

Institution: University of Lincoln
Unit of Assessment: UoA3 Allied Health Professions, Dentistry, Nursing and Pharmacy
<p>1. Unit context and structure, research and impact strategy</p> <p>1.1 Context and structure</p> <p>Allied Health Professions research from the Schools of Health and Social Care, Life Sciences and Pharmacy, has seen a 68 percent FTE growth to 32.8 FTE reflecting the institution's strategic plan commitment articulated in, Thinking Ahead 2016-2021, "to create purposeful research on the key challenges facing the world, working collaboratively with partners to meet the needs of the 21st Century." Interdisciplinary research is coordinated through the Lincoln International Institute for Rural Health (LIIRH) and its predecessor the Lincoln Institute for Health, under the University research theme of Health and Wellbeing (https://www.lincoln.ac.uk/home/researchatlincoln/healthandwellbeing/).</p> <p>LIIRH and UoA3 activity focusses on four main areas: (i) chronic disease; (ii) early detection, treatment, and prevention (iii) health informatics, big data and disease modelling; and (iv) improving service quality. These link with the other University research themes of Rurality, Communities and Digitalisation to impact global research goals (https://www.lincoln.ac.uk/home/researchatlincoln/). LIIRH, led by Tanser and Gussy is the umbrella Institute for centres and groups conducting health-related research, of which five are submitting to UoA3: Cancer and Ageing (C&A); Diabetes Metabolism and Inflammation (DMI); Microbiology and Biotechnology (M&B); Drug Discovery, Design and Delivery (4D); and the Community and Health Research Unit (CaHRU).</p> <p><i>Lincoln International Institute for Rural Healthcare (LIIRH: https://liirh.lincoln.ac.uk/)</i></p> <p>Achievements include development of (a) systematic review training and outputs (Curtis, Gussy); (b) infectious disease epidemiology and modelling for treatment and prevention (Tanser); (c) behavioural change interventions (Tanser, Gussy, Curtis) and (d) coproduction for implementation (Gussy). Research groups and centres are described in more detail below:</p> <p><i>Cancer and Ageing (C&A):</i> https://www.lincoln.ac.uk/home/lifesciences/research/cancerandageingresearchgroup/: Achievements include advances in (a) cancer biology including cancer prevention and treatment, cancer stem cell biomarkers and drug interactions, and development of new treatment strategies targeting heat shock proteins and DNA damage response (Bachrati, Hussain, Millson, Palmai-Pallag, Rinaldi, Odell and Ray); (b) genetics of atherosclerosis and stroke (Bevan) and genetics and molecular mechanisms of motor neurone diseases (Bennett); (c) nanomedicine: Ferrari and Bachrati are characterising uptake of gold nanoparticles collaborating with Midatech Pharma (http://www.midatechpharma.com).</p> <p><i>Diabetes, Metabolism and Inflammation (DMI):</i> https://www.lincoln.ac.uk/home/lifesciences/research/diabetesmetabolisminflammation/ Achievements includes advances in understanding (a) adiponectin and molecular causes of obesity (Whitehead), (b) inflammatory responses in type 1 diabetes informing preventative therapies and development of predictive and diagnostic markers (Christie), (c) pathophysiology of diabetic renal disease (Squires, Hills), (d) genetic predictors of pancreas transplant function (Simmonds), molecular basis for development of type 2 diabetes (Herbert) and (f) molecular mechanisms of inflammation (Holden).</p> <p><i>Microbiology and Biotechnology (M&B):</i> https://www.lincoln.ac.uk/home/lifesciences/research/microbiologyandbiotechnology/ Achievements include advances in characterisation, evaluation and testing of microorganisms and enzymes providing novel insights into molecular basis and treatment of disease including (a) novel antimicrobials evaluating resistance and biocontrol strategies (Dixon, Bates, Odell and Taylor); (b) structural biology: Odell investigates expression and modification of proteins</p>

involved in neurodegenerative disorders, e.g. Parkinson disease, and **Taylor** investigates bacterial cell wall peptidoglycan modifiers; (c) molecular self-assembly: **Ferrari** produces molecular nanodevices with applications in drug delivery; (d) molecular surveillance, epidemiology and trials: **Bates** conducts research into epidemiology of infections (HIV, tuberculosis, malaria) in Africa.

Drug Discovery, Design and Delivery (4D):

<https://www.lincoln.ac.uk/home/lsp/research/lspdiscovery/>)

Achievements include a) discovery and identification of novel drug targets (**Herbert, Ngomba**); b) discovery and development of new and improved drugs (**Singh, Lancaster**), and c) drug formulation and novel drug delivery modes (**Ferrari, Christie, Hunter, Wright**).

Community and Health Research Unit (CaHRU): <https://www.cahru.org.uk/>

Achievements include translational improvement research which helps understand gaps in treatment, develops health technologies to address these, and evaluates interventions including (a) effects of flu vaccine in preventing stroke (**Asghar, Siriwardena**) (b) healthcare of people on probation (**Sirdifield**); (c) diabetes in pregnancy (**Law**) (d) sleep medicine (**Law, Siriwardena**), and (e) new technologies, pathways and quality indicators for ambulance services (**Armstrong, Siriwardena**).

1.2 Achievement of previous strategic aims for research

Since 2014, we have **consolidated** previous strengths in **co-production, interdisciplinary** and **translational** research, building on these to achieve and surpass the three aims for research and fourth on impact set out in REF2014 despite huge impacts of the pandemic. These are listed below.

i. *Aim 1: 'Responding to priorities' in health and care*

Throughout 2014-2021, priorities were identified through a series of research development seminars coordinated through the Institute, bringing together constituent research groups, health service partners and patients. This led to a greater focus on thematic issues such as national and global problems of prevention, obesity, diabetes, sleep, antimicrobial resistance, rurality and more recently the COVID-19 pandemic, while considering key challenges for local and regional services such as primary and emergency care, particularly in rural areas.

The **LIIRH**, developed as a strategic response to the health problem of rurality, works with local people, NHS, and industry 'as a living laboratory' to 'find solutions to local problems that can be translated across the world'. It is based in the new Lincoln Medical School, which was awarded based on its focus on widening access to medical training in the under-doctored rural and coastal area of Lincolnshire. The Institute has facilitated the research pipeline from 'cell to community', where basic science leads to its application in the NHS and wider health sector.

For example, our research teams have worked with industry to develop new antibiotics to overcome problems of antimicrobial resistance (**Singh, Taylor**), interacted with diabetes patient groups and charities to explore causation, prediction and prevention of diabetes and its complications (**Squires, Hills, Whitehead, Christie, Law**), collaborated with the public and ambulance services to develop new ambulance measures (**Siriwardena**) and worked with patient groups and general practices to refine and implement psychological treatments for insomnia (**Siriwardena**). In response to the growing burden of diabetes globally and in Lincolnshire, there has been a strategic investment in a critical mass of expertise to research diabetes from its genesis to treatment (**Whitehead, Christie, Squires, Hills, Simmonds, Herbert, Law**). **Curtis** and colleagues in LIIRH have delivered regular **systematic review training** to support interdisciplinary teams and postgraduate research students and inform external funding grants, (e.g. an NIHR award to investigate the role of rural Community First Responders: <https://www.fundingawards.nihr.ac.uk/award/NIHR127920>) or postgraduate theses (e.g. a study of Interventions to reduce sickness absence among healthcare workers: a systematic review <https://doi.org/10.1108/IJES-05-2018-0028>). Health care professionals have been seconded from local health service trusts (e.g. Lincolnshire Partnership Foundation Trust)

to complete systematic reviews that inform future research projects, for example on insomnia in autism (<https://doi.org/10.1371/journal.pone.0221428>).

ii. *Aim 2: Investment in infrastructure for research from cell to community*

Following **investment in facilities for health and health-related research** of £20m between 2008-13 in the Lincoln Science and Innovation Park (LSIP), there was a further investment since 2014 of **£14M in LSIP**, **£19M** in a new health and social sciences building and **£21M** in the new Lincoln Medical School, also enabling strategic expansion in staff numbers in areas of strength (e.g. diabetes research) or future need (rural health studies) (see next paragraph and section 2.1 for further detail).

iii. *Aim 3: Investment in people in areas of strategic growth*

Investment in facilities has been accompanied by **strategic investments in staff** at all levels including **professorial, mid and early career staff** in areas of strategic importance amounting to an additional staff budget of £1.8 million per year since 2014 (see section 2.1). Major investment in the LIIRH links with the new **National Centre for Rural Health and Care**, a multi-university social enterprise based in Lincoln and developed in partnership with the Universities of Lincoln, Birmingham, Keele and Chester (<https://www.ncrhc.org/about>).

1.3 Achievement of previous strategic aims for impact

Our *overarching aim* was to *co-create health research to maximise impact*, specifying that we would achieve this through the following:

- i. *To involve individual, organisational and corporate stakeholders (e.g. public, practitioners, commissioners, policymakers and industry) in each stage of the research process*

Impact case studies submitted in this UoA provide examples of working with patients on improving primary care for insomnia, and with patients, ambulance services and commissioners to develop new ambulance outcome measures. Other examples of involvement include working with: patient groups including the *Healthier Ageing and Together Patient Participation & Involvement (PPI) groups* at the University of Lincoln, and *South Lincolnshire Diabetes Forum* on diabetes studies (**Squires, Siriwardena, Law, Smith**) and a Parkinson's disease and Neurological conditions patient group (**Ngomba**); health service partners (**Siriwardena** working with general practice on drug safety and **Asghar, Law and Siriwardena** with ambulance services on care homes, diabetes emergencies and seizures); commissioners (**Sirdifield** with commissioners for probation); third sector organisations (**Squires** with Diabetes UK and **Smith** with Community First Responder Schemes and **Jones, Siriwardena, Law, and Smith** with the British Lung Foundation). LIIRH is a partner in *East Midlands Sharebank Network for Patient and Public Involvement*, which develops individual and organisational skills in patient and public involvement (PPI) by gathering and sharing PPI knowledge and experience among members. **Simmonds** sits on the Society for *Endocrinology Public Engagement Committee* (<https://www.endocrinology.org/about-us/governance/public-engagement-committee/>) and supported their public outreach and public knowledge of endocrinology and diabetes, including redesigning and relaunching the '**You and Your hormone**' website (<http://www.yourhormones.info>), which has become the *most frequented site on Google for endocrine related diseases in the world*.

To meet the research priority focussing on chronic conditions, we worked closely with the **public** through **local disease support groups**, for example the *Lincoln & District Diabetes Group*, *Uppingham Diabetes Self-Help group* and *patient forums already established at Pilgrim Hospital Boston* to discuss development of new and support for ongoing diabetes-related projects. This has included lay presentations to end-user groups, e.g. Diabetes UK Midlands Volunteering Conferences (**Squires**) and Engagement & Fundraising Away Days (**Hills**).

Cooperation with **industry** is also part of this key strategic goal and includes work with Zealand Pharma (Denmark) where agreements are in place to test the ability of new agents, e.g. Danegaptide (**Squires, Hills**) and with Ocunexus Therapeutics (US), formally CoDa Therapeutics, supported by Diabetes UK and EFSD/Boehringer Ingelheim European Research

Programme grants to address problems of eye and kidney disease and develop therapeutics for unmet clinical need in ophthalmology and diabetes. In addition, there are strong collaborations between the School of Pharmacy and the pharmaceutical industry which includes ongoing support from the Lincolnshire Co-operative into the Pharmacy Masters Programme and joint research projects in formulation/crystal engineering (**Blagden**) with GSK, Astra Zeneca, Pfizer, Kirstal and Neutrapharm. Another example of the pipeline from 'cell to community' includes **Christie's** (DMI) patent for Tetraspanin-7 (International publication number: WO 2016/193714A1) which is being used as a method for diagnosis of type 1 diabetes (T1DM), predisposition towards T1DM, and to monitor efficacy of a therapy to prevent T1DM.

We have also used **blogs, infographics and animations developed with the public** to communicate our findings to wider lay and professional audiences. Examples include increases in our understanding of the genesis of diabetes and its complications, advances in therapies for diabetes, development of new antibiotics to overcome antimicrobial resistance, advances in care for insomnia (<https://www.health.org.uk/improvement-projects/resources-for-effective-sleep-treatment-rest>) and new ambulance measures (<https://www.youtube.com/watch?v=g2saLhBv9-U&feature=youtu.be>).

- ii. *To conduct national and international multidisciplinary research to develop innovative health and social care technologies, treatments and systems*

International multidisciplinary studies, include molecular surveillance for emerging pathogens in *Zambia, Central and South Africa* (**Bates**) and Telemonitoring in COPD (CHROMED) trial (EU-FP7, **Siriwardena**) in six *European* countries evaluating a new technology for measuring breathing in COPD (<https://www.ncbi.nlm.nih.gov/pubmed/29557669>).

Other strong **international collaborations** are developing in Africa (**Tanser**) and Australia (**Gussy**). **Bates'** PANDORA project in Africa involves training and capacity development and the CANTAM project, involves the EDCTP network of excellence for central Africa, which is developing clinical trial capacity for HIV, tuberculosis, malaria and neglected tropical diseases through the EMPIRICAL study (www.empiricaledctp.eu) funded by European and Developing Countries Clinical Trials Partnership (EDCTP: €7.6m)

Tanser leads a Wellcome Trust and Howard Hughes Medical Institute funded group in the Africa Health Research Institute (<https://www.ahri.org/scientist/frank-tanser/>) aiming to seek cures for HIV, TB and related diseases. **Gussy** works with LaTrobe University, Melbourne, researching oral disease as a marker of wider health (<https://scholars.latrobe.edu.au/display/mgussy>).

In response to the **global challenge** of antimicrobial resistance, **Taylor and Singh** collaborate with a **global network** including, the Singapore Eye Research Institute and Lee Kong Chian School of Medicine (Singapore) University of Utrecht (Netherlands) and University of Ghent (Belgium) to develop **novel antibiotic classes**, active against drug resistant micro-organisms, teixobactins and moenomycins, which has led to five *patents* and is progressing towards *clinical trials* (see: <http://www.itv.com/news/calendar/2018-03-26/breakthrough-on-road-to-superbug-killing-antibiotic/>). **Dixon** works with Arden Biotech (<https://www.ardenbiotechnology.com>), looking at new ways of detecting antimicrobial resistance.

- iii. *To examine the performance and functioning of health and social care practice, organisation and delivery, with an emphasis on promoting quality, efficiency and equity*

Siriwardena, Asghar and Armstrong with colleagues in CaHRU have conducted research with ambulance services supported by funding from the DH, NIHR, Health Foundation, Wellcome Trust and other charities (£3.5 million) over the past ten years, leading to development of new clinical indicators and training of ambulance staff to provide innovative and improved care. The Ambulance Services Cardiovascular Quality Initiative (ASCQI) led to improvement in quality measures for heart attack (from 43% to 79%) and stroke (from 83% to 95%) within 2 years (www.ascqi.org.uk). This was cited in a recent national publication, '100+ ways universities have improved everyday life' (<https://www.universitiesuk.ac.uk/facts-and-stats/impact-higher-education/Documents/made-at-uni-breakthroughs.pdf>).

In response to the problem of insomnia, **Siriwardena**, **Sirdifield** and CaHRU staff have developed new ways of addressing care of insomnia through psychological therapies delivered online and face-to-face in primary care. Both examples are described further in our impact case studies.

- iv. *To ensure outcomes are appropriately and widely disseminated using the concept of 'dissemination by design' and using a variety of media*

The use of 'dissemination by design' involves research where dissemination and impact are part of the research process. For example, research conducted by **Sirdifield** on health needs of people on probation funded by the NIHR led directly to development of a '*Probation Healthcare Commissioning Toolkit - a resource for commissioners and practitioners*'

(<https://probhct.blogs.lincoln.ac.uk/>). **Siriwardena** led collaborative research which promoted development of *ambulance clinical indicators* which were adopted by ambulance services and used to benchmark and improve care (<https://emj.bmj.com/content/27/4/327>) from 2010 onwards. The findings fed into the UK Ambulance Research Programme and informed new Ambulance Quality Indicators introduced in 2017 and since then adopted by all English ambulance services. Key findings from the Prehospital Outcomes for Evidence Based Evaluation NIHR programme for applied research, led by CaHRU, were developed into an animation by and for patients and the public which had over 2000 views within 6 months of its launch in November 2017 (<https://youtu.be/g2saLhBv9-U>). CaHRU have also used infographics to illustrate the impact of their research (<https://www.cahru.org.uk/research-impact/>).

- v. *To develop a sustainable research infrastructure and environment.*

Investment in people and infrastructure (see sections 2.1 and 3.2 below) have led to a sustainable research environment which continues to attract new staff, students and funding for research and infrastructure.

1.4 Details of future strategic aims and goals for research, how these relate to the structure of the unit, and how they will be taken forward

Future strategic research aims develop and expand on the previous successful strategy:

- i. *Responding to local priorities and global challenges*

This aim is in line with the University strategy of "**local to global**", prioritising research that is both relevant to our locality and has global significance in relation to the UN Sustainable Development Goals, driving economic development and enhancing social and cultural life both within and beyond our immediate community. As well as continuing work on current priorities of rural healthcare, detecting and preventing infections and tackling the growing problem of antimicrobial resistance, prevention and treatment of long-term conditions such as obesity and diabetes, and translational research, there will be further investment in newer areas such as pandemics including COVID-19, mental health (e.g. sleep research through the newly developed Lincoln Sleep Research Centre, LiSReC), older people and emergency medicine, artificial intelligence, machine learning, robotics, and clinical trials through investment in infrastructure and faculty described below.

- ii. *Strategic infrastructure development*

The new Lincoln Medical School incorporates the Lincoln Clinical Trials Unit (LinCTU) which has expanded opportunities for collaboration and improved the infrastructure for undertaking major trials of health interventions. There will also be continued consolidation of developing interdisciplinary research areas into new research centres, for example the Lincoln Sleep Research Centre, co-led by scientists from the Schools of Health and Social Care (**Law**) and Psychology.

- iii. *Targeted investment in new and existing staff*

There will be continuing strategic investment in joint posts with local healthcare trust. We will also nurture and support existing staff including mentorship, pump-priming grants and opportunities to develop international collaborations through the Lincoln Institute for Advanced Studies (<https://lias.lincoln.ac.uk>) fellowship programme. The University has been recognised as an eligible HEI by the Academy of Medical Sciences for their Springboard Scheme, involving a

Champion (**Squires**) working with the Research and Industrial Partnership Team to mentor and support ECRs within four years of their first permanent post to help establish independence.

iv. *Increased support for interdisciplinary research*

We will strengthen and expand existing structures which support interdisciplinary research in key research areas, for example interdisciplinary seed funding (e.g. research pump-priming schemes) and interdisciplinary doctoral studentships (the university are advertising for a joint PhD between Life Sciences [**Holden**] and Computer Science to develop AI enabled biomarker identification from exhaled breath condensates for early detection of secondary infection in patients with COPD) which will increase opportunities for internal collaboration, innovative research, and impact.

v. *Development of new international funding streams*

We will build on our success in UKRI, NIHR and major charity funding by expanding funding sources to include within 5 years at least 25% international grants (currently less than 10%), for example through the Global Challenges Research Fund, MRC-collaborative grants with Australia and Canada and US National Institutes of Health. We will provide time and financial support to develop strategic networks, encouraging collaboration with international partners through a visiting fellowship scheme funded through the Lincoln Institute for Advanced Studies (<https://lias.lincoln.ac.uk>). Previous visiting fellowships have included Prof Colin Espie (Oxford University) to expand our sleep research and Prof Gina Agarwal (McMaster) with CaHRU and LIIRH through the EDGE consortium (<https://www.cahru.org.uk/research/partnerships/partnerships-edge/>) to grow our prehospital research. We will build on links with international partners, for example through existing links with La Trobe University, Australia and new links with the University of Witwatersrand, South Africa.

vi. *Expansion in postgraduate research students*

We will seek to attract increased numbers of PGR students and to at least double PhD completions over the next 5 years, increasing this through maintaining the University fund for staff development, NIHR Integrated Clinical Academic Internship award, successful funded PhDs through NIHR Applied Research Collaborations, other NIHR clinical doctoral research fellowships and other doctoral programmes.

1.5 Details of future strategic aims and goals for impact, how these relate to the structure of the unit, and how they will be taken forward

Our approach to impact will build on and extend our previous successful strategy:

i. *Co-creation to maximise impact*

We will continue to strengthen our successful collaborations with PPI groups, local and regional health service partners, commissioners and industry (see section 1.2), to co-create research relevant to local and regional communities and capable of being translated elsewhere in the UK and internationally, thereby providing stronger routes to impact.

ii. *Supporting Patient and Public Involvement and Engagement (PPIE)*

In this UoA PPIE means developing, conducting and sharing research with patients, families and carers to ensure our research is relevant to end-users of services, thereby enhancing the likelihood of achieving impact. We will continue to invest in groups such as the Healthier Ageing Patient and Public Involvement Group, which has provided advice to support new active programmes of research and projects (see: <http://cahru.org.uk/about/>).

iii. *Translational and implementation research for impact*

We will continue to invest in regional partnerships which have the explicit aim of impactful research. For example, the University of Lincoln are partners in the successful NIHR Applied Research Collaboration East Midlands (<http://arc-em.nihr.ac.uk/>). As part of the £9 million investment from NIHR in implementation and translational research over the next 5 years,

CaHRU (**Siriwardena, Law, Asghar, Smith**) lead a workstream using ambulance data to support a programme Building Community Resilience and Enabling Independence.

iv. *Structural support for impact*

Structures enabling impact include the University Director of Research Impact Development, dedicated impact leads for schools and investment for impact generation. Processes include training for impact, sharing of impact knowledge through seminars and meetings, impact being integral to annual Individual Research Plans and staff appraisals, impact support for bids as part of the internal peer review mechanism for bids, and an institutional investment in public engagement through the EPSRC funded **Public Engagement for All in Research (PEARL: <https://pearl.lincoln.ac.uk/>)** in Lincoln.

1. 6 Approach to interdisciplinary research

The **LIIRH** is an important vehicle for promoting and supporting interdisciplinary research in this UoA. New interdisciplinary collaborations have been fostered through seminars, sandpits, joint meetings involving research groups and external health service partners, University-funded interdisciplinary studentships and joint University-NHS funded systematic reviews, all coordinated through the Institute and used to seed and support novel research (see 3.2).

1.7 Progress towards open research

The University is committed to open data as a partner in the JISC-funded open research project and a signatory to the San Francisco Declaration on Research Assessment (DORA, see institutional environment statement). The University policy for Research Data Management developed in May 2018, supports academics to publish data as openly as possible in line with the institutional Code of Practice for Research and reflecting University Open Access and Research Ethics Policies. The policy supports UKRI common principles on data policy and best practice for storage and sharing of data. adhering to the RCUK Data Sharing Policy and including a 3-year review cycle to account for evolving practices, legislation, and ensuring suitability of curation and applicability of management resources. The University Research Data Management Working Group led by **Law**, and supported by a dedicated member of the Research and Enterprise team at the University supports academics in this UoA to follow institutional policy on open research, advocating open access publication of research data for other researchers to use within research ethics and governance approvals. The University provides an open access platform (ePrints) to store, backup, register, deposit and retain datasets in support of current and future open access, during and after completion of projects, e.g. <http://eprints.lincoln.ac.uk/26948/>.

1.8 Support for research integrity

Research integrity is governed by the University's *Code of Practice for Research* (see institutional environment statement), *Concordat to Support Research Integrity* and *University Research Ethics Committee* new ethical approval procedure and online system implemented in 2018. The *Human Tissue Act Oversight Group* oversees storage and access to human material. All staff or student research requires University or external NHS ethics committee approval. Staff and students receive advice, support and training in research ethics. Ethics and research integrity are standing items on School Research Committees, which oversee research. Ethical aspects of student research are examined during annual monitoring reviews. Staff have access to training in research misconduct, governed by the University's application of the UKRIO Procedure for the Investigation of Misconduct of Research. The University publishes an annual Misconduct Statement.

2. People

2.1 Staffing strategy

A significant and **sustained investment** in new staff, in line with our stated research and impact plans, includes **68 percent** staff increase from **19.4 to 32.8 FTE** academics since 2014 with an additional annual staff budget of **over £2 million per year**, reflecting expansion and intensification of research *in areas of strategic importance and current strength*. This includes 7

new professorial appointments in medical statistics and clinical trials (**Law**), pharmaceutical science and diabetes (**Herbert**), diabetes (**Squires**), obesity (**Whitehead**), genetics (**Bevan**), and international appointments in global rural health (**Tanser** from South Africa, **Gussy** from Australia). *Four new Associate Professors* have been appointed in related research areas of workforce development and cancer (**Kane**), diabetes (**Hills**) and antimicrobial resistance (**Taylor, Singh**). Also appointed were *new Senior Lecturers, Lecturers and Research Fellows*. Early career researchers (ECRs) submitted previously for REF2014 have been promoted to associate professor (**Singh, Taylor**), along with new internal promotions at this level (**Bachrati, Christie, Hills**).

2.2 Staff development

Wider **support mechanisms** include the *University's People Strategy*, a comprehensive range of policies around employment, equal opportunities, research management and ethics, each with elements designed to facilitate and support research activity among staff and students. The UoA is fully committed to the provisions of the *Concordat to Support the Career Development of Researchers* (see institutional environment statement), which is promoted through the *Continuing Professional and Personal Development Framework*, which highlights key staff development objectives. The commitment is demonstrated by the fact that while 15.2 FTE members of staff submitted to the UoA are employed at senior level (Associate Professor or above), 4 (including 2 women and 1 BAME member) achieved this role through internal promotion, evidencing the University's and UoA's commitment to planning succession and a new generation of academic leaders. All staff are employed on permanent contracts, with none on fixed term or atypical contracts returnable in this UoA. Staff are supported in developing their career progression through annual appraisals, helping them to set goals and identify the resources they need. Regular workshops are held on the promotions process and staff are encouraged to take part in the University's *Pipeline Mentoring Programme* (see Institutional Environment Statement). The EDI aspect of staff promotions is dealt with below.

Staff development is also supported through the following **activities**:

- New and existing staff are attracted, recruited and retained with interests complementary to existing groups and research priorities, and staff working on externally funded studies have been supported in their development to permanent posts through provision of new lectureships (**Armstrong**), research fellowships (**Sirdifield, Jones, Curtis**) and senior research fellowships (**Smith**).
- ECR support includes appointment of leads for each school, tailored personal and professional development programmes, study review meetings to discuss journal articles and research bids prior to submission, writing retreats, a mentorship programme, annual appraisals and individual research plan reviews and dedicated support for research writing.
- Leadership development opportunities include specific leadership training for individuals seeking and on track for promotion with support for BAME staff through INSPIRE (<http://sdf.ac.uk/cms/wp-content/uploads/2016/07/Inspire-Programme-Module-Outline-University-of-Lincoln.pdf>), and an internal promotion process with clear criteria for advancement.

2.3 Support, training and supervision of PGR students

We have **increased doctoral student enrolment to 53 since 2014**, and **increased PhD completions from 10 to 34**, with more than three times the completions over this census period compared to the last, achieved through a comprehensive programme of support for PGR students at School, College and University level.

The increase in student numbers has been driven by several key mechanisms:

- Funding for PGR students in allied health has increased substantially. The University was a founder member of the *Doctoral Training Alliance* (DTA: <https://unialliance.ac.uk/dta/>), which provides central University funding for PGR students

on Applied Biosciences for Health. Doctoral studentships for staff and new students initially via the DTA are provided through open competition.

- In addition to DTA funding, institutional funding has been provided through the College of Social Science, with on average three PhD and several MRes students each year funded within the UoA. The School of Life Sciences has funded 5 PhDs and 2 MScs in research. The School of Pharmacy has also provided funding support for PhD and MRes students including PhD students funded partially and fully through collaboration with the pharmaceutical industry.
- Increased external income has included provision for *PGR studentships*, for example through two partly internally funded NIHR CLAHRC-HEEM doctoral fellowships and two Diabetes UK Studentships (**Squires and Hills**).
- The School of Health and Social Care hosts a Health Education England funded (£450,000, 2016-2019) programme to support development of *Clinical Academic Research Careers* for health professionals across the Midlands and East of England through the NIHR Research Internship Programme (<https://www.nihr.ac.uk/our-research-community/NIHR-academy/nihr-training-programmes/nihr-hee-ica-programme/>).
- A previous *MSc in Social Research Methods* and more recently a *MSc in Research* since 2018 have provided key training in research methods for graduates, positioning them to continue to doctoral studies.
- The substantial increase in research-active staff has led to an increase in the number of available supervisors and the range of specialised research areas available. The significantly increased international research profile of many staff has ensured greater visibility and applications from international students who have comprised 11 (42%) PhD completions. Success has been self-fulfilling with enthusiastic feedback from existing students directly contributing to increased applications from other students seeking a quality experience in higher education.
- Improved research facilities and significant investment in research laboratories and equipment has made the University attractive to potential applicants, including self-funding doctoral students (see Section 3.2).

Ongoing supervision, support and training are provided by means of the following:

- All PGR students follow a comprehensive supervisory programme including Training Needs Analysis, Annual Progress Reviews and reviews at least monthly for full-time and bimonthly for part-time students, as described in the institutional environment statement which has ensured over 95% of completions on time during this REF period.
- Oversight for postgraduate research is led by School Directors of Postgraduate Research (PGR leads) assisted by a PGR administrator in each school and the Doctoral School (<https://doctoralschool.lincoln.ac.uk>). The PGR administrator within each School tracks, monitors and guides PGR students and supervisors in adhering to University protocols. School PGR leads report to School Directors of Research, Heads of School, and School Postgraduate Research Committees which includes PGR representatives as well as staff.
- The College of Social Sciences which includes CaHRU, and other groups based in the School of Health and Social Care organises an annual two-day residential ECR Development workshop, which PGR students are invited to attend. Sessions at this 2-day residential workshop are run by experienced researchers, senior academics and external experts with topics such as research project development, obtaining funding and publication success. In addition, the School of Health and Social Care has recently introduced a workshop aimed specifically at writing for publication.
- Each school has a fully equipped PGR room which provides dedicated desk space and IT facilities for students.
- All PGR students have access to school-level funds to support their research and are supported in applications to attend conferences and encouraged to disseminate their research. For example, Phung presented his work on Community First Responders at the recent Mediterranean Emergency Medicine Congress (MEMC in Lisbon, Portugal in

2017. An annual University PGR student conference provides students initial conference experience and boost their confidence to attend external events.

- The Doctoral School provides generic research training, career development programmes and a support network for all PGR students. Each school provides more tailored discipline-specific research training, for example day courses on motivational interviewing and 3-day (over a 6-month period) systematic review training courses. Staff in each School also contribute to the Doctoral School programmes, helping ensure a two-way flow of experience and expertise. The Researcher Development Programme (RDP) at institutional level, ensures that all PGR students obtain the necessary skills to successfully carry out all aspects of PGR work and develop the transferrable skills needed for their future careers.
- A number of PGR students go on to postdoctoral work (e.g. Jenkins now Respiratory Research Officer at University of Nottingham, Akanuwe now research assistant at University of Lincoln) or permanent positions elsewhere (Simmons appointed lecturer at University of Wolverhampton in 2019) either in academia or in national health-related organisations (Togher is senior analyst at the Care Quality Commission).

2.3 Equality, diversity and inclusion

The UoA has a collaborative approach to **Equality, Diversity and Inclusion (EDI)** which supports and encourages all under-represented groups, promotes an inclusive culture, and values diversity is a core feature in the university and schools. We recognise that we have not achieved equality in scientists attaining professor and senior positions and this acknowledgement underpins our aim to do better.

The UoA has 34 (32.8 FTE) staff including 9 female and 7 BAME staff members. In terms of FTE staff, the UoA includes female 26.8%; BAME 20.1%, disabled 8.9%, with BAME and disabled staff around twice the sector average. There were 5 staff promotions in the UoA during the census period, of which 2 (40%) were female and 1 (20%) BAME.

Two out of three schools involved in the submission, the School of Life Sciences (SLS) since 2016 and the School of Health and Social Care (SHSC) since 2019, hold the *Athena SWAN Bronze award*, and the School of Pharmacy is working towards its Bronze award. SHSC also hold the *Lincolnshire Carers' Award*, in recognition of staff who are also carers, achieved in 2019 and 2020.

Work on EDI is ongoing at school and University level, led by the cross-University *Eleanor Glanville Centre* (<http://eleanorglanvillecentre.lincoln.ac.uk>) which coordinates institutional engagement with the *Equality Challenge Unit's Athena SWAN/Gender and Race Equality Charters*, and provides centralised support, and sharing of best practice, across all academic schools. The university holds a Race Equality Charter mark. Equality and diversity are a standing item on the senior leadership team meetings. We have an active research team working on LGBTQ issues, and their findings inform our approach to EDI, through the school EDI committees.

Equality Diversity and Inclusivity (EDI) committees in each school, include student educators, researchers, professional services, and research students. The committees are engaged in a continual self-evaluation process, implementing actions designed to improve equality and diversity. Analysis of annual monitoring statistics on students, staff appointments and promotions, and submissions for funding are carried out to better assess rates and trends and to inform the development of targeted initiatives for under-represented groups. All staff attend EDI training, including unconscious bias which seeks to ensure internal and external processes and procedures deliver a level playing field for all current and potential staff. Female staff in the UoA, including **Hills and Sirdifield** provide important role models for women in STEM, and **Hills** was featured as a Diabetes UK rising star for Women in Science in 2017.

There is a commitment to a *core-hours model* for important management and leadership meetings. This was introduced in the School of Health and Social Care from 2019 and has been

introduced in the other schools, to recognise staff who care for children or other family members. The Eleanor Glanville Centre provides targeted support workshops for under-represented groups (e.g. building confidence, effective networking), informed by staff consultation.

Staff in the UoA engage with the institutional *Pipeline Mentoring Scheme* (<https://staffnews.lincoln.ac.uk/2019/09/05/pipeline-mentoring-programme-2019-2/>), open to all staff, which includes 'maternity mentoring' and 'work-life balance' support pathways, alongside the more usual career progression support. Further support for female researchers around maternity leave is provided through the centre's Academic Returners' Research Fund, which enables staff to sustain their research before, during and after maternity leave.

The construction of the UoA's submission, including the selection of outputs, has been governed by the University's REF Code of Practice. EDI was at the heart of this process and Equality Impact Assessments (EIAs) occurred annually 2018-20 on the University's REF procedures, in order to identify potential EDI issues, including any disparities identified in the inclusion of outputs for staff with protected characteristics, and to take action to correct these if necessary. All members of staff involved in creating the Allied Health Professions UoA submission received specific EDI and unconscious bias training around these procedures. The selection of staff outputs for inclusion was based on a rigorous process that involved not only an internal panel with an independent Chair (from another College in the University), but also external assessment. Staff were encouraged to declare individual circumstances that might affect their submission through a confidential procedure.

3. Income, infrastructure and facilities

3.1 Research Income

External grant income at Lincoln in UoA3 has grown by **188%** from £1.75 million during the previous REF period to **£5 million** in this period.

The growth has been due to our **strategic focus on local, national and global priorities** (of chronic disease, prevention, big data and improving care quality in rural and ageing communities as described in 1.1), working with service users, health service, industrial and other academic partners, to develop and refine research ideas, improving track records of applicants through prior evidence synthesis and feasibility studies, and increased quality of bids through formal processes for rigorous expert and lay pre-submission peer review, together with mentorship for ECRs. For example, **Siriwardena** supported **Sirdifield** to achieve her first NIHR grant in 2017 (£150k) and this was followed by a further NIHR award (£148k) in 2020.

Major grants since 2014 with UoA3 staff as chief investigator include £2 million for *Ambulance pathways* (NIHR 5-year Programme for Applied Research, **Siriwardena**), £484k for *Synthetic teixobactins: a new class of antibiotics to combat multi drug resistant bacterial infection* (Department of Health and Social Care, **Singh**), and £471k for *Community First Responders role in the current and future rural health and care workforce* (NIHR Health Services and Delivery Research Programme, **Siriwardena**).

Awards over £100k with UoA3 staff as chief investigator include £131k for *Preclinical testing of IA-2-IgG Fc chimeric proteins for antigen-specific B-cells* (Diabetes UK, **Christie**), £133k for Phenotype and specificity of the islet inflammation in Type 1 diabetes (JDRF, **Christie**), two successive grants on *Measuring and improving the quality of health and healthcare for offenders on community sentences* with £150k in 2016 for *developing recommendations for commissioners and practitioners* and £148k in 2020 for *developing quality indicators* (NIHR Research for Patient Benefit, **Sirdifield**), £500k for a programme of work funded by Diabetes UK (**Squires and Hills**, 11/0004215: £216,139, 12/0004546: £79,885, 16/0005427: £202,820, 16/0005544: £88,519, 16/0005509: £15,000; 18/0005919: £89,775) including *Determination of a role for connexin mediated cell communication in the progression of renal fibrosis in the diabetic kidney* (Diabetes UK, **Squires and Hills**), £309k for studies on the *Organelle-specific functions of human Type 1A topoisomerase TOP3A* (BBSRC, **Bachrati**).

Staff have also been **collaborators on major grants** including £300k for *Telemonitoring in Chronic Obstructive Pulmonary Disease* (CHROMED, EU-FP7 €200M, **Siriwardena**), £282k for *HABIT: A Pragmatic, Multicentre, Randomised Controlled Trial comparing nurse-delivered sleep restriction therapy for insomnia disorder to sleep hygiene in primary care* (NIHR Health Technology Assessment £2M, **Siriwardena**), £253k for *Empirical treatment against cytomegalovirus and tuberculosis in severe pneumonia in HIV-infected infants: a randomized controlled clinical trial* (European & Developing Countries Clinical Trials Partnership, **Bates**).

The reach and breadth of our funders reflects the types and extent of our research; ranging from the Royal Society (**Singh, Sharma, Hills**) to grants from the NIHR (**Siriwardena, Smith, Sirdifield, Law**), MRC (**Law, Siriwardena**), BBSRC (**Goddard, Bachrati**), EPSRC (**Blagden, Villasaliu**), NIHR (**Siriwardena, Law, Sirdifield, Smith**), EU (**Bates, Siriwardena**), pharma including AstraZenca, Glaxo Smith Kline (**Blagden**) and charities including the Wellcome Trust (**Villasaliu, Siriwardena**), Health Foundation (**Siriwardena**), Rosetrees (**Taylor, Squires, Hills**), Diabetes Wellness Research Foundation (**Herbert, Hills**), Juvenile Diabetes Research Foundation (**Christie**), European Foundation for the Study of Diabetes and Diabetes UK (**Squires, Christie, Hills**), the British Lung Foundation and European Regional Development Fund (**Jones**) and Epilepsy Research UK – ERUK (**Ngomba**).

3.2 Infrastructure and facilities

The **Lincoln International Institute for Rural Health (LIIRH)** provides a research hub, allowing individuals and groups working on health-related and applied health research to meet regularly through joint meetings, research methods seminars and an interdisciplinary research development exchange. It also provides expertise in evidence synthesis and training in Cochrane systematic reviews which has provided a basis for new interdisciplinary studies. The LIIRH has also supported 15 interdisciplinary PhDs where co-supervision from staff in the different centres and groups is an essential feature.

Examples of interdisciplinary research which developed through these approaches include ground-breaking studies of new classes of antibiotics active against resistant micro-organisms (e.g. teixobactins <https://pubs.acs.org/doi/10.1021/acs.jmedchem.7b01634>) from **Singh** (4D) and **Taylor** (M&B). Evidence syntheses for example on sleep and children with autism were funded through the Clinical Research Network to support a secondment from the local mental health trust (e.g. <http://doi.org/10.1371/journal.pone.0221428>) from LIIRH (**Curtis**) and CaHRU (**Law, Siriwardena**).

Pump priming grants have led to database studies in drug safety (e.g. <https://link.springer.com/article/10.1007%2Fs00198-019-05045-z>) from CaHRU (**Asghar, Siriwardena**) and 4D (**Grassby**).

Other examples include collaborations between health, computing, industry and health services in the EPSRC funded ENACT study (<https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/I000615/1>) on digital platforms for delivery of psychological treatments for sleep.

New interdisciplinary collaborations include health with computing (robotics, machine learning). Interdisciplinary collaboration has also been achieved through specific funding for doctorates and involving two or more schools and disciplines. For example, Jenkins, supervised by **Jones** and **Holden**, completed his PhD investigating changes in inflammatory markers during pulmonary rehabilitation (<http://eprints.lincoln.ac.uk/37754/>). Boasman, supervised by **Simmons** and **Graham** is elucidating molecular mechanisms in myelodysplastic syndromes to predict treatment response (<https://doi.org/10.1007/s00277-019-03627-9>).

Since 2014 there has been a significant and continuing **investment** in biomedical and health services research. In partnership with the Lincolnshire Co-operative Society, £14m has been invested to build Lincoln Science and Innovation Park (<https://www.lincolnsciencepark.co.uk/facilities/joseph-banks-laboratories-minster-house>). Housed within a 10-acre site in the heart of the city, this includes the Joseph Banks Laboratories (JBL), and Boole Technology Centre (<https://www.lincolnsciencepark.co.uk/facilities/boole->

[technology-centre](#)) and Bridge Laboratories, accommodating biology, biomedical science and the new School of Pharmacy, which together opened in 2014. The JBL provide state-of-the-art facilities and modern infrastructure needed to support cutting edge biomedical research.

A wide range of **laboratory facilities and equipment** at JBL include biophysical tools such as Atomic Force Microscopy (AFM), X-ray crystallography, Dynamic Light Scattering (DLS), and Nanoparticle Tracking Analysis (NTA) to investigate the interface between materials and biomolecules, physical properties of extracellular vesicles and exosomes and cell biomechanics. AFM-single-cell force spectroscopy is used investigate changes in cytoskeletal reorganization, membrane dynamics and cell-cell adhesion as early biophysical markers of biomedical changes seen in disease onset and progression. Imaging includes Optical – Bright/Dark field Fluorescence, 3D Imaging, confocal, and nanodrop microscopes, a micro-CT scanner and digital imager. Measurement includes scanning vibrometer and particle sizers. Other equipment includes dual laser Raman spectrometer, rheometer, ion chromatography, and a UV-Vis spectrometer. Materials are processed using ultra-high-speed centrifuges, cytospin cytocentrifuges, ion chromatography, flash chromatography, microwave acid digester, and a range of dryers (freeze, spray, solvent), mills (freezer, ball mixer), synthesizers (peptide, organic molecule), chemical reaction stations and an electrochemistry system.

A **£19 million investment in 2016**, led to the Sarah Swift Building for health, psychology and social sciences (<https://www.lincoln.ac.uk/home/collegeofsocialscience/facilities/>), which has clinical wards, a two-bed sleep laboratory with full polysomnography, body imaging and a **Human Tissue Act** licensed storage facility with tissue culture facilities in four laboratories, have expanded our research capability and enabled collaborations across centres, nationally and internationally.

These developments contributed to approval for the new **Lincoln Medical School** (<https://www.lincoln.ac.uk/home/medicalschoo/>) in 2019 and a **£21 million** state-of-the-art building completed in 2021, with funding support from Greater Lincoln Local Enterprise Partnership, charitable and local donors, and local community backing. These investments have attracted research funding from pharmaceutical and biotechnology companies, linking academia, industry and technology, which has further strengthened our research infrastructure and environment.

CaHRU is a collaborative partner in the *NIHR East Midlands Research Design Service* (<https://www.rds-eastmidlands.nihr.ac.uk>), supporting applied health research bids and is a partner in the *NIHR Applied Research Collaboration East Midlands*.

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

4.1 Research collaborations, networks and partnerships

Allied Health Professions research at Lincoln has built **longstanding and extensive interdisciplinary partnerships and networks** focussed on regional, national and global priorities, enabling our research to generate wider impacts.

Work with NHS trusts allows us to evaluate innovations in healthcare workforce and staff wellbeing. For example, **Siriwardena and Smith** were funded by Public Health at *Lincolnshire County Council* to evaluate an innovative Community First Responders (CFRs) falls pathway which led to a major NIHR award in 2020 (£471k, **Siriwardena, Asghar, Smith**) to study CFRs' contribution to the rural health and care workforce.

We work extensively with *national and local patient and public organisations and their charities to explore the needs of service users*. **Siriwardena, Asghar and Curtis**, funded by the *Guillain-Barré and Associated Inflammatory Neuropathies (GAIN) charity* (£35k) researched experiences of patients with this condition and how they can be supported to return to health. **Sirdifield** studying health needs of people on probation (NIHR, £150k) collaborated with representatives from *Together Women, Her Majesty's Prison and Probation Service, Public Health England, the*

Probation Institute, and HM Inspectorate of Probation, to develop a Probation Healthcare Commissioning Toolkit (<https://probhct.blogs.lincoln.ac.uk/>) included in Public Health England guidance.

With a strong focus on **translational research** in primary care, **Siriwardena**, funded by the Health Foundation (£500k) and *East Midlands Academic Health Science Network* (£250k), led by the Lincolnshire community trust and in partnership with University of Nottingham, undertook a large-scale regional Quality Improvement Collaborative to implement a pharmacy intervention which reduced clinically important errors in general practice prescribing involving *380 general practices in 12 Clinical Commissioning groups in the East Midlands region*. The HABIT trial (<http://dx.doi.org/10.1136/bmjopen-2019-036248>), *the largest randomised controlled trial of its kind worldwide*, comparing nurse-delivered sleep restriction therapy for insomnia disorder to sleep hygiene in primary care (NIHR, £1.8M, co-applicants **Armstrong and Siriwardena**), is being conducted in collaboration with Oxford University Sleep and Circadian Neuroscience Unit and University of Manchester in *24 practices* including 8 in Lincolnshire. In Organic disease masquerading as Irritable Bowel Syndrome (NIHR, £304k) **Law, Smith and Siriwardena** collaborate with a Lincoln gastroenterologist to manage the condition better in primary care. **Siriwardena** is research director for *NIHR Applied Research Collaboration East Midlands* and is funded (NIHR ARC, £200k) to lead research using ambulance data. He was also co-applicant and chairs the Regional Management Board of *NIHR East Midlands Research Design Service* (NIHR, £5M).

Siriwardena has developed strong links with *UK ambulance services* over 15 years leading to major studies involving one or all English ambulance trusts. He led the first NIHR programme (£2m) in ambulance services to develop new ambulance measures which reported in 2019. He was a collaborator in the 'Rapid Intervention with Glyceryl trinitrate in Hypertensive stroke Trial-2' (British Heart Foundation, £1.4M) involving 8 ambulance services and 32 hospitals, 'Understanding variation in rates of ambulance service 'non-conveyance of patients to an emergency department' (NIHR, £329k) involving 8 ambulance services, and 'Electronic Records in Ambulances to support the shift to out of hospital care' (NIHR, £387k). He leads the NIHR funded (£471k) study of CFRs' role in the rural health and care workforce, involving 7 ambulance services.

Taylor, supported by the *Rosetree trust* has developed and tested *new antimicrobials* (with **Singh**, 4D). Together they enabled the University to file two *patents* relating to novel analogues of teixobactin and moenomycin A (New Antibacterial Products WO2018162922A1 and EP3193908A2), currently being exploited via industry interactions mediated through the University research office. Taylor in collaboration with Q biotechnologies (<https://www.qtechnologiesgroup.com/>) is developing a new test for persistent biocides. **Ferrari** funded through an EU collaborative project Immuno-NanoDecoder (Horizon 2020 grant number 645684) and the Analytical Chemistry Trust (Tom West Analytical Fellowship) has generated *biomolecular nanomaterials* with potential application as *diagnostic and analytical tools* and for the delivery of therapeutic molecules. He collaborates with Midatech Pharma (<http://www.midatechpharma.com/>), studying the interaction of therapeutic nanoparticles developed by the pharmaceutical company with cellular components.

International collaborations in key strategic areas have helped to build on these successes in the UK. Of the 143 papers published from the unit of assessment between 2015 and 2019, 41.3% included international collaborations. For example, **Taylor** has collaborated with University of Greifswald, Germany on *antibiotic resistance to S. pneumoniae* (<https://www.nature.com/articles/s41429-020-0296-3>). **Siriwardena's** research on primary care for insomnia includes collaborations with *University of Ghent, Belgium* (e.g. <https://doi.org/10.1080/02813432.2019.1663591>), and his research in ambulance services involves collaborations with the University of the Sunshine Coast, Australia (<https://doi.org/10.1016/j.ajem.2018.05.041>). **Neil Squires** (<https://www.gov.uk/government/people/neil-squires>), honorary professor at Lincoln is Director of Global Health for *Public Health England*, and Champion of Global Health for the Faculty of

Public Health Board and FPH Brexit Advisory Team. **Christie** is collaborating internationally to validate predictive markers for T1DM, including participation in the *Islet Autoantibody Standardisation Program (IASP)*, which aims to optimise assays for identifying individuals at risk of T1DM. **Ngomba** is Visiting Associate Professor at *Stanford University (US)* where he collaborates with Huguenard and Rivara at *University of Parma, Italy*, on the role of melatonin receptors and novel ligands in epilepsy. He also collaborates with Nicoletti, *University of Rome*, and Striano, *University of Genoa* on the role of thrombospondin-1 in epilepsy. The School of Health and Social Care are members of the *Udine-C Network: Understanding Development Issues in Nurse Educator Careers* which has led to research collaborations on development of the nurse workforce (e.g. <https://doi.org/10.1177/0969733019845136>) and work on community care for cancer led to collaboration with La Trobe University, Australia.

International collaborations have also led to *international trials*, e.g. **Christie** has identified factors that affect outcome in clinical trials of T1DM immunotherapy, most recently in the Diamyd® immune intervention trial. **Siriwardena** was collaborator on the *Telemonitoring in COPD (CHROMED: <https://doi.org/10.1164/rccm.201712-2404OC>)* trial funded by EU-FP7 with Restech SRL – Del Politecnico Di Milano, Italy, Tallina Tehnikaulikool, Estonia, Universitat De Barcelona, Spain, Uppsala Universitet, Sweden, Universitetssykehuset Nord-Norge HF, Norway, Bolnissnica Sezana Zavod, Slovenia. **Bates** is a collaborator on a major trial *Empirical Treatment Against Cytomegalovirus and Tuberculosis in HIV-infected Infants With Severe Pneumonia (EMPIRICAL)* led by Hospital Universitario 12 de Octubre in Madrid with partners in Europe and Africa including University Hospital, Bordeaux, Institut National de la Santé Et de la Recherche Médicale, France, PENTA Foundation, Centre Hospitalier Cocody, Malawi-Liverpool-Wellcome Trust Clinical Research Programme, Eduardo Mondlane University, Centro de Investigação em Saúde de Manhiça, Stichting Katholieke Universiteit, Barcelona Institute for Global Health Makerere University, University Teaching Hospital, Lusaka, Zambia, University of Zimbabwe.

4.2. Relationships with users, beneficiaries and society

i. *Patients, public and community*

Service users are our most important beneficiary, as much of our research is directly or indirectly related to developing or improving health care technologies or outcomes for **patients**. We conduct public engagement activities which bring together patient groups, academic scientists, clinicians, policy makers, charities and the general public to inform families about research at Lincoln and its potential in the management of various chronic conditions. This is supported by *Public Engagement for All with Research* at Lincoln (PEARL, <https://pearl.lincoln.ac.uk>), the *Together (public involvement) group* and School Liaison Officers, responsible for promoting engagement and participation of local Schools in particular those with lower attainment rates to encourage access to higher education. through lab visits and a University public lecture and engagement series. This includes the Marie Curie funded *Lincoln LIGHTS* (<https://lights.sites.lincoln.ac.uk/>). For example, staff provided repeated events for schoolchildren as part of the 2018 LIGHTS expo with presentations about ambulance research and opportunities for 83 school children (aged 11-18 years) attending to train in cardiopulmonary resuscitation. Feedback included: “A wonderful event and a great opportunity to witness the scope of public engagement activity taking place at the university.” Other public events include science talks and debates for the public through various initiatives including a monthly *Café Scientifique* in venues in Lincoln and Market Rasen and ‘Pint of Science’ at public houses across the county where academics engage with the public on scientific topics.

ii. *Health service organisations*

Our relationship with health service organisations and leaders is critical to our strategy, by helping focus our research on their research and development priorities, enabling us to co-create studies which address these concerns, facilitating use of findings in a responsive way that helps to increase our research impact. For example, research with ambulance services (CaHRU) led to changes in the education and training of over 1000 ambulance practitioners in the East Midlands alone on management of conditions (such as hypoglycaemia, seizures and falls) leading to implementation of new pathways for hypoglycaemia and falls, with patients benefitting through improved processes and outcomes of care. The work featured in the

Universities UK 100+ ways universities have improved everyday life in 'Relieving the pressures on the NHS through better training' (<https://madeatuni.org.uk/university-lincoln/relieving-pressures-nhs-through-better-training>). Research undertaken by CaHRU with English ambulance services led to the development of the *first national ambulance clinical indicators* which have given rise, through a quality improvement project funded by the Health Foundation (£400k, **Siriwardena**), to significant improvements in heart attack and stroke care delivered to patients throughout England.

iii. National bodies

Other beneficiaries are national bodies, including **guideline development organisations** such as the *National Institute for Health and Care Excellence (NICE)*. An example included in an impact case study involving CaHRU staff (**Siriwardena**) has been cited in draft UK NICE guidance: 'Flu vaccination: increasing uptake. July 2017' (<https://www.nice.org.uk/guidance/indevelopment/gid-phg96>). Other studies have been cited in the UK Joint Royal Colleges Ambulance Liaison Committee national ambulance guidelines on seizure and on overdose. The REST e-learning programme (<http://elearning.restproject.org.uk/>) on primary care for insomnia (see 4.3) was cited in the *Parliamentary Office on Science and Technology (POST)* note on Sleep and Health in 2018.

4.3 Wider contributions to the research base, economy, and society

Key contributions to the economy and society from the unit's research include: *patents* for new antimicrobials effective against resistant bacteria (**Singh, Taylor**); implementation of new ambulance measures and technologies (**Siriwardena**) adopted in the UK, US, Canada and Middle East; *improvements* in primary care for insomnia (**Siriwardena, Sirdifield**) used internationally with uptake from an e-learning programme (<http://elearning.restproject.org.uk/>) by over 15,000 users in 166 countries between 2011 and 2019; large-scale quality improvement initiatives such as a pharmacy intervention to reduce clinically important errors in general practice prescribing involving 380 general practices in 12 Clinical Commissioning groups in the East Midlands region which led to identification of over a 21,000 potential prescribing errors in almost 3 million patients with steps taken to reduce these (**Siriwardena**); and interventions to widen use of influenza vaccine (**Asghar and Siriwardena**) which have been included annually in the Chief Medical Officer annual guidance on influenza and advice to general practices. Examples of these are included in *impact case studies* being submitted to this UoA.

Researchers in this unit hold **key regional, national and international roles**, holding fellowships, honorary appointments and editorships, all peer reviewing for internationally recognised journals, most reviewing grant applications for major UK and international award bodies, and many invited as international conferences speakers. Notable contributions include:

Known for enhancing the profile of women in STEM and featured as *Diabetes UK's rising star for Women in Science 2017*, **Hills** is a member of the *European Foundation for the Study of Diabetes expert group (2018)*. She has presented several state-of-the-art talks, including "Cell-cell communication and Diabetes" at the 10th World Congress on Prevention of Diabetes and its Complications in Edinburgh in 2018 and was an invited speaker on "Non-prescription drugs and the kidney", during UK Kidney Week held by the British Renal Society and the Renal Association SECC, Glasgow 2015. In 2019, she delivered the *Physiological Society Joan Mott Prize lecture*, one of the Society's most prestigious international awards, acknowledging a female physiologist with longstanding contribution to the field, and her presentation will be published in the society's Journal 'Experimental Physiology'.

Tanser was a founding member of the Africa Centre for Health and Population Studies (now *Africa Health Research Institute*) and was responsible for building Africa's first comprehensive population-based geographic information system. He was awarded the *South African Medical Research Council's Gold Medal* as well as the *Royal Geographical Society's Back Medal* for conducting seminal research that has made an outstanding contribution to development of national and international public policy.

Squires has been a member of the Research Advisory Boards for Diabetes UK, Diabetes Wellness Network Sverige, Sweden 2016-2019, Diabetes Research & Wellness Foundation 2010-2016, and European Foundation for Study of Diabetes 2014. He was session Organiser for the 10th World Congress on Prevention of Diabetes and its Complications, Edinburgh 2018. Squires is a member of the European Association for the Study of Diabetes, Diabetes UK and British Society and is Fellow and University representative for the Physiological Society.

Law is Fellow of the Royal Society of Public Health and is committee member of UK Biobank Sleep & Activity. He is a member of NIHR East Midlands Research for Patient Benefit Programme Regional Advisory Committee.

Siriwardena gave the keynote at the North American EMS Physicians conference 2018 and invited lectures at British Sleep Society conferences, 2017 and 2019. He is a member of the 999EMS Research Forum international executive committee. He has chaired the Wales Centre for Primary and Emergency Care Research (PRIME Centre Wales) External Advisory Board since 2016 and was awarded an honorary professorship at the University of Cardiff in 2019. He has been member of NIHR East Midlands Research for Patient Benefit Programme Regional Advisory Committee since 2020 and HEE/NIHR Integrated Clinical Academic Programme's Clinical Doctoral Research Fellowship Scheme Selection Committee since 2019.

Expert committee memberships: **Bevan** is an expert international member and reviewer for National Medical Research Council, Singapore, steering committee member of International Stroke Genetics Consortium, member of the METASTROKE Consortium, and Heads of University Biosciences Steering Executive member; **Dixon** chairs East Midlands Branch of American Society of Microbiology and is member of the British Society for Antimicrobial Chemotherapy, Forensic Science Society, Microbiology Society, and Society for Applied Microbiology; **Singh** was Panel member on the EPSRC grant committee in 2018; **Tanser** is member of the International Scientific and Technical Advisory Committee to the director of UNAIDS; **Asghar** was Panel member on NIHR Infectious Disease Dynamic Modelling in Health Protection Call 2019. **Smith has been a member of NIHR East of England Research for Patient Benefit Programme Regional Advisory Committee since 2017.**

Unit staff have contributed to **conference organising committees**. In particular, **Herbert** was the conference organiser for Translation UK, Leicester, UK, 2014 and conference lead for Australian Islet Study Group Meeting, Melbourne, 2016; **Ngomba** is a member of the Scientific Committee for triannual international meetings on mGlu receptors (<https://www.mglu.it>) and was an invited speaker in 2020; **Law** was the treasurer of British Sleep Society and conference committee member from 2014-2019; **Siriwardena** is a member of the 999 Emergency Medical Services Forum conference organising committee; **Christie** was an organiser of the 9th European Conference on Tetraspanins Mainz, Germany, September, 2019.