff** are comparable to those for permanent and full-time staff (IES 3.6).

Staff in the unit are encouraged to engage with **student internship programmes**, which provide researchers with assistance to generate data and pump-prime projects, but primarily support undergraduates with valuable training and research experience. 21 supervisors in this unit engaged with internships over the REF period, recruiting 48 students, which resulted in 6 publications. Some of the student internships were funded by the Wellcome Trust and Royal Society of Chemistry.

The unit provides short **writing retreats** (IES 3.1) and **research awaydays**, in which staff and research students are given days on campus or week-long retreats off campus to prepare bids or outputs, or to generate collaborations. 18 staff in this unit benefitted from 35 writing retreats in this REF period, resulting in the generation of 24 outputs and 1 funding bid.

Staff are supported by the **University Sabbatical Scheme** (IES 3.1), which relieves academics of teaching responsibilities in order to support research activities. This competitively awarded sabbatical scheme provides staff with dedicated research time to support the generation of outputs or the initiation of new research projects and collaborations. It also supports completions for staff working towards a doctorate. In the REF period, ten staff in this unit have taken advantage of the sabbatical scheme, two of them to support doctorate completions. These sabbaticals led to ten publications and several funding applications. *Gautam* used her sabbatical period to support work on her impact case study on drug-facilitated sexual assault (1.6.1). *Chichger* spent her sabbatical period at Brown University, USA, and produced four joint publications.

We facilitate exchanges between the unit and business, industry, public and third sector bodies through a number of different routes, including honorary positions, voluntary positions and events. The unit has been supported by one **emeritus professor** and 23 **visiting honorary professors**, most of whom are based at local NHS Trusts. These links not only build strategic connections and support our research funding bids, but also enrich the postgraduate research students' journey in ARU. The staff in this unit **volunteered their time in advisory groups** of public and third sector bodies particularly in the NHS, Public Health England and Health Education England, as detailed under Indicators of Recognition and Esteem (section 4.4). We also **hosted events** that involved business and industry (sections 4.2 and 4.3).

## 2.3 Early Career Researchers

We place particular importance on recruiting and supporting early career researchers (ECRs). Since 2014, the number of ECRs in this unit has increased from 3 to 15, again in response to the significant investment by the University and through external funding. Some of the current ECRs were previous ARU research students (*Ahmed, Beukes, Ilg, Karamasis*), demonstrating our commitment to nurture, retain and develop our own talent.

We support ECRs through engagement with the ***ARU ECR Charter*** (2019), which ensures that all ECRs have appropriate time allocated to research on their work balance models, providing concentrated periods of time to research activities. ECRs are allocated **£2,000 each** to support their research and are provided with an appropriate **mentor** to assist with their CPD needs during their time as an ECR. All ECRs are aligned to one of our four research clusters, where they receive **peer support** with outputs and grants. ECRs are regularly invited to review research papers and grants, with feedback provided by senior staff. Other benefits for ECRs include invitations to **internal research sandpits**, and **inclusion on doctorate supervisory teams**. ECRs are successfully integrated into our research culture, benefitting from access to QR funds, support and training for grant preparation, statistics, research methods, knowledge transfer and intellectual property through the **Researcher Development Programme** (IES 3.8).

We further facilitate the **academic career development** of our ECRs by providing them with opportunities to develop their teaching profiles with the opportunity to gain their PGCert and fellowship of the Higher Education Academy. Such initiatives have helped our ECRs to gain the skill sets they need to obtain substantial academic posts also enriched our teaching curriculum. 18 staff (24%) in this unit hold PGCert and 32 (55%) are fellows or senior fellows of HEA.

As a result of our unit's support, our ECRs have made exemplary **career progress to substantial academic posts.** Previous research fellows now hold lectureship positions in other parts of ARU (*Garcia-Porta, O'Mahoney*) or in other HEIs (*Hoque-Tania* to University of Oxford, *Liu* to Coventry University, *Nakafero* to University of Nottingham, *Taylor* and *Lopes Pires* to Imperial College London). One career progression story of particular note is that of *Allen,* who undertook his PhD in at ARU in 2004, worked as an ECR and subsequently achieved promotion to a professorship in 2014. Other notable successes are those of *Gautam* and *Price,* who obtained their PhDs at ARU in 2006 and 2010 and were promoted to senior lecturer positions in 2019 and 2012, respectively. (See also IES, 3.3).

## 2.4 Research Students

Developing the next generation of scientists capable of addressing future healthcare problems remains an important part of our unit's role. We had 109 **Postgraduate Research** (PGR) students in this unit as of the census date, of whom 39 were part-time students. We have increased the **number of research doctoral degrees** awarded from 13.5 in REF2014 to 69 in this cycle. **Notable destinations** of some of our PGR students after leaving ARU are other HEIs in the UK (such as Bath, Bournemouth, Cambridge, Leicester, London, Manchester, Oxford, Sheffield, Warwick), and abroad (Australia, Bangladesh, Botswana, China, France, Hong Kong, India, Malaysia, Nigeria, USA), the private sector (Charles River, UK; A-TEK Inc, USA; Gamma Delta Therapeutics, UK) and NHS Trusts (Cambridge, London, Nottingham, Sheffield).

University strategies, including the centrally funded **Vice Chancellor's Studentship Programme** have played a part in increasing the PGR population. This programme aims to recruit high calibre candidates to specific research projects, some of which are externally funded. Recruitment rounds are run annually, based on a competitive and rigorous selection process. The stipend and fees of successful students are covered by University central funds. 5 out of 69 doctorate completions in this REF period were supported by the VC's Studentship Programme.

We have also successfully recruited PGR students who are partly or fully **funded externally** by institutes such as the Sanger Genome Centre, Babraham Institute, GlaxoSmithKline and charities such as the European Society for Sexual Medicine and Peterborough Burns Unit Appeal Fund. All of our twelve MD (research) students at the census date are clinicians who are **funded**, and their projects are **sponsored by NHS Trusts** such as Basildon & Thurrock University Hospital Trust, Mid Essex Hospital Trust and Southend University Hospital Foundation Trust.

PGR student development is supported by the **ARU Doctoral School** (IES 3.10), which provides supportive educational and training programmes to all PGR students across the University. These programmes comprise several mandatory training elements (welcome and induction, writing, presentation, thesis preparation and viva) that are spread evenly throughout the PGR student journey. Moreover, the Doctoral School offers further optional training programmes such as statistics, research methodology, leadership skills, entrepreneurship, career development and public engagement. Our PGR students in this unit take advantage of these training programmes, and our unit staff make a significant contribution to the delivery of the programmes content.

The progression of our PGR students is **closely monitored** through several milestones in their journeys such as project proposal, research ethics application, annual review, upgrade of registration and mock viva. At each milestone, their progress is assessed by at least two examiners who are independent of the supervisory team. Our unit staff take an active part in these milestones as supervisors, examiners and chairs.

Our PGR students are allocated at least two **supervisors,** one of whom is always a member of staff. Most of our PGR students, particularly those on the MD(Res) programme, have an external clinical supervisor. All supervisors attend the mandatory supervisor training programme and are offered further career development opportunities through the training opportunities delivered via our Researcher Development Programme.

Our PGR students are offered opportunities to **present their work** and **form new networks** at Departmental Research Seminars, the Annual Faculty Research Conference and the Annual Research Student Conference, where the best presentations are rewarded. The Faculties also support the presentation of PGR student work at national and international meetings by utilising Faculty research funding schemes. Some of our PGR students in this unit have presented their work at national and international meetings in the UK, Australia, Canada, China, Denmark, France, Greece, India, Italy, Netherlands, Poland, Portugal, Slovenia, Sweden, Switzerland and USA.

We provide PGR students with open plan **office space and social spaces**, including PGR lounges, where PGR students from different subjects can meet and discuss ideas. The **laboratory spaces** provided for postgraduate research students are further described in Section 3.3.

## 2.5 Clinical academics

Five of our unit staff are clinical academics and have part-time clinical contracts with the NHS (*Bourne*, *Frame, Karamasis, Keeble*) or Royal Air Force (*Almond*). They are effectively integrated into HRC (*Almond, Frame, Karamasis, Keeble*) and VERI (*Bourne*) by taking part in and leading joint grant applications, impact case studies, supervision of research students and training of researchers and research students, while playing an essential part in maintaining our links with the NHS partners. Part of the pay costs of the clinical academics are supported by QR funds.

## 2.6 Equality and Diversity

ARU actively promotes **equality, diversity and inclusivity** (IES 3.11) in its research activities, providing a supportive environment where everyone is treated with courtesy, dignity and respect. Of our research-active staff, 47% are female and 21% BAME.

All researchers undertake a mandatory training programme covering all aspects of diversity including gender, race/ethnicity, disability, sexuality, religion/belief, age, and the other

characteristics given protection by the Equality Act 2010. Institutional membership of **Athena SWAN** was granted in 2012, and our Institutional Bronze Award in 2015 (renewed 2018) was enhanced by FSE's Bronze Awards in 2019; the other two Faculties represented in this submission (FHEMS and FBL) are currently working towards bronze awards. *Chichger*, *Cole*, *Latham*, *MacKinnon, Meads, Parris*, *Schutte* and *Walker* from this unit have contributed to Athena SWAN Working Groups.

We have embedded the university's equality and diversity guidelines into our unit, promoting **flexible and part time working**. We support staff who wish to utilise the University's Flexible Working Policy, which has options for condensed hours and frequent homeworking. A number of staff in this unit have benefited from this scheme, with options such as home and flexible working being embedded in their contracts.

We support research-active staff returning from **maternity leave** with up to £4,000 in internal grant funding to re-establish their research. This was taken up by one member of staff during this REF cycle.

Staff are further supported by **inclusivity networks** such as the Women's Network, Part-time and Flexible Working Staff Forum, Aurora (leadership development initiative for women), Diversifying Leadership Programme, BME Network, LGBTQ+ Network and Disabled Staff Network, which aim to support staff and share good practice. *Price* co-chaired the Part-Time and Flexible Working Forum, and *Meads* is the chair of the LGBTQ+ Network. Several staff from this unit have attended these programmes.

ARU is committed to supporting staff with **disability** and helping colleagues to progress regardless of disability. We offer a Job Interview Guarantee Scheme for disabled applicants who meet the essential criteria for an advertised role. We are committed to promoting disability awareness in the workplace as evidenced by our accreditation as a *Disability Confident Employer*.

Furthermore, *Gautam, MacKinnon* and *Nisbet* were given two awards from the **Royal Society of Chemistry Inclusion and Diversity Fund** to investigate 1) the enablers and barriers to access and participation of black chemists in higher education and workplace environments; and 2) the effect of pre-university chemistry education on engagement, to identify the barriers to inclusivity. *Pardhan* has contributed two invited editorials on vision scientists breaking the glass ceiling to **Ophthalmic & Physiological Optics** and has delivered invited keynote talks on **Women in Vision** and **Women in Leadership** at local and international conferences.

**2.7 Health, safety and wellbeing**

We take **health and safety** of our staff and PGR students extremely seriously. All of our staff and PGR students who work in research laboratories are regularly trained in protection from biological and chemical hazards. Their health is regularly monitored by Occupational Health through University Health Surveillance Policy. Any research work that will utilise biological or chemical hazardous material is reviewed and monitored through well-established health and safety risk management systems. ARU holds an ISO 14001 certificate for effective environmental management systems and the Royal Society for the Prevention of Accidents (RoSPA) Gold Award for excellence in health and safety.

Ensuring staff and student **wellbeing** is a priority within the unit, and we are supported by the Institution with regards to information, support, initiatives and helplines for staff and students (IES 3.7).

We place great importance on our staff and students' **mental health** as demonstrated by our pledges to the *Mindful Employer Scheme,* committing to support people with mental health problems in the workplace; the *Time to Change Scheme,* helping to change the way we all think

and act about mental health; and our membership of Inclusive Employers, who work with us on building our inclusive culture.

We support our staff through the *Employee Assistance Programme,* which is a confidential employee benefit designed to help staff deal with personal and professional problems that could be affecting their home or work life, health and general wellbeing. The programme offers a 24/7 helpline available 365 days a year.

Our staff are further supported by **Workplace Health & Wellbeing Champions** and **Mental Health First Aiders**, who are trained volunteers from across the university and play a vital role in promoting healthy lifestyles and encouraging positive mental health in and outside of the workplace.

**3. Income, infrastructure and facilities**

**3.1 Income**

During this REF period, the research and innovation activities within this unit have attracted £11,097,908 from external sources, an **eleven-fold increase** compared to the research income in REF2014. This amount comprised funding from the EU (33%), NHS and NIHR (28.5%), industry (17.3%), charities (11.5%), UK research councils (2.6%) and others (7.2%), demonstrating **the international and translational nature** of the research and innovation activities undertaken by this unit.

Research and innovation activities in this unit have been further supported by allocations from **QR funding**; we have allocated £334k from the University's QR funding to support research fellows, PGR students, dissemination activities, seed funding, impact development, and the purchase of equipment and consumables.

Furthermore, the unit has been supported by the **University's central budget** to a total of £2.6m within this REF period to support the staffing of VERI and MTRC.

**3.2 Infrastructure**

Staff and research students in this unit receive a significant amount of support from the **Research and Innovation Development Office (RIDO**, IES 1.1, 2.1), which supports research and innovation activities across the University. RIDO provides support on research funding management, partnership development, research data management, research ethics and integrity, commercialisation, intellectual property, project management and researcher development. Every Faculty is supported by at least one Research and Innovation Funding Manager and Partnership Development Manager based in RIDO. Since this unit is formed of staff from three Faculties, the coordination and synchronisation of these managers are undertaken by Deputy Directors of RIDO and the Research and Innovation Leadership Team. These managers are further supported by each Faculty's finance teams. This coherent and coordinated way of working has resulted in a 14% average **increase in successful funding applications** for this unit in the 2019-2020 financial year, compared to the previous year.

The research and innovation activities in this unit are further supported by the **RIDO Commercialisation Officer** and the **University Legal Team** who collectively ensure that intellectual property created by the unit's work is appropriately protected. This includes financial support for patenting costs and a generous revenue sharing policy. In this REF period, two patent applications (*Cellek, Chichger*) from this unit have been supported. Furthermore, the ARU Innovation Centre (see 4.3.1) and ARU Biometrics (4.3.9) have been supported by these mechanisms.

Clinical research activities in this unit are supported by the **ARU Clinical Trials Unit (CTU),** which gives support in clinical trial design and coordination, project and data management, costing and budget management, site management, trial oversight, randomisation, data analysis and reporting. During this REF period, CTU supported 14 projects for this unit, worth £466,923 in total.

**3.3 Facilities**

Significant investment by the University has **increased dedicated research space** from 344m$^2$ to 1,555 m$^2$ during this REF period.

The £45M **Science Centre** on the Cambridge campus (completed in 2018) is home to 410 m$^2$ of dedicated research space with cutting edge research facilities. This includes containment level 2 (CL2) research space for over 50 researchers, with dedicated cell culture and microbiology laboratories, venepuncture room, microscopy suite, clean DNA/RNA preparation room, GC-MS suite, chemical storeroom, cold room, dark room and large equipment room. The centre is equipped with a confocal microscope, HPLC systems, gas/liquid chromatography mass spectrometry, flow cytometry systems, spectrophotometers, PCR/qPCR equipment and freezers. Further research laboratories in the **David Building** (209 m$^2$) on the same campus provide CL2 space for this unit for microbiology, chemistry and forensic analytical equipment.

State-of-the-art laboratories and clinical areas (190 m$^2$) which were opened in our **Young Street** building in December 2014 support research in **VERI**. Facilities include: (i) the *Low-Vision Suite* featuring a new Vicon mobility analysis system to examine the impact of low vision on everyday tasks such as step ascent and obstacle crossing; (ii) the *Diagnostic Suite* which includes anterior and posterior OCTs, microperimeter, fundus camera, and wide-field specular photomicroscope; (iii) an *Anterior Eye Research Suite*, incorporating a room-sized environmental chamber which allows independent manipulation of temperature, wind speed and humidity; wavefront sensor, IOL Master and a power refractor; (iv) the *Psychophysics Suite* with Cambridge Research Systems Visage and SR Research EyeLink 1000 eye tracker. Vision and eye research in this unit is further supported by the **University Eye Clinic Labs** on the same campus, which are also utilised as research space (33 m$^2$; opened in 2014) and include relevant equipment for low vision, colour vision and electrophysiology.

The **Medical Technology Research Centre** has three research laboratory spaces: i) **Molecular and Cell Biology Laboratory** (135 m$^2$; opened in 2009) comprising CL2 laboratory equipped with cell culture suite, microscopy suite, PCR/qPCR equipment, FACS, protein detection equipment, automated liquid handling machine for drug screening and cryostat; ii) **Medical Technology Research Laboratory** (36 m$^2$; opened in 2018), which comprises small device fabrication area and human volunteer testing area; iii) **Pharmaceutical Research Laboratory** (131 m$^2$; opened in 2016), comprising a chemical analytical laboratory and cell culture suite equipped with high performance liquid chromatography (HPLC), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), advanced rheometer, micro viscometer, rotary evaporator, freeze-dryer, UV double beam spectrometer, Zeta sizer, FT-IR spectrometer, high pressure homogeniser, breathing simulator, next generation impactor and spray droplet measurement system.

The researchers and PGR students are further supported by the Chelmsford **SuperLab** (411 m$^2$; opened in 2015) which is used for teaching, training and research. It comprises a human physiology suite and CL2 laboratories which are equipped with spectrophotometers, microscopes and a tableting machine, a fat extraction unit, imaging systems, rotary evaporators, and a stability chamber.

All staff and lab-based PGR students have **desk space** within easy reach of their labs and are further supported with refreshment areas, cafes, kitchenettes, social interaction areas and meeting rooms. Non-lab-based PGR students also have access to dedicated **PGR Rooms**,

which are open plan offices that are dedicated to only PGR students and equipped with desktop computers and teleconference facilities.

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

Part of this unit's mission is **collaboration,** which is particularly important in this unit because of its size and diversity. Collaborations within the unit, across the university and with external partners are always encouraged, supported at all management levels and coordinated through Deputy Deans for Research and Innovation and colleagues in RIDO.

**4.1 Intra-unit and inter-unit collaborations**

Interaction and collaboration between different research groups has been successful and ongoing and is evidenced through joint research papers and projects. The clusters are encouraged to undertake inter-disciplinary and collaborative research activities not only among each other but also with other clusters in the University. This has been facilitated through Sandpits and Interdisciplinary Research Conferences organised either by Faculties or RIDO.

Some notable examples of collaborations by the researchers within this unit and across the University are:

1. **VERI** researchers have actively participated in collaborative and inter-disciplinary research and innovation activities with colleagues from other clusters in this unit (BFRG; *Chichger*) and other parts of the University such as computing sciences, human movement sciences, psychology and sports sciences, as detailed in Section 1.2.
2. **MTRC** and **BFRG** jointly organised three annual **ARU Biomedical Research Conferences** between 2016 and 2019, which were open to external attendees. From these interactions, one successful funding bid (*Ilg, Dyer, Cellek*; ESSM €30,000) arose.
3. A collaboration between *Meads* and colleagues in **UoA4** and **UoA17** on preparing for later life, secured funding from the Centre of Ageing Better (£47k) and resulted in a publication.
4. A collaboration between *Bungay* and colleagues in ***UoA20*** on arts in therapeutic interventions secured funding from AHRC (£23,750).
5. A collaboration between *McVicar* and colleagues in ***UoA20*** on citizen research groups resulted in further collaborations with Age UK and Essex County Council, and a successful funding bid to the National Lottery Grant scheme.

**4.2 External collaborations**

The research and innovation activities of the clusters have involved **external** organisations in both the public and private sectors such as local councils, charities, NHS Trusts, commercial companies, and academics in the UK and abroad, supported through the involvement of RIDO-based Partnership Development Managers (IES, Section 4). Within this REF period, researchers in this unit established collaborations with academics and clinicians at **41 other HEIs** in the UK, HEIs in **31 other countries, 14 NHS Trusts,** and a wealth of other external organisations**.**

Some notable examples of such collaborations include (full list could not be shown due to space limitations):

1. In partnership with the **World Health Organisation (WHO)**, **VERI** (*Bourne*) has initiated and led a worldwide consortium (Vision Loss Expert Group; VLEG) of more than 100 ophthalmic epidemiologists to ascertain the global burden of visual impairment and blindness. The work has been published in 13 papers in The Lancet and has led to the formation of the UK National Eye-Health and Hearing Survey (UKNEHS). This work forms the basis of our first impact case study (1.6.1)
2. **VERI's** research (*Pardhan*, *Sapkota*) on diabetic retinopathy was conducted through collaborations with academics and clinicians at the **University of Cambridge** and in

**China, Hong Kong, India, Nepal,** and **USA.** The work attracted £200k in funding and resulted in 18 publications; it forms the basis of our second impact case study (1.6.1).

3. *Gautam*'s research on drug-facilitated sexual assault, which is featured in our third impact case study (1.6.1), involved collaborations with academics and clinicians in **Botswana, India, Nepal,** and the **UK** and resulted in six publications.
4. *McVicar* and *Wilson* collaborated with the **Mid-South Essex NHS Trust** and **Cambridge NHS Trust** on reducing physical restraint in mental health patients, which was funded by NIHR and led to the development of our fourth impact case study (1.6.1).
5. *Hall*'s research on the flammability of skin creams/emollients involved collaboration with the **West Yorkshire Fire and Rescue Service**, **London Fire Brigade** and **Essex Fire and Rescue Service.** It won FIRE Magazine's ***Collaboration of the Year Award*** in 2019 and formed the basis of our fifth impact case study (1.6.1).
6. Collaborations between *Cole* and academics in **Botswana, Poland, South Africa** and **Forensic Science Services in South Africa** and **Botswana** on forensic science, drug analysis and public health resulted in eight publications.
7. Support Monitoring and Reminder Technology for Mild Dementia (SMART4MD) was an EU Horizon 2020-funded project (€3M) led by ARU (*Cellek, Zhang*) and supported by the **ARU Clinical Trials Unit.** It comprised eight international partners in **Belgium, Czech Republic, Israel, Spain**, and **Sweden**, and aimed to develop a global health management platform to empower people living with dementia and support their carers. It resulted in two publications and a prototype app which is being further developed.
8. *Knight-Davidson, Rose* and *Sanchez-Vasquez* are part of an international consortium with partners from the **UK**, **Belgium, France** and **Netherlands** in the SEAS2 Grow project funded by European Regional Development Fund (€3.2M), which aims to develop a proactive silver economy ecosystem (focused on the over-60s) in the EU.
9. A collaboration between *Meads* and **Brunel University** on wellbeing in culture and sport resulted in joint funding from ESRC (£1.2M) and five joint publications.
10. Collaborations between *Meads*, **Public Health England**, the **University of Leeds** and the **University of Cambridge** on evidence synthesis about NHS Health Checks attracted funding from PHE (£75k) and produced four joint publications.
11. Collaborations between *Karamasis, Keeble*, and clinicians at **Imperial College London**, in the **Netherlands** and **Sweden,** with private sector funds from **Abbott Vascular**, **Zoll Corporation**, **Philips Volcano** and **Astra Zeneca,** focused on the clinical management of coronary disease and cardiac arrest. The work led to 35 publications, the completion of four PGR students and £720k in funding.
12. COM-GAP-S (Integrating mental health into primary care for post-conflict populations in Northern Sri Lanka) was a collaborative project between ARU (*Doherty*), **London School of Hygiene and Tropical Medicine**, **King's College London** and partners in **Sri Lanka** aiming to reduce the treatment gap for conflict-affected populations with mental disorders. It was funded by Centers for Disease Control and Prevention (USA) ($752k) and produced three publications.
13. Post-Research Ethics Analysis (PREA) is a research project investigating ethical issues in health research in humanitarian crises and comprised partners at ARU (*Doherty*)**, Dublin City University, University of Sydney and London School of Hygiene and Tropical Medicine.** It was funded (£417k) by ELHRA and produced two publications.
14. A collaboration between **MTRC** (*Cellek, Ilg*), clinicians from **University College London, Broomfield Hospital Burns Unit** and academics from **Belgium** on the discovery of novel medicines for fibrotic diseases through phenotypic screening attracted funding from charities totalling £120k. It produced one patent, four publications and two PhD completions.
15. A project investigating the optimal method for measuring visual fields in people with low vision involved a collaboration between *Latham,* clinicians from **Moorfields Eye Hospital** and academics from the **University of Hertfordshire**. The project was funded by the College of Optometrists (£60k) and resulted in two publications and one PhD completion.
16. Collaboration between *Allen, Beukes* and academics from the **University of Nottingham, Sweden** and the **USA** focussed on developing an internet-based intervention for tinnitus

and attracted funding from the British Society of Audiology (£5k). It resulted in ten publications and one PhD completion.

17. *Allen* has been working with the **International Paralympic Committee** (IPC) and colleagues from **Vrije Universiteit Amsterdam** to develop evidence-based, sport-specific classification systems for athletes with a vision impairment. The project attracted funding (£33k) from the Agitos Foundation, IPC and College of Optometrists and resulted in six publications and a new classification system approved by the IPC in 2019.
18. Collaborations between *Chichger* and academics at the **University of Cambridge, University College London and Brown University** (USA) on vascular biology attracted £217k in funding and resulted in one patent application and three PhD completions. It produced 14 publications.
19. Collaborations between *Pugh* and academics at the **Universities of Cambridge, Leicester, and Reading,** as well as researchers in **Germany** on platelet biology attracted £392k in funding and produced 12 publications.
20. Collaborations between *Najlah* and academics at the **Universities of Wolverhampton, Lincoln** and **Qatar** on nanoencapsulation of drugs attracted $700k in funding from the Qatar Research Fund and produced three publications.

## 4.3 Commercial activities

In alignment with our University Research and Innovation Strategy (IES Section 1) to "*build and develop stronger and more productive relationships with collaborators and stakeholders, including industry, public sector and businesses in areas linked to our research strengths*", this unit has taken a proactive approach to initiating, developing and nurturing relationships with industry.

Some notable examples of interactions by researchers in this unit with the **private sector** are:

1. *Parris* and *Pugh* have led the University's **Innovation Centre** plans since 2019. The Centre aims to drive the growth of the life sciences sector in the city of Cambridge through innovative, inclusive and entrepreneurial activity, working closely with the city's thriving business sector. It is envisaged that 15 life science companies will be given business-laboratory space which will create collaborative academic research projects, joint grant funding applications, contract research projects and student employment opportunities such as internships, work placement and graduate jobs.
2. *Bourne* has been responsible for setting up and co-ordinating the **US Global Ophthalmology Network**, which received £63k in funding from the **NIHR**, and has worked with **Santen Pharmaceuticals** on uveitis trials which attracted funding of £479k.
3. Working with **VOPTICA**, *Pardhan* worked on validating new techniques for anterior eye measurement, funded by a Horizon 2020 SME partnership grant.
4. *Cellek* has collaborated with **GlaxoSmithKline** on the effect of microenvironment on endotoxin tolerance, which resulted in a doctoral completion.
5. *Parris* established a collaboration with **Hydrophis Gas Ltd** (£339k) for the development of a carbon capture device for marine environments.
6. *Parris* established collaborations with **Advanced Oncotherapy** and **MedAnnex** on cancer biology that resulted in £450k in funding.
7. *Bustin* established collaborations with **Olm Diagnostics**, **Optisense**, **Applied Biosystems, PCRMax/Techne, Nanostring, Thermofisher** and **Agilent** for the development of novel PCR platforms for research and diagnostic purposes. These collaborations resulted in twelve publications and four new CE-marked diagnostic kits.
8. Collaborations between *Najlah, Arafat* and **Lipolife, Detox People** and **GMPharma** on the nanoencapsulation of drugs attracted £300k in funding.
9. **BFRG** (*Nisbet, Pugh, Chichger, Dyer, Parris, Pirianov*) established an independently branded commercial arm, known as '***Anglia Biometrics***' within ARU research facilities in 2019, providing consultancy opportunities, expertise, and service.

## 4.4 Other contributions to the research base and indicators of recognition and esteem

Staff in this unit made significant contributions to the research base during this REF period in the following ways:

### *4.4.1 Editorial:*

*Bourne* has been a **section editor** (since 2016) and an **associate editor** (since of May 2020) of Eye (the journal of Royal College of Ophthalmologists)*; Bustin* was **editor-in-chief** of Biomolecular Detection and Quantification between 2014 and 2020 and is currently **editor-in-chief** of the International Journal of Molecular Sciences (since 2010); *Cellek* has been an **associate editor** for the Journal of Sexual Medicine since 2017; *Meads* was **deputy editor** for the International Journal of Technology Assessment in Healthcare between 2013 and 2019; *Zhang* has been **statistical adviser** to Developmental Medicine & Child Neurology since 2017.

The staff in this unit have been **editorial board members** of Aesthetic Surgery Journal; American Journal of Physiology; Biomarkers in Medicine; BMC Molecular Biology; British Journal of Nursing; Cambridge Scholars Publishing; Clinical Medicine; Drug Delivery Letters; Experimental Physiology; Eye; Forensic, Legal and Investigative Sciences; Gene Regulation and Systems Biology; International Glaucoma Review; Journal of Intellectual Disability - Diagnosis and Treatment; International Journal of Stress Management; International Journal of Technology Assessment in Healthcare; Journal of Forensic Chemistry and Toxicology; Journal of Personalised Medicine; Journal of Sexual Medicine; Materials Science in Semiconductor Processing; Molecules; Nutrients; Ophthalmic and Physiological Optics; Physiology News; PLOS One; Problems of Forensic Sciences; Public Health Journal; Sociology of Health and Illness; Scientific Reports.

### *4.4.2 Invited keynote lectures:*

Unit staff have been invited to give keynote lectures at national and international research conferences in the **UK, Australia, Austria, Belgium, China, Denmark, Finland, France, Germany, India, Indonesia, Iraq, Italy, Malaysia, Malta, Nepal, Netherlands, New Zealand, North Korea, Poland, Portugal, Singapore, Slovenia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Thailand** and the **USA**.

### *4.4.3 Advisory committee memberships:*

Staff have sat on, or chaired, the following councils, committees and similar bodies:

- *Allen* (member of Council as well as Research and Education Committees at College of Optometrists)
- *Bourne* (National Specialty Lead for NIHR; Chair of the Early Detection of Neovascular Age-related Macular Degeneration [EDNA] Steering Committee; technical advisor to WHO; member of the Advisory Board, Retina Global)
- *Bungay* (member of Arts & Wellbeing Group at the Royal Society of Public Health)
- *Bustin* (member of Scientific Board, TATAA Biocentre, Gothenburg, Sweden; scientific advisor to Momentum Biotechnology; member of Programme Expert Group in Chemical and Biological Metrology Programme, LGC and BEIS; member of Scientific Advisory Board Pentabase, Copenhagen, Denmark)
- *Cellek* (Grants Committee Chairman and Executive Committee Member of European Society for Sexual Medicine)
- *Chichger* (member of Covid-19 review panel for lung research related to infection since July 2020; member of diabetes research steering group for Diabetes UK since June 2020)
- *Frame* (president of UK Association of Aesthetic and Plastic Surgeons, national representative for International Society of Aesthetic Plastic Surgery; member of organising committee of Annual Conference UK Association of Plastic Surgeons)
- *Gautam* (UK representative on the UNESCO Associated Schools Cooperation Council, Nepal)

- *Ilg* (member of Basic Science Committee of European Society for Sexual Medicine)
- *Knight-Davidson* (member of Social Isolation Forum at Essex County Council)
- *Latham* (Executive Secretary of European Society for Low Vision Research and Rehabilitation)
- *MacKinnon* (founding member of Physiological and Psychological Acoustics Special Interests Group - Engineering and Physical Sciences Research Council)
- *McLachlan* (founding member of Helicopter Emergency Medical Service Regional Research Group for the East of England)
- *McVicar* (associate member of International Consortium for Occupation Resilience (ICOR), Central Queens University, Australia)
- *Meads* (member of East of England Public Health Research and Evaluation Hub Steering Group, member of LGBT Advisory Panel in UK Government Equalities Office, member of Reproductive Health Expert Reference Group in Public Health England, member of ESRC-funded Wellbeing Methods Group)
- *Norgett* (member of Examination and Editing & Writing Committees of College of Optometrists).

***4.4.4 Grant review panel memberships:***

*Bourne* (Fight for Sight; Wellcome Trust); *Bungay* (Arts and Humanities Research Council); *Bustin* (BBSRC, MRC); *Cellek* (EU Horizon 2020); *Chichger* (American Heart Association; Physiological Society); *Cole* (Engineering and Physical Sciences Research Council); *Keeble*, *Pugh* (British Heart Foundation); *Hooks*, *McVicar*, *Wilson, Zhang* (NIHR); *Parris* (BBSRC; Breast Cancer Now); *Kolarik* (Italian Ministry of Education).

***4.4.5 Fellowships, prizes and awards:***

The excellence of our research was recognized through the following fellowships, prizes and awards for individual staff members:

- *Allen* (fellow of European Academy of Optometry and Optics since 2019; fellow of American Academy of Optometry since 2018; fellow of College of Optometrists since 2013; Shapiro Prize from British Tinnitus Association in 2017, 2018, 2019)
- *Beukes* (Halpike Prize from British Association of Audiovestibular Physicians 2019; Shapiro Prize from British Academy of Audiology 2017, 2018, 2019)
- *Bourne* (fellow of Royal College of Ophthalmologists; Vision Excellence Award from IAPB 2020)
- *Cellek* (fellow of British Pharmacological Society since 2017)
- *Cole* (fellow of Royal Society of Chemistry since 2018)
- *Frame* (member of Royal Colleges of Surgeons London & Edinburgh)
- *Gautam* (award from UNESCO Schools Cooperation Council)
- *Latham* (Neil Charman Medal for outstanding research by College of Optometrists 2017; fellow of College of Optometrists since 2013)
- *Meads* (David Harvey Award from GLADD [LGBT Association of Doctors and Dentists] 2018)
- *Najlah* (fellow of Royal Society of Chemistry since 2019)
- *Nisbet* (Experimental Design and Impact on Toxicology (EDIT) Award from Society of Forensic Toxicology 2018; Education Research Award from Society of Forensic Toxicology 2016; Student Scholarship Award from Forensic Science Foundation 2016; Excellence in Solid Phase Extraction Award from United Chemical Technologies 2014)
- *Norgett* (fellow of College of Optometrists since 2014)
- *Pardhan* (listed on Ophthalmologist's Powerlist as Champion of Change 2019)
- *Waugh* (fellow of American Academy of Optometry since 1994)
- *Bungay* and *Wilson* (Outstanding Achievement Award at You Make a Difference Awards from Essex County Council 2019).

***4.4.6 Expert witness:***

*Bustin* served as an expert witness in two cases in Court of Appeal in New Zealand (2014-2015) and Swiss Patent Office (2014-2017).

## 4.5 Dissemination of research

Unit staff hosted the following research conferences:

- International Symposium & Imaging Workshop on Giant Cell Arteritis, Polymyalgia Rheumatica and Large Vessel Vasculitis (2016, Southend)
- Heads of University Centres of Biomedical Sciences Conference (2017, ARU)
- Innovate UK, East of England Conference (2019, ARU)
- Cambridge New Therapeutics Forum (2019, ARU)
- Zinc Net (2019, ARU)

Staff also took active roles in organising University and Faculty annual research conferences and disseminated their research through publications and presentations at national and international meetings.

## 4.6 Public engagement: media and community level

The staff in this unit and their research have featured in 2,905 **news pieces,** 145 of which were printed by local and national newspapers. 1,509 pieces were featured in online news outlets and 441 in television and radio broadcasts.

Unit staff have also taken active roles in engaging with **local primary and secondary schools,** where either the staff visited the schools to give lectures about science, or the schoolchildren were invited to visit our research facilities. *Gautam* was awarded £2k from the Royal Society of Chemistry in 2017 for a school engagement project entitled "*Applying Chemistry to Solve Crimes*".

The unit staff have taken part in the annual **Cambridge Science Festival** since 2015 and were part of the first **Chelmsford Science Festival** in 2019. The research in the unit has featured in **University's publications** such as *Research & Innovation Highlights* and *Connect,* which aims to engage with the public and alumni. ARU has agreed to host the next **British Science Festival** on the Chelmsford campus in 2021 (originally scheduled for 2020, but postponed due to Covid-19), a project with which our unit staff will be fully engaged.