

Institution: London School of Hygiene and Tropical Medicine
Unit of Assessment: 1

1. Unit context and structure, research and impact strategy

The London School of Hygiene & Tropical Medicine (LSHTM) is a specialist postgraduate institution. Its mission is to improve health and health equity worldwide, working in partnership to achieve excellence in public and global health research, education and the translation of knowledge into policy and practice.

LSHTM performs strongly on the world stage. In the 2020 Shanghai World Rankings it was placed third globally and first in the UK for public health. In the 2020 CWTS Leiden Ranking, the School was:

- fifth in the UK for research impact in all sciences based on the proportion of publications that belong to the top 10% most frequently cited publications
- first in the UK in all sciences for the proportion of female authorships, reflecting our commitment to equality and diversity
- ninth in the world, fifth in Europe and first in the UK in all sciences for inter-institutional collaborative publications
- sixth in the world, and first in Europe and the UK, for long-distance collaborative publications.

In May 2020, as the COVID-19 crisis deepened, Edurank named @LSHTM the most influential university Twitter feed in the UK and Ireland.

1.1. How research is structured across the unit

Our UOA1 submission (69.4 FTE, 77 staff) includes 100% of Category A eligible staff in the Department of Infection Biology, together with laboratory-based and clinical staff in the Departments of Disease Control and Clinical Research, in the Faculty of Infectious and Tropical Diseases (ITD). This represents a 23% increase in FTE on our 2014 submission. It includes staff working at the interface of basic laboratory science, clinical medicine, and public health, to progress knowledge and impact in infectious disease.

ITD comprises all LSHTM laboratory-based researchers and clinicians working on infectious diseases. It studies the biology of pathogens relevant to populations in low-and-middle-income countries (LMICs), their interactions with hosts and the diseases they cause, and the development and evaluation of control measures.

The Medical Research Council (MRC) Unit The Gambia (MRCG) and the MRC/UVRI Uganda Unit (MRCU) joined LSHTM in 2018, with status equivalent to Faculties. MRCG aims to reduce the burden of illness and death in LMICs. MRCU focuses on improving the control of infectious and non-communicable diseases in Uganda, Africa and globally. Unit staff are allocated across our two UOAs.

LSHTM has 14 School Centres which actively draw together expertise in priority areas (listed in full in REF5a). Those relevant to UOA1 include Malaria, Tuberculosis (TB), Genomics, AMR (antimicrobial resistance), Vaccines, MARCH (Maternal, Adolescent, Reproductive and Child Health) and Evaluation.

Research activity across LSHTM is centred on flexible and dynamic teams, often spanning Departments, Faculties and Units.

1.2. Research objectives during the assessment period and over the next five years, including review of unit's research plans in REF 2014

The assessment period encompassed two School-level strategy phases – 2012-2017 and 2017-2022 – with considerable continuity for UOA1, reflecting the overarching aims in our REF 2014 submission: to focus on areas of strength and prioritise research particularly benefiting from an interdisciplinary approach. We intended to achieve these by establishing the Bloomsbury Research Institute with University College London (UCL), including new infectious disease laboratories; building industry partnerships; and embedding research capacity for global health.

In 2019, LSHTM decided instead to consolidate and expand London-based laboratory research into co-located space at our Keppel Street site. The inter-connected space includes entomology, virology, bacteriology, parasitology and our Biological Services Facility. Co-location ensures optimum benefit from our unique expertise, e.g. enabling study of the full life cycle of vector-borne diseases including leishmaniasis and schistosomiasis. The integration of the MRC Units meant we adjusted our plans for embedding research capacity for global health. Nonetheless, our overarching aims remained intact, and we summarise progress below.

Malaria

Research was strengthened by the recruitment of Blackman, Moon and van Ooij. The integration of MRCG brought d'Alessandro and Ngwa. Grants included an MRC Career Development Award to investigate the red blood cell invasion pathways of *P. knowlesi* (£1.1m, 2015-2020); Wellcome Investigator Awards for analysing the cyclic nucleotide signalling pathway's role in malaria parasites (£0.7m, 2015-2021; £0.7m, 2020-2024); and a Wellcome Innovator Award to provide *in vivo* proof of concept for antimalarial drug development (£0.5m, 2019-2021).

Respiratory infections

Our TB research expanded, recruiting Cortes, Dheda, Kranzer and adding J Sutherland (MRCG). Research awards included a European & Developing Countries Clinical Trials Partnership (EDCTP) -funded trial to measure the impact of a TB/HIV intervention and evaluate new TB diagnostic tools (€12.9m, 2017-2021); a Wellcome Fellowship to investigate undiagnosed TB after TB/HIV case-finding in the community (£4m, 2016-2021); and a Horizon 2020 consortium to advance TB vaccine candidates from discovery to development (€25m, 2015-2019).

Enteric infections

Research increased considerably, supported by the recruitment of Allen, Gundogdu, Mostowy and N Thomson. Grants included a European Research Council Consolidator Grant (€2.7m, 2019-2024) and Wellcome Senior Fellowship (£1.8m, 2019-2023) for determining the role of septins in the innate immune response to *Shigella*; a Wellcome Collaborative Award to investigate norovirus (£2.8m, 2017-2022); and a Wellcome Investigator Award to analyse glycosylation in *Campylobacter jejuni* and *Vibrio cholerae* (£1.1m, 2014-2019).

HIV and other sexually transmitted infections (STIs)

HIV research was strengthened by the inclusion of Kaleebu (MRCU). Funding included a Wellcome Fellowship to test a community-based intervention's impact on virological suppression among HIV-positive adolescents in Zimbabwe (£3.1m, 2017-2022); an EDCTP-funded trial to develop an alternative treatment for cryptococcal meningitis in HIV-positive patients (€10m, 2017-2021); and an NIHR Global Health Research Professorship to improve adult meningitis management in African settings with high HIV prevalence (£2m, 2018-2023).

Neglected tropical diseases

The recruitment of Furnham and T Walker strengthened capacity. Grants included a Wellcome Fellowship to test novel treatments to reduce blindness from microbial keratitis (£3.1m, 2018-2023); a Wellcome Collaborative Award to improve treatment and prevention of Chlamydia trachomatis (£3.8m, 2017-2022); and an NIHR grant to improve outcomes for patients with stigmatising skin diseases in Africa (£5m, 2019-2023).

Emerging/re-emerging infectious diseases

The 2014 West African Ebola outbreak catalysed huge expansion of work in this area. We played a leading role in trials of the Ad26.ZEBOV and MVA-BN-Filo vaccines, funded by the Innovative Medicines Initiative: EBOVAC1 (€58.3m, 2014-2021), EBOVAC2 (€22.8m, 2014-2021) and EBOVAC3 (€29.4m, 2018-2023). The recruitment of Cotten and E Thomson increased genomics capacity. We were able to respond rapidly to COVID-19, with MRCG generating whole genome sequences of the first imported cases and investigating the disease's effects on pregnant women and newborns. MRCU supported sequencing in Uganda and studied genomic diversity of SARS-CoV-2; and London-based staff led a Bill & Melinda Gates Foundation-funded project in Kenya and Burkina Faso investigating malaria infection's effect on immune response to SARS-CoV-2 (£1.2m, 2020-2021).

Vaccines

Research into bacterial glycosylation led to Protein Glycan Coupling Technology (PGCT) – applied to develop inexpensive vaccines for human and veterinary use. Key awards included Biotechnology and Biological Sciences Research Council (BBSRC) funding for PGCT research (£4.3m, 2016-2021); the above-mentioned Ebola vaccine trials; and MRC-funded HPV vaccine trials in Tanzania (£3m, 2016-2022). LSHTM was a founding partner in the UK's first dedicated Vaccines Manufacturing Innovation Centre (VMIC), enabled by a £66m UK Research and Innovation (UKRI) investment in 2018; we are a partner on the UCL/Oxford Engineering and Physical Sciences Research Council (EPSRC) Future Vaccine Manufacturing Research Hub (£7.2m, 2018-22). Under the directorship of Kampmann, MCRG's vaccine theme lead, the Vaccine Centre expanded its internal and external contributions, notably developing an online tool to track development of COVID-19 vaccine candidates.

AMR

Our AMR Centre was launched in 2015, reflecting AMR's status as a new imperative. Key recruitments included Holt and Antonio (MRCG). Funding included an Economic and Social Research Council (ESRC) award on infection prevention and control for drug-resistant TB in South Africa (£1.7m, 2017-2021); a Foreign, Commonwealth and Development Office (FCDO) grant to study causes of fever in Africa and Asia (£10m, 2017-2022) and the Global Challenges Research Fund (GCRF) One Health Poultry Hub, led by the Royal Veterinary College (RVC), to monitor AMR and achieve sustainable poultry production in LMICs (£18.1m, 2019-2024).

1.3. Achievements in the REF period

We list below our major discoveries and innovations in our main areas of research, including delivery on intentions in our 2014 submission, and priorities for the next five years. Staff leading research teams are noted; our research overseas involves extensive collaboration with local partners.

Malaria (Baker, Blackman, Campino, Conway, Delves, Drakeley, Moon, Ngwa, Roper, C Sutherland, Tetteh, van Ooij, Wassmer)

- We have advanced understanding of parasite invasion into erythrocytes, including linking protection from severe malaria to natural variation in erythrocyte receptors, and demonstrating cAMP and PKA signalling's role in the invasion process.
- We found male and female *P. falciparum* gametocytes respond differently to antimalarial drugs, with implications for the design and efficacy measurement of transmission-blocking drugs.
- We linked a steep rise in human cases of *P. knowlesi* malaria in Malaysia to deforestation and environmental changes, and showed distinct parasite strains in humans are associated with different monkey reservoir host species.
- Future research will investigate downstream elements of cAMP signalling in blood-stage malaria parasites, determinants of parasite sexual commitment rates, and the quiescence of gametocytes, to identify drug targets. A dedicated new facility will study malaria transmission biology.

Respiratory infections (Ayles, T Clark, Corbett, Cortes, Dheda, Dockrell, Fletcher, Grant, Hibberd, Kranzer, J Sutherland)

- We identified a novel biosignature distinguishing TB from other respiratory diseases; and helped discriminate between latent infection and TB disease.
- We showed in a large trial in South Africa that mass testing and treatment were inadequate to interrupt TB transmission and that six months' isoniazid preventive therapy may be inadequate to cure latent TB among those heavily exposed to infection.
- We identified 62 single-nucleotide polymorphisms (SNPs) that discriminate known circulating Mycobacterium TB strains into distinct lineages. The resulting SNP-based "barcode" is the first to cover all the main lineages.
- Future research priorities include developing a human infection model to evaluate TB immunopathogenicity and vaccine efficacy; examining the contribution of subclinical TB to TB transmission; and investigating novel genetic determinants in the pathogenesis of invasive *S. pneumoniae* infections.

Enteric infections (Allen, CG Clarke, Dawson, Dorrell, Gundogdu, Mostowy, Stabler, N Thomson, Wren)

- We used zebrafish to study the cell biology of *Shigella flexneri* infection *in vivo*, discovering the role of septins in host defence against bacterial infection.
- We discovered *Clostridium difficile* produces a unique compound, para-cresol, which prevents other bacteria growing. The largest-ever genomic study of *C. difficile* found it was evolving into two separate species, one highly adapted to hospital spread.
- We identified the sources and routes of transmission of epidemic cholera over a 50-year period, supporting the development of approaches to reduce global cholera burden.
- We discovered the importance of the unfolded protein response in Campylobacter disease and determined mechanisms by which Campylobacter colonises poultry.
- Future research priorities include investigating the mechanisms underlying the assembly of septin cages in the innate immune response to Shigella; developing a pre-clinical antimicrobial compound against *C. difficile*; and poultry vaccines to reduce Campylobacter in the food chain.

HIV and other STIs (Ayles, Corbett, Ferrand, Jarvis, Kaleebu, Mabey, Mayaud, Watson-Jones)

- We showed support visits by community health workers significantly reduced deaths and increased viral suppression among HIV-positive children in Zimbabwe. We also demonstrated the feasibility of community-based STI testing of 16-to-24-year-olds.
- We demonstrated that HIV self-testing in Southern Africa was safe, accurate and cost-effective.
- We found a high prevalence and incidence of HPV infection in Tanzanian young women shortly after sexual debut, paving the way for the first sub-Saharan Africa HPV vaccine trials.

- Future research will evaluate the effectiveness of community-based services among adolescents and young people. The PrEPVacc HIV prevention study in Uganda will evaluate two experimental HIV-1 prophylactic vaccine regimens.

Neglected tropical diseases (Burton, Croft, Furnham, Hibberd, Holland, Kelly, Lewis, Mabey, S Walker, T Walker)

- We changed World Health Organization (WHO) policy by finding its recommended surgery to correct trachomatous trichiasis produced worse outcomes than an alternative procedure.
- We showed in a community randomised trial in 3 African countries that twice yearly mass treatment with azithromycin, used for trachoma control, reduced all cause under 5 mortality.
- We supported the control and elimination of visceral Leishmaniasis in six countries and informed mass distribution of azithromycin for trachoma in 29.
- We developed an *in vivo* model to investigate the progression of Chagas disease and test drug effectiveness.
- Future research aims to improve outcomes for patients with stigmatising skin diseases and use genomics approaches to develop novel treatment for dengue.

Vaccines (Cuccui, Elliott, Fletcher, Kampmann, Roy, Watson-Jones, Wren)

- We identified changes in gene and protein expression, and metabolites in the first seven days of life, relevant to understanding health and disease in babies and improving newborn vaccines.
- We developed Protein Glycan Coupling Technology (PGCT) for producing inexpensive glycoconjugate vaccines for human and veterinary use; this led to the establishment of the spin out ArkVax.
- We completed the first HPV vaccine trials in sub-Saharan Africa, demonstrating high-coverage in schools.
- Future research will include exploiting PGCT to develop and produce vaccines against the human pathogens *S. pneumoniae*, Group A Streptococcus, *Francisella tularensis*, Shigella; and testing the population-level impact of giving HPV vaccines to boys.

AMR (Antonio, Grant, Holt, Stabler, N Thomson)

- We examined health worker practices and health worker/patient perceptions of infection risk in South Africa, leading to interventions to prevent transmission of drug-resistant TB.
- We recommended improved surveillance approaches after studying methicillin-resistant *Staphylococcus aureus* transmission dynamics in healthcare and community settings in England.
- We demonstrated that *Klebsiella pneumoniae* is a key trafficker of drug resistance genes from environmental to clinically important bacteria.
- We compared bacteria isolated from livestock and retail meat with those responsible for bloodstream infections in the UK, demonstrating that human infections were probably not derived from livestock.
- Future research will focus on One Health themes, including the impact of increased poultry production in LMICs. We will also develop tools to identify genetic regions associated with drug resistance in TB and malaria.

1.4. Enabling impact

Our approach to impact has been built on four main elements, outlined below and illustrated through our case studies (italicised in brackets) where appropriate.

Generic activities designed to support staff to achieve impact

Our Communications and Engagement Department helped increase understanding, shape public debate and influence policy, practice and behaviours around health. Our researchers made frequent media appearances to explain COVID-19 developments. Our events team supported major dissemination events, including Global Health Lab public debates co-hosted with *The Lancet*.

Our School Centres (REF5a) helped ensure our impact case studies benefited from shared expertise and external networks. They also supported communication of research findings and interacted with stakeholders, including all-party parliamentary groups (e.g. malaria, TB, global health).

Maximising research's reach and influence by encouraging external engagement has been a key strategic priority. Dissemination activities and seeking policy and practice impact are explicit expectations in our promotion criteria. Our HR policies have supported staff to be based overseas (16 in UOA1), where they can interact closely with local research users.

We enhanced support for translational research and innovation, forming an Innovation Committee and winning a Wellcome Institutional Translation Partnership Award. Increased Higher Education Innovation Fund (HEIF) income from Research England further strengthened activities.

Support to spinouts ensured the translation of ideas and knowledge into innovative products and services. For example, Peek Vision, a social enterprise providing sustainable access to eye care, was built on the work of Burton and Bastawrous (UOA2) and spun out in 2015 (*Smartphone technology for innovative targeted treatment of poor vision and blindness*). Cuccui and Wren established ArkVax (2020), using novel technology to develop low-cost veterinary vaccines.

Mechanisms to help build long-term relationships with research users

We encourage academic staff to engage with global, regional, national and local organisations that shape health policy and practice (see section 4.7). For example:

- Our close relationships with WHO have supported policy and guidance. Our expertise on azithromycin, used for trachoma control, led to further LSHTM studies showing azithromycin reduced all-cause child mortality, which informed a 2020 recommendation on mass treatment of children with azithromycin to reduce under-5 mortality in sub-Saharan Africa (*Eliminating trachoma via azithromycin*).
- Our industry engagement included collaborations with the Medicines for Malaria Venture (MMV) to screen lead compounds for activity against non-falciparum malaria, leading to studies to develop novel antimalarial drugs with MMV and Salvensis.

We hosted two UOA-1 relevant WHO Collaborating Centres, which support WHO programmes:

- Our WHO Collaborating Centre for STIs worked on preventing cervical cancer, improving progress towards elimination of mother-to-child transmission of HIV and syphilis (*Preventing newborn mortality due to syphilis*), point-of-care testing for STIs and interventions to improve STI control.
- MRCG's WHO Collaborating Centre on New Vaccines Surveillance supported African countries, e.g. by quantifying the burden of invasive bacterial diseases to inform vaccine introduction and impact measurement.

Activities relating to specific research projects and programmes

Researchers often feed their findings into policy and practice discussions to generate impact. For example:

- Researchers who developed the Portable Eye Examination Kit (Peek) engaged with NGOs and country eye health programmes to support its use (*Smartphone technology for innovative targeted treatment of poor vision and blindness*).
- MRCU HIV researchers helped develop national treatment guidelines on antiretroviral regimens.
- MRCG researchers conducting trials on pneumococcal conjugate vaccines informed the Gambian vaccination programme, and their real-time research informed the Gambian government's response to COVID-19.

Impact via learning and understanding

There is a deliberately close match between our research and our Masters, doctoral and short-course programmes.

We provide a huge range of MSc modules offering the latest knowledge in particular fields. For example, our Master's module on HIV features work on new diagnostics including HIV self-testing, and the use of rapid diagnostic tools Xpert and lateral flow lipoarabinomannan for TB in HIV-positive people.

Our short-course programmes also share research knowledge; e.g. the Applied Genomics Centre has provided training in genomic epidemiology and data analysis.

In 2015 we introduced Massive Open Online Courses (MOOC). Examples include the International Centre for Eye Health's Open Education for Eye Health Programme, which has reached over 23,000 people in 188 countries and territories; one evaluation found training had influenced the practices of 85% of participants.

Research programmes featuring educational materials as specific outputs have included the 'Her Life Matters' campaign, which grew out of the WOMAN trial to educate the public about the number of LMIC women bleeding to death after giving birth. Individuals were encouraged to lobby MPs to prioritise reducing maternal mortality (*Repurposing tranexamic acid as a life-saving treatment for severe bleeding*).

Shaping and adapting plans to ensure they continue to support the vitality and sustainability of unit's impact in the future

We will continue our multi-pronged approach to achieving impact, reshaping it in light of experience and new opportunities – including digital developments.

In recent years we have focused on supporting translational research activities through a dedicated staff member in the Strategic Research Office (SRO) and the appointment of an Intellectual Property Manager. Funding from HEIF and the Wellcome Institutional Translational Partnership will be used to enhance our approach through competitively awarded small grants, training and support.

We will continue to engage with policy and practice communities in the UK and globally, including through membership of WHO Advisory Committees, local Technical Working Groups, UK advisory bodies and our WHO Collaborating Centres.

1.5. Unit's approach to supporting interdisciplinary research in the context of unit's research strategy

Interdisciplinary research is an acknowledged LSHTM strength. In UOA1 this involves integrating expertise in epidemiology, clinical medicine and trials, parasitology, virology, bacteriology, immunology and genomics, plus collaborations with UOA2 researchers in areas including entomology, statistics, health economics and mathematical modelling. Our Centres support this activity, and we also ensure minimal barriers to cross-department working.

As a Centre example, the Malaria Centre brings together researchers in fields ranging from basic laboratory science to social science. Discussions in 2019 catalysed plans among parasitologists, entomologists and immunologists, leading in 2020 to a successful bid to Wellcome for a dedicated malaria transmission biology suite.

As a cross-department example, the ESRC-funded 'Umoya Omuhle' project used a whole systems approach to identify interventions to reduce TB transmission within primary health care clinics in South Africa. Rather than presenting parallel, disciplinary-specific findings on barriers to infection control, evidence-informed group modelling by researchers across UOAs (e.g. clinical and social scientists, epidemiologists, mathematical modellers), practitioners and policymakers was used to build common understanding and identify feasible solutions to improve infection control.

1.6. Open research environment

Principles of open research are instilled in all researchers, supported by our Library and Archives Service. Our 2017 Open Access Policy mandated open-access for all research outputs.

Our research data management service offers in-depth advice and maintains our Data Compass repository, where data are discoverable, accessible and re-usable. The repository held over a thousand datasets by 2020.

In the 2020 CWTS Leiden Ranking indicators for all sciences, 90.7% of our publications were open-access, placing us second in the UK and third in the world for this indicator. This achievement underlines our successful commitment to and support for an open research environment, as does the fact that our modellers and statisticians routinely post online their statistical packages, R codes, and models.

Our Academic Expectations and Promotions Guidance make clear that all types of research output are valued and all, including underpinning data, should be made freely available at the earliest opportunity.

1.7. Research Integrity

Our Research Governance Committee oversees relevant policies and procedures and our ethics committees; promotes best practice; ensures effective monitoring and reporting arrangements for investigating allegations of research misconduct; and receives reports of research governance audits/inspections and monitors our responses.

The Research Governance and Integrity Office (RGIO), expanded during the assessment period, provides the secretariat to the Committee and ensures research is conducted in accordance with good practice, professional frameworks and relevant legislation everywhere we work. These commitments are underpinned by a Good Research Practice policy, which follows guidance from UKRI and the UK Research Integrity Office and conforms with the Concordat to Support Research Integrity.

Procedures and templates are available to help researchers develop compliant protocols. Clinical trials, projects involving human tissue, and tissue storage facilities are regularly audited by RGIO to

ensure compliance with study protocols, regulations including the Human Tissue Act, and other LSHTM policies.

International projects require approval from the relevant partner country's ethics committee; clinical trials of investigational medicinal products or medical devices also require approval from the relevant regulatory authority. A new Commercialisation and Rapid Response Committee was established to review research projects where quick turnaround times are needed.

The MRC Units have their own ethics review processes, with projects fast-tracked through central committees to ensure oversight. LSHTM's ethics training was made available online in 2019.

We are a signatory to the Concordat on Openness on Animal Research. Laboratory rodents – mostly mice – and zebrafish are used in the small proportion of laboratory research which requires animals.

2. People

2.1. Staffing strategy and staff development

2.1.1. Staff development strategy

LSHTM is a signatory to the Concordat to Support the Career Development of Researchers and was awarded the EU HR Excellence in Research Award in 2019. As part of the award, we established a Research Staff Forum to work alongside the Concordat Monitoring Group.

Our Talent and Educational Development (TED) team and SRO oversee researchers' career development. TED is responsible for professional development and improving skills. SRO provides support to early- and mid-career researchers with fellowship applications.

Since 2015, when SRO was established, fellowship and personal award applications have notably increased, with a 40% average success rate. In 2019-2020, LSHTM ran 311 in-house training workshops, with 3,098 places filled. 43% were offered virtually.

In 2017 LSHTM launched a Pathway to Academic Leadership Programme. Over 80% of participants reported this developed their leadership confidence. Senior staff also benefit from external training opportunities, such as the leadership programmes of Wellcome, NIHR and the Academy of Medical Sciences.

In 2015, drawing on the Vitae Researcher Development Framework and Advance HE's UK Professional Standards Framework, we created our Academic Expectations, setting performance criteria at each grade and in four categories: knowledge generation, education, internal contributions and external contributions. We introduced Professorial bands to ensure fair pay and expectations and explicitly described how personal circumstances would be considered.

Our promotion cycle is reviewed annually, scrutinizing applications and outcomes by gender and ethnicity. In 2020 we enhanced guidance on adhering to our San Francisco Declaration of Research Assessment commitment and further stressed the value of a supportive academic environment.

Our annual online Performance and Development Review assesses whether objectives have been met and agrees goals and activities for the coming year. Completion rates increased from 63% in 2018 to 78% in 2019.

The School runs a mentoring programme, open to all staff. It was evaluated and relaunched in 2018 and is complemented by mentoring in research groups and Departments.

2.1.2. Clinical academics

Eleven clinical academics in UOA1 hold honorary consultant contracts or joint academic NHS appointments. We support the career development of clinical researchers through NIHR awards. Since 2014 there have been nine Academic Clinical Fellowships and seven Academic Clinical Lecturers in infectious diseases. We lead a consortium of 5 universities which in 2016 was awarded a Wellcome Clinical PhD Programme in Global Health Research.

Our academic expectations allow for time spent in clinical duties. We collaborate closely with the NHS, including with University College London Hospital. We joined the board of UCLPartners in 2013 and are part of its Academic Health Science Centre.

2.1.3. Staffing and recruitment policy

Our REF submission includes all staff at Assistant (17), Associate (27) and Professor (37) grades who have significant responsibility for research.

LSHTM's Recruitment and Selection Procedures ensure new staff are selected via a fair, transparent process. Our promotion process ensures junior researchers' achievements are recognised, and an average of 7% of each grade pool are promoted each year.

Joint appointments have been used to support partnerships, including with the Francis Crick Institute, Wellcome Sanger Institute, and universities of Glasgow and Cape Town.

In 2017, a 'big splash' recruitment drive led to Professorial and junior supporting appointments in a range of strategic areas (see section 1).

2.1.4. Fixed-term contracts

LSHTM reviewed fixed-term contracts for Professors in 2014, reducing the proportion of female fixed-term Professors from 53% to 0%. In 2016 all staff at Associate Professor level and above were reviewed for transfer to permanent contracts, leading to a sharp reduction in Associate Professors on fixed-term contracts.

35% of UOA1 staff are on fixed-term contracts, mostly linked to time-limited grant funding. Fixed-term contract levels by gender are monitored in fulfilment of commitments to Athena SWAN awards, and ethnicity monitoring was added in 2020.

2.1.5. Support to early-career researchers

We nurture early-career researchers (ECRs) through individually tailored activities, including reviewing grant proposals, pump priming grants and facilitating external research/policy links. Two major funders – MRC and Wellcome – have established career frameworks, which we use as points of reference. SRO, TED and our Careers Service support staff exploring career options outside academic research.

UOA1 staff and their team members won 27 fellowships and personal awards during the assessment period. Five have subsequently been promoted internally. We won several training awards, including two Doctoral Training Partnerships relevant to UOA1 (MRC, BBSRC) and our Wellcome Clinical PhD Programme.

Research Assistants and Research Fellows can register for an LSHTM doctorate at a reduced fee. In 2019-2020 19 such staff working with UOA1 researchers were registered, benefiting from the creation of our Doctoral College in 2018. All ECRs and postdoctoral research staff can freely access our MSc modules and in-house TED programme.

In 2018 we initiated a biennial internal fellowship scheme for researchers at the transition to mid-career stage. So far eight fellows have received 18 months' support. In addition, 35 pump priming grants have enabled Research Fellows and Assistant Professors to undertake small research projects. In 2019 we set up an Early-Career Researcher Network to assist with professional development and networking, training and funding opportunities.

The MRC Units share in the above initiatives. They also have their own systems of support for ECRs.

MRCG is a regional training hub for West Africa, nurturing young talent through internships and technical positions. Its leadership and development programme for PhDs and postdoctoral fellows had supported 10 early- and mid-career scientists to attract grants by 2019. The Unit hosts the

African Research Excellence Fund, established by MRC to invest in emerging researchers. MRCU has similarly strong capacity-strengthening programmes.

LSHTM played a key role in seven Wellcome/Alliance Developing Excellence in Leadership, Training and Science (DELTAS) Africa programmes; the DELTAS award led by Elliott has provided career paths to Ugandan and East African scientists – with several alumni achieving leadership roles at institutions in the region.

2.1.6. Research, impact and sabbatical leave

Assistant Professors and above with five years' continuous service can apply for study leave of three to eight months. Most academic time is spent on research, so take-up is relatively low.

2.1.7. Exchanges between academia and business, industry, public or third-sector bodies

Requests for exchanges and secondments are welcomed. Staff seconded to policy and implementing agencies include Whitty (Department for International Development, Chief Scientist, 2009-2015; Department of Health and Social Care (DHSC), Chief Scientific Adviser, 2017-2018; HM Government, Chief Medical Officer for England, 2019-present). Shared appointments include D Schellenberg (WHO Global Malaria Programme, Scientific Adviser) and Fletcher (UKRI, Director of International Development).

2.1.8. Rewarding research and impact

We recognise and reward research and impact in the following ways:

- Our Academic Expectations and Promotions Guidance state how research and impact are valued and how achievements can be evidenced to support career progression.
- Our internal staff newsletter, *Chariot*, highlights research successes and has Centre/Publication of the Month features.
- LSHTM's website publicises impactful research publications, thought leadership, awards and honours.
- Our annual LSHTM Week showcases research, innovation and impact.
- Faculties, Departments, Units and Centres regularly celebrate successes via their own newsletters and research days.
- Launched in 2018, our Director's Awards include categories covering individual and team performance, ECRs and public engagement.

2.2. Research students

2.2.1. Doctoral study environment

A Doctoral College was launched in 2018, encompassing MPhil/PhD and our professional Doctorate in Public Health (DrPH). We launched a joint doctoral training programme with Nagasaki University in 2017. We also support the development of doctoral training overseas (see 2.1.5).

LSHTM doctoral students represent 70 countries. In 2019-2020 48% were over 36 years old (sector average: 22%), 67% were part-time (24%), 40% were from a BME background (18%) and 8.4% declared a disability.

Staff undertaking PhDs made up 31% of the UOA1 doctoral student body in 2019-2020. In 2019 a PhD-by-publication route was introduced to enable researchers with significant experience to prepare and submit a PhD within 6-18 months, based on work already completed.

Our most recent PRES results show improvements in almost all areas. Our research culture score increased most and we scored particularly well compared to others. There was 90% reported satisfaction with supervision.

2.2.2. Recruitment into Doctoral Training Programmes

We advertise all funded studentships. These include Doctoral Training Programmes and individual opportunities. Our Capacity-Strengthening Research Degree Scheme has provided highly subsidised fees for LMIC students employed by 15 major overseas partners.

We were members of the following multi-institution Doctoral Training Programmes during the assessment period (LSHTM studentship numbers in brackets):

- The BBSRC London Interdisciplinary Doctoral Programme supported projects in basic biology (2-4 p.a).
- The MRC London Intercollegiate Doctoral Training Partnership supported research on global infectious diseases and evaluation of complex interventions (5 p.a.).
- The Wellcome Clinical PhD Programme in Global Health Research supported fellows in global health (2-3 p.a.).
- The Bloomsbury Colleges PhD Studentships offered interdisciplinary research opportunities with joint supervision across two institutions (2 p.a).

Annually, via a competitive selection process, MRCG has recruited three/four PhD students funded by the MRCG Doctoral Training Programme. Opportunities arising at MRCU are awarded on a competitive basis; staff have also supported students at Makerere University. Staff at both Units can access LSHTM doctoral degrees at discounted fees.

2.2.3. Support, monitoring and progression

In the assessment period we enhanced requirements and monitoring systems for student supervision, and ensured regular progress monitoring by a Departmental Research Degree Coordinator to improve progression.

2.2.4. Skills development and preparation for future career

Our Doctoral College's programme includes in-house training and shared courses in the Bloomsbury Postgraduate Skills Network, enabling doctoral students to acquire skills in Vitae's Researcher Development Framework. Many doctoral students have contributed to our Masters teaching.

DrPH students study two specific modules during their first term and complete an organisational and/or policy analysis, the latter usually involving three to six months' study, to equip them for their future professional career.

2.2.5. Integration into research culture

Doctoral students are considered full Department members. They are invited to meetings, seminars and social events and welcomed by Centres. Many already have a wealth of experience, which enhances the integration process.

Work-in-progress seminars involving staff and students were run at research team, Department and Faculty levels during the assessment period, augmenting the more formal upgrading and pre-viva seminars and the annual doctoral student poster day. Students were also encouraged to submit work to external conferences and seminars, with funding available to support attendance. Doctoral students were represented on our Research Culture Working Group.

2.3. Equality and diversity

2.3.1. LSHTM's commitment

LSHTM is committed to an inclusive research environment. As stated in our Equality, Diversity and Inclusion (EDI) Strategy, our vision is 'to embrace and value the diversity of the staff and student population and to embed equality and diversity activities as an essential element in enhancing our contribution to the improvement of health worldwide'.

We explored EDI issues in staff surveys in 2015, 2017 and 2019 and through an in-depth qualitative study. These led to a framework for enhancing leadership, values, culture and wellbeing. Staff's engagement with Decolonising Global Health (DGH) and Black Lives Matter (BLM) networks further underlined the importance of keeping EDI central to everything we do.

We reformed our EDI Committee in 2020. In developing its action plan we have drawn on surveys and follow-up activities, DGH and BLM testimony, Athena SWAN submissions, external focus groups, ongoing discussions, data analysis and progress against our previous strategy. We are committed to continued, positive change.

2.3.2. Arrangements for supporting flexible and/or remote working

Our policies and practices support flexible working arrangements. Options include part-time work, flexible hours, job-sharing, term-time contracts and remote working.

We provided extensive support during the COVID-19 outbreak, supporting managers and their teams to balance work with caring responsibilities. Requesting leave to manage commitments, or 'making up' missed hours, were not required. Equipment for ergonomic working was paid for by School or project funds.

We especially emphasised mental health and wellbeing. To maintain our sense of community, all LSHTM communications and events continued online. We held regular webinars with all staff, attracting up to 600 participants.

A June 2020 survey reported 90% satisfaction with line management support, plus increased trust and collegiality. New initiatives have since been implemented to address concerns such as burnout and isolation, and mixed home and office working, a preference of 66% of academic staff, is being piloted.

2.3.3. Career pathways for part-time and fixed-term staff

We have a structured, single career path for academics, progressing from Research Assistant to Professor. The promotions process runs annually, and Heads of Department are tasked with ensuring anyone – regardless of FTE and contract length – can apply.

In 2018 an external consultant reviewed our promotion decisions for part-time staff and found no evidence of disadvantage. Our Academic Expectations and Promotions Guidance clearly state how personal circumstances, including part-time working, are allowed for. Our UOA1 submission includes 14 part-time staff (18% of the submission).

2.3.4. Taking equality and diversity into account in structures and processes

EDI principles are embedded throughout LSHTM's training provision; we also run EDI-specific workshops. An online Report & Support tool was launched in 2020, enabling staff and students to report bullying or harassment.

We monitor our research workforce's diversity as part of an annual, publicly available report. This presents data across protected characteristics, highlights activities supporting EDI and identifies areas for further investigation and action.

Recruitment panels and promotion committees must have diverse membership. Promotion data are analysed by gender and ethnicity after each round and made available to all staff via *Chariot* and included on promotion committees' agendas.

LSHTM has introduced several career re-entry fellowships, complementing external schemes. Since 2014, ITD has awarded ten Athena SWAN Career Restart Fellowships for Carers.

Gender

Our UOA1 submission is 30% female and 70% male. LSHTM's Athena SWAN bronze award was renewed in 2018, as was ITD's.

School-wide data show that women became equally represented at the associate professor grade at the start of the assessment period, and achieved this for the entry band for professors (Band C) in 2017/18. In Bands B and A, the share of women increased from 31% in 2014/15, to 35% in 2019/20. We seek further improvement through targeted support to women nearing the point of promotion to professor and progressing through the professorial bands, and especially in ITD where gender balance has improved more slowly than in other Faculties.

Recruitment data show women were more likely to be appointed than men overall, but relatively fewer women applied to advertisements for higher academic grades.

School promotion data 2017-2020 show women and men each had slightly higher application success rates for promotion to grades where they were less represented (Associate Professor and Professor for women, Research Fellow and Assistant Professor for men).

Promotions by gender (2017-2020) from grade of:	% pool applied		% pool promoted		% applications successful	
	Women	Men	Women	Men	Women	Men
Research Assistant	14	6	9	6	69	100
Research Fellow	12	9	7	7	64	78
Assistant Professor	10	16	6	8	60	53
Associate Professor	12	10	9	5	75	50

MRC, one of our largest funders, reports gender-specific data on our applications annually. The number and share of applications, and successful applications, from female LSHTM staff have increased over time. Our gender balance exceeds that of all other universities applying to MRC. The 2020 CWTS Leiden Ranking named LSHTM the UK's top university in all sciences for the proportion of academic research with women listed as authors (48.1% LSHTM).

We attribute these improvements to various activities to support female progression, including active Athena SWAN committees, extensive development programmes for women, supporting eight women each year on the Advance HE Aurora Programme, SRO investment to support career progression, and mentoring by leading female academics.

Ethnicity

Our UOA1 submission is 77% white, 18% BME, and 5% not declared.

In 2018 LSHTM funded archival research to explore its colonial legacies. Progressing race equality has been a key focus in developing our new EDI action plan, and all staff are required to undergo mandatory EDI training.

School-wide data show that in 2020, 29% of Research Assistants identified as BME, but this decreased to 15% at Professorial level. There was an increase in the proportion of BME staff at all grades between 2015 and 2020, though to a lesser degree for higher grades. Recruitment data show white applicants were more likely to be appointed than BME applicants, and analysis by grade shows fewer BME applicants for higher academic grades.

School promotion data for 2017 to 2020 reveal similar application success rates for BME and white staff for promotion to Research Fellow and Professor, with lower application success rates for BME staff at Research Fellow and, in particular, Assistant Professor level.

Promotions by ethnicity (2017-2020) from grade of:	% pool applied		% pool promoted		% applications successful	
	BME	White	BME	White	BME	White
Research Assistant	11	12	8	8	73	73
Research Fellow	10	10	6	8	59	73
Assistant Professor	15	11	5	7	32	65
Associate Professor	17	10	11	7	64	64

Observers invited to attend Faculty and School staff review committees in 2020 found all applicants received a fair hearing and constructive feedback. A recommendation that EDI contributions be more strongly embedded in reward and recognition criteria is being taken forward, along with strengthened positive actions to support BME staff career development.

LSHTM has reaffirmed its commitment to ending racial injustice and racial disparities in public health. DGH and BLM members have addressed our Council, and a new Council Committee on Diversity and Inclusion monitors structural and cultural change. The School is undertaking Race Equality Charter self-assessment.

Other protected characteristics

LSHTM supports parental and adoption leave. Staff and line managers are encouraged to use Keeping in Touch days and benefit from training and development opportunities. Our maternity return rate for academics is 92% (sector benchmark: 88%).

We are a Stonewall diversity champion. Our LGBT and Friends Network hosts a range of LGBT+ events, open to all. Trans identity is included in our Anti-Bullying and Harassment Policy and in training on respectful working cultures.

3% of UOA1 staff declared a disability. LSHTM is a Disability Confident Employer and is working to become a Level 3 Disability Confident Leader. We are a certified user of the Two Ticks Disability Scheme. Our International Centre for Research on Disability works extensively with people with disabilities and has a work experience scheme for students with disability.

2.3.5. Supporting the wellbeing of staff and research students

In 2017 LSHTM achieved the London Healthy Workplace Charter Award and signed the Time to Change Pledge, which recognised our action plan to end mental health discrimination in the workplace. We have also set up a Mental Health Network of staff volunteers and a team of Mental Health First Aiders. LSHTM's Wellbeing Committee coordinates efforts in collaboration with our EDI Committee.

We provide free counselling to all staff. Occupational health support has been increased. Wellbeing resources offered during the COVID-19 outbreak have included a Microsoft Teams site for parents and carers, and dedicated disability resources. LSHTM's Student Support Services offers confidential support and advice for students on non-academic issues, including counselling, disability and dyslexia support, and a financial hardship fund.

2.3.6. REF Code of Practice

Our Code of Practice was drafted to ensure an inclusive process. It enabled us to identify all independent researchers and the outputs produced by Category A eligible staff across all protected groups and with individual circumstances that may have constrained their ability to undertake research during the assessment period.

A mock REF scoring exercise for outputs was conducted, with the scoring profile and number of outputs allocated to submitted staff compared with the equality profile of submitted staff at those grades. This was done to determine whether the outputs from any groups in relation to their protected characteristics were underrepresented in the final submission. Analysis of the submitted outputs by gender, ethnicity and disability demonstrated that no groups were underrepresented. Equality Impact Assessments of the outcome of the exercise and the preparation for final REF submissions were also undertaken.

3. Income, infrastructure and facilities

3.1. Research funding

LSHTM's grant portfolio grew during the assessment period, with research income in UOA1 of £10.9m in 2013-2014 and £45.2m in 2019-2020. The total value of the 43 new grants awarded to UOA1 staff in 2019-2020 was £30.7m.

UOA1 research income increased overall by 314%:

- EU funding increased by 913%, especially reflecting the Ebola vaccine trials
- DHSC and FCDO income increased by 420%
- UKRI income increased by 200%, reflecting our success with GCRF and the incorporation of the MRC Units
- UK charity funding, mainly from Wellcome, increased by 59%

We frequently receive awards as the lead institution and transfer funds to partners, usually in LMICs. The average research income per FTE submitted staff member in 2019-2020 was £650,696. We have attracted substantial awards to evaluate major innovations and ensured the inclusion of funds for dissemination and policy engagement.

We have used allocations from Research England's QR GCRF, HEIF and QR Strategic Priorities Fund to amplify impacts achieved from grant funding. Internal funding calls have awarded small grants to staff to translate research into benefits beyond academia. We dedicated a proportion of QR GCRF funding in 2019-2020 to support COVID-19 projects in LMICs.

3.2. Organisational infrastructure supporting research and impact

Our SRO supports academics in identifying funding opportunities, developing grant applications and coordinating institution-level strategic applications. It runs Funder Showcases and an annual Fellows' Showcase and is responsible for knowledge exchange, international partnerships, implementing QR GCRF and HEIF strategies and managing institutional grants. It has five staff, including a position supporting impact work.

Our Research Operations Office manages LSHTM's portfolio of external funding. The team increased from 20 to 34 between 2017 and 2019 and managed 1,000 applications and a UOA1 portfolio of 194 active grants, worth £243m, in 2019-2020.

We enhanced support to staff in communicating research. We have over 150,000 followers across Twitter, Facebook, Instagram and LinkedIn, and our monthly external e-newsletter now has over 15,000 subscribers and open (36.4%) and click-through (21.3%) rates far above sector averages (17.4% and 2.6% respectively).

In 2015 we introduced a Research in Action feature series, which was highly commended at the 2017 Medical Journalists' Association Awards. We have also provided support for staff to demonstrate thought leadership via external media. More than 20,000 pieces of LSHTM coverage were generated each year across print, online and broadcast media globally.

LSHTM has developed an inclusive strategy to embed and facilitate public engagement. In 2017 a UKRI SEE-PER (Strategic Support to Expedite Embedding Public Engagement with Research) grant supported a School-wide survey of attitudes and needs around this goal. Our public engagement action plan developed new training, networks and champions.

The MRC Units' incorporation enhanced synergies between Units and LSHTM research groups. Unit scientists can apply for the award of an academic title, bringing attachment to a Department and Faculty; School funding has been used to support two-way visits and seed funding for joint projects; and Unit staff have enriched Centres' activities.

3.3. Operational and scholarly infrastructure

UOA1 research is housed across the LSHTM estate. It encompasses London-based staff at our Keppel Street (ITD) site; MRCG staff at the Unit's three campuses with state-of-the-art facilities; and MRCU staff at the campus of the Ministry of Health's Uganda Virus Research Institute (UVRI) in Entebbe, which includes research clinics and laboratories.

In 2017 the School's Council agreed a programme to increase space and renovate old buildings. £23.6m was spent between 2017 and 2020, with £38.6m committed to further phases. Key work completed during the assessment period included new insectaries for entomology research; refurbishment of the bacteriology laboratories; and a new entomology laboratory at MRCG. Further details are listed in section 3.6.

LSHTM is committed to achieving carbon neutrality by 2020 and factors environmental sustainability into all its operations. The biggest solar power generation system of its kind in the Gambia was completed at MRCG in 2019. We have invested in new virtual conferencing facilities and rolled out related software to all staff as an alternative to business travel.

These and other changes resulted in the following:

- A 42% reduction in Scope 1 and Scope 2 carbon emissions between 2012/13 and 2018/19
- Increased recycling rates – from 54% in 2016/17 to 66% in 2018/19
- An 18% reduction in water consumption between 2016/17 and 2018/19
- A 66-place rise in the People & Planet University League between 2016 and 2019

Chariot Innovations Ltd, a wholly owned subsidiary of the School, was launched in 2013 as an incubator for spin-out companies established by LSHTM academics. During the assessment period we enhanced support for translational research and innovation by recruiting a new Intellectual Property Manager and an SRO staff member to support funding applications, and filed nine patents for new inventions.

Our School Library has extensive collections of print and electronic material. Evaluations and ongoing acquisition policies ensure resources are relevant. The Library and Archives Service offers advice on literature searching and systematic reviews and is responsible for our open-access research repository (LSHTM Research Online) and our research data repository (LSHTM Data Compass). Staff provide guidance on open-access publishing and research data management. In 2015 we became fully compliant with the EPSRC Policy Framework on Research Data.

LSHTM runs high-performance computing clusters in London and at each MRC Unit. We reviewed our facilities in 2019 and agreed additional staffing.

3.4. Equality and diversity considerations in infrastructure

Our new buildings provide accessibility solutions not available in our Grade II listed premises. Enhancements include more wheelchair-accessible toilets, asymmetrical door sets and coloured plug sockets for the visually impaired.

Our flexible working policy and remote access support enables researchers to work from home to help manage caring and related responsibilities. Our TED and Technology-Enhanced Learning teams have developed various materials to support digital accessibility, include training in best practice when designing resources.

3.5. Use of infrastructure, facilities and expertise in impact activities

Before COVID-19 we used our central London facilities to host our own and others' events. Notable examples during the assessment period included:

- The launch of the AMR Centre, featuring the Chief Medical Officer for England

- High-profile talks in our annual Women in Science series, including a lecture by then WHO Director General Margaret Chan
- The John Snow Annual Pumphandle Lectures, featuring (among others) Joanne Liu, International President of Médecins Sans Frontières, and Richard Horton, *The Lancet* Editor in Chief

Although the event was not held at our own facilities, in 2018 LSHTM hosted the second Women Leaders in Global Health conference. Over 900 participants from 70+ countries of residence attended. Speakers included Soumya Swaminathan, WHO Deputy Director General for Programmes, and Sally Davies, then Chief Medical Officer for England.

3.6. Specialist research infrastructure and facilities

In 2019 we consolidated most of our London-based infectious diseases laboratory research into one department, the Department of Infection Biology, merging the Departments of Pathogen Molecular Biology and Immunology and Infection. This enhanced the interdisciplinary working environment and was supported by the redevelopment of our laboratories.

New state-of-the-art facilities included a Schedule 5 suite for studying pathogens listed under the Anti-terrorism, Crime and Security Act 2001 (*Shigella* and cholera research), with three Containment Level 3 and two Containment Level 2 laboratories. An integrated Malaria Suite enabled us to expand a key area of strength and increase inter-group collaboration.

Pathogen-handling facilities with biocontainment for small animal infection studies by clinically-relevant routes and monitoring of infected animals by *in vivo* bioimaging have enabled research on *Mycobacterium tuberculosis* and *Burkholderia pseudomallei*; *Trypanosoma cruzi*, *Leishmania donovani* and *Plasmodium falciparum* and their vectors; and animal pathogens regulated by the Department for Environment, Food and Rural Affairs (*Trypanosoma brucei*, bluetongue virus). Our animal facility was expanded in 2019 to include a zebrafish facility.

We host the Public Health England (PHE) Malaria Reference Laboratory, which provides malaria diagnosis, epidemiological data for the Centre for Infectious Disease Surveillance and Control, and training and technical advice on methodology and laboratory procedures. Our Diagnostic Parasitology Laboratory, an ISO 15189:2012 UKAS accredited medical laboratory, provides a reference facility offering a range of parasitological investigations for enteric and blood parasites to all hospitals, NHS and PHE laboratories, GPs and private medical laboratories in the UK and abroad. The Diagnostic Parasitology Laboratory also specialises in the diagnosis of non-human parasites, offering this service to veterinary practitioners.

Reflecting LSHTM's 2017-2022 strategy, ITD has further strengthened laboratory science through a technical support review. This improved service delivery and knowledge-sharing and created a structure supporting career progression. The 49 technical staff were formed into new teams in 2019, and a new Head of Research Laboratories appointed.

The inclusion of MRCG brought further specialist infrastructure and facilities. MRCG played a key role in expanding genomics capabilities in Africa by building a new international-standard molecular biology laboratory, the base for the Centre for Genomics' research and training for West Africa. A new entomology laboratory supports research on novel interventions against vector-borne diseases.

MRCU's General Population Cohort monitors trends in HIV infection and their determinants. The Entebbe Mother and Baby Study explores how early-life experiences affect health outcomes. The MRC/UVRI Medical Informatics Centre supports the integration of epidemiological methods with genomic and computational technologies, to study the biology of various diseases and strengthen medical informatics capacity in sub-Saharan Africa.

3.7. Cross-HEI shared/collaborative research infrastructure and major research facilities

3.7.1. Overseas

A priority in LSHTM's 2017-2022 strategy is to create and consolidate national and global partnerships. Below we address major cross-HEI shared use of research infrastructure overseas and in the UK. These partnerships are all with locally owned institutions.

Africa (in addition to MRCG and MRCU)

- *Ethiopia*: The Ethiopian Federal Ministry of Health and Armauer Hansen Research Institute are key partners for LSHTM research projects in vaccination and infectious diseases.
- *South Africa*: The Africa Health Research Institute (AHRI) is an independent scientific research institute based in KwaZulu-Natal and is a key partner in research on TB and adolescent health.
- *Tanzania*: The Mwanza Interventions Trials Unit is a longstanding partnership with the Tanzania National Institute for Medical Research Mwanza Centre, with shared clinical trials expertise and strengthened laboratory infrastructure.
- *Uganda*: UVRI, a key partner of MRCU, is home to several national and international reference and specialised testing laboratories. UVRI researchers have access to shared enhanced bioinformatics and laboratory facilities at MRCU.
- *Zambia*: Zambart is a research organisation that grew out of a 20-year collaboration between the University of Zambia's School of Medicine and LSHTM which includes epidemiological and clinical research.
- *Zimbabwe*: The Biomedical Research and Training Institute, a Zimbabwean NGO, is a key partner for the Zimbabwe LSHTM Research Partnership working on TB and HIV.

Asia

- *Japan*: Our partnership with Nagasaki University has supported the Nagasaki School of Tropical Medicine and Global Health, created shared resources and provided LSHTM researchers with access to research opportunities in the region. Two members of staff are based in Nagasaki full-time.
- *Singapore*: Our partnership with the National University of Singapore focusses on infectious diseases research. Two joint appointments develop research on TB and malaria.

3.7.2. UK

LSHTM is a member of the London International Development Centre, a consortium of seven institutions facilitating interdisciplinary research and training. Members collectively fund a core team and associated infrastructure. Major successes include a Research England Connecting Capabilities Fund award on AMR.

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

Collaboration in doctoral training was addressed in section 2.2.2.

4.1. Research collaborations, networks and partnerships

LSHTM is a member of global networks including the M8 Alliance of Academic Health Centers, Universities and National Academies and the Consortium of Universities for Global Health. The 2020 CWTS Leiden Ranking for all sciences placed us first in the UK and ninth in the world for proportion of papers published in collaboration with researchers from other institutions (95%) and first in the UK and seventh in the world for proportion of papers published with researchers from outside the UK (78.3%). InCites data show that between 2014 and 2020 we collaborated on over 10 publications each with close to 1,500 institutions across Africa (118), Middle East (74), Asia Pacific (295), Latin America (66), North America (319), EU-27 (420), UK (167).

Our major collaborations are in Africa, Asia, Latin America, Europe and the UK.

4.1.1. Africa

In 2020 we had over a hundred researchers based in Africa outside the MRC Units, embedded within local institutions. Sixteen are included in our UOA1 submission. Our principal collaborating institutions for UOA1 staff are shown below. These were fundamental to much of the research and related achievements described in section 1.

<i>Botswana</i> : Botswana Harvard AIDS Institute Partnership
<i>Burkina Faso</i> : Centre Muraz, Centre National de Recherche et de Formation sur le Paludisme
<i>Democratic Republic of Congo</i> : Institut National de Recherche Biomédicale
<i>Ethiopia</i> : Ministry of Health; Armauer Hansen Research Institute
<i>Ghana</i> : Kintampo Health Research Centre; Kwame Nkrumah University of Science & Technology; Noguchi Memorial Research Institute, University of Ghana
<i>Senegal</i> : Université Cheikh Anta Diop; Institut de Recherche en Santé, de Surveillance Epidémiologique et de Formation
<i>Sierra Leone</i> : College of Medicine and Allied Health Sciences, University of Sierra Leone
<i>South Africa</i> : Africa Health Research Institute, University of KwaZulu Natal; Universities of Cape Town, Stellenbosch and Witwatersrand
<i>Tanzania</i> : Mwanza Intervention Trials Unit; National Institute for Medical Research; Kilimanjaro Christian Medical University College; Sokoine University
<i>Uganda</i> : Uganda Virus Research Institute; Makerere University
<i>Zambia</i> : Zambart
<i>Zimbabwe</i> : Biomedical Research Training Institute

LSHTM has supported the development of regional networks to share expertise and strengthen capacity. For example, MRCG initiated the development of a West Africa network building on existing connections with Senegal through the West Africa Global Health Alliance and, more

widely, the West African Network of Excellence for TB, AIDS and Malaria. MRCU has expanded links in East and Southern Africa, including with AHRI and Zambart.

4.1.2. Asia

In section 3.7.1 we covered partnerships in which we share research resources in Japan and Singapore. Collaborations between London-based researchers and universities in China, Indonesia, Laos, Malaysia, the Philippines, Thailand and Vietnam have strengthened research and capacity around malaria, TB, STIs, NTDs and non-malarial febrile illness. Collaborations in India focus on leprosy, leishmaniasis and eye health.

4.1.3. Latin America

We have strong links with Brazil, including on Chagas disease research; this collaboration was reinforced by our work on the Zika epidemic. The Fundação Oswaldo Cruz (Fiocruz) has emerged as a major partner, with a focus on the 'triple epidemic' of dengue, chikungunya and Zika. We also collaborate with the Universidad Cayetano Heredia in Peru on TB and STI research.

4.1.4. Europe

LSHTM works with many European institutions and leads and/or contributes to numerous EU and EDCTP research consortia. We joined the new European Global Health Research Institutes Network in 2020.

4.1.5. UK

LSHTM collaborates with leading institutions in the UK, including UCL, Imperial College, the Universities of Cambridge and Oxford, the Francis Crick Institute, the Wellcome Sanger Institute and PHE. Many of these collaborations include partners in Africa, Asia and elsewhere.

4.1.6. Evaluation of collaborations

Our indicators of success for our research collaborations around the world include the following:

- Significant discoveries, especially in the control of infectious diseases and vaccines (see section 1.3)
- High citation rates for our published outputs with partners, as illustrated by the Category Normalized Citation Impact (CNCI) for our top four partnerships in South Africa during the 2014-2020 period:
 - University of Witwatersrand: 682 publications, CNCI of 6, 10% of papers in top 1%
 - University of Cape Town: 642, 8, 13%
 - University of KwaZulu Natal: 309, 15, 18%
 - Stellenbosch University: 294, 14, 19%
- Strengthened research capacity in key locations – as illustrated by decades of collaborative research in Zambia resulting in an established local NGO research institution, Zambart, undertaking high-quality science
- Increased joint working with product development partnerships, the biotech sector and large pharmaceutical and diagnostics companies
- Impact on policy and practice – all our UOA1 case studies draw on research produced through overseas partnerships

4.2. Collaboration with external organisations, including health services, industry and government bodies

We have developed productive links with partners in government, the NHS and its executive agencies, PHE, industry and charities. For example:

- We host PHE's Malaria Reference Laboratory
- LSHTM is a member of UCLPartners, providing valuable links into the local NHS
- MRCG works with the Gambian Ministry of Health, providing outpatient medical care to the general public
- MRCU works with the Ugandan Ministry of Health and its AIDS control programme, including providing HIV counselling and testing services
- We contribute expertise to the Coalition for Epidemic Preparedness Innovations which finances and coordinates vaccine development
- LSHTM is a founding partner in VMIC (see section 1.2)
- Collaborations with the Medicines for Malaria Venture have expanded during the assessment period, including establishing *in vitro* susceptibility assays for *P. knowlesi*
- LSHTM's collaborations with charities are extensive; e.g. the International Centre for Eye Health works closely with CBM and Sightsavers

4.3. Relationships with key research users

The table below summarises our key research users and the areas in which they have enriched our research environment. Section 4.7.4 features specific evidence on advisory roles.

Global users/beneficiaries	Research areas
Governments in LMICs; regional agencies (e.g. Africa CDC)	Disease control; adolescent health
International agencies (e.g. WHO; UNICEF; UNAIDS; Global Fund to Fight AIDS, TB and Malaria; PEPFAR; UNITAID; GAVI Alliance)	Vaccines; adolescent health; sexual health; HIV, TB, malaria, other infectious diseases
European agencies (e.g. EU)	Infectious diseases surveillance and control
Bilateral aid agencies	Infectious diseases; adolescent health
Industry (e.g. Medicines for Malaria Venture; Janssen Pharmaceuticals; DNDi; Sanofi; GSK)	Clinical trials; Ebola vaccines; malaria prevention and drug discovery
Major NGOs (e.g. Sightsavers; CBM)	Eye health; Ebola; COVID-19
UK users/beneficiaries	Research areas
DHSC; NHS England; PHE	Vaccines; COVID-19; AMR
FCDO	Malaria; neglected tropical diseases

4.4. Wider contributions to economy and society and engagement with diverse communities and publics

In line with its mission, LSHTM seeks to especially engage with vulnerable communities. Two examples are given here.

Staff in Uganda undertook innovative public engagement activities to tackle HIV stigma and address misconceptions about lumbar punctures in diagnosing brain infections associated with advanced HIV disease. Research participants who had survived advanced HIV disease designed and implemented activities, helping researchers engage effectively with the community and empowering participants as advocates.

Community engagement in Zimbabwe underpins all research, ensuring work is relevant and respectful to the local context. A life skills course for adolescents living with HIV in Harare focused

on issues faced by adolescents. The team also runs a Youth Researchers Academy, enabling 18-to-24-year-olds to conduct research informing sexual and reproductive health interventions.

4.5. Contribution to sustainability of discipline, support for interdisciplinary research, responsiveness to national and international priorities

LSHTM laboratory and clinical researchers play a major role in maintaining UK capacity in disciplines critical to global health and UK health security, including clinical virology, clinical bacteriology, diagnostic parasitology and vector sampling, identification and incrimination. Our Professional Diploma in Tropical Medicine & Hygiene provides clinicians with the learning required for professional competence in this field. Our Professional Diploma in Tropical Nursing trains nurses, midwives, paramedics and allied health professionals to recognise malaria, TB, Leishmaniasis, Filariasis and other parasitic diseases.

Our researchers' embeddedness in national and global policy has enabled them to respond quickly to health emergencies including Ebola, Zika, AMR and COVID-19. For example, the MRC Units were at the forefront of augmenting the COVID-19 response in Africa, using their labs and expertise to boost national testing capacities; they continue to monitor the outbreak in population samples, providing real-time analyses of its evolution.

4.6. Encouraging reproducibility

All laboratory work is performed to ensure it can be repeated and that results obtained can be replicated. For example, LSHTM has been a partner in the EU-funded TRANSVAC and EURIPRED consortia, which have developed standardised protocols for cellular assays for use in vaccine trials following parallel testing of shared reagents and protocols in leading European laboratories.

4.7. Wider influence, contributions and recognition of UOA1 staff in the assessment period

4.7.1. Honours, awards and prizes

Honours, awards and prizes received by LSHTM staff during the assessment period include the following:

- *UK honours*: CB – Whitty; CBE– Mabey; OBE – Roy
- *Election to Learned Societies*: Fellow of the Academy of Medical Sciences – Riley, Corbett, Kaleebu; Royal Society of Biology – Roy; Fellow of the African Academy of Sciences – Elliott and Antonio; Fellow of the Uganda National Academy of Sciences – Elliott
- *Awards and prizes*: Prince Mahidol Award – Mabey; Union Scientific Award – Kranzer; Royal Society of Tropical Medicine and Hygiene Chalmers Medal – Ferrand; Royal Society of Tropical Medicine and Hygiene – Mabey (President); International Society of Protistologists – CG Clark (President); British Society for Parasitology – C Sutherland (President-elect)

4.7.2. Fellowships

There were 27 external fellowships and personal awards to UOA1 staff and their team members during the assessment period, including the following:

- *MRC*: Career Development Award – Moon, van Ooij; African Research Leader (with DFID) – Tiono/Drakeley; Strategic Skills Fellowship – Furnham
- *BBSRC*: Enterprise Fellowship (with RSE) – Cuccui
- *Wellcome*: Sir Henry Wellcome Fellowship – Ludden, Coll, Stresman, Stone; Sir Henry Dale Fellowship (with Royal Society) – T Walker; Senior Research Fellowship – Elliott, Corbett, Ferrand, Burton, Mostowy; Investigator Award in Science – Baker (2), Wren
- *Research England*: Bloomsbury SET Innovation Fellow – Tetteh
- *EU*: Marie Curie Fellowship – Lewis, Hachani, Dyson, Jimenez

- *ERC*: Starting Grant – Cortes; Consolidator Grant – Mostowy
- *NIHR*: Global Health Professorship – Jarvis
- *African Academy of Sciences/Royal Society*: FLAIR Fellowship - Tientcheu

4.7.3. UK Research grant committees

There were at least 25 instances of service on UK research grant committees during the assessment period, including the following:

- *MRC*: Infections and Immunity Board – Baker; Adolescent Health Call – Ferrand; AHRC/MRC GCRF – Grant; Clinical Academic Research Partnerships – Jarvis; African Research Leader – Kampmann; Joint Global Health Trials – Corbett; Developmental Pathway Funding Scheme – Fletcher; Experimental Medicine – Kampmann; Global Adolescent Health – Ferrand
- *UKRI*: GCRF/Newton Agile Response to COVID-19 – Fletcher (Chair); Future Leadership Fellowships – Fletcher
- *BBSRC*: Tools and Resources Development Fund – Ward, Wren
- *NIHR*: Global Health Research Units – Elliott; Global Effort on COVID-19 Health Research Call – Jarvis; Research and Innovation for Global Health Transformation – Jarvis
- *EDCTP*: Senior Fellowships – Dockrell, Elliott, Ferrand, Jarvis; Strategy Advisory Board – Croft
- *British Council*: Commonwealth Scholarships – Croft
- *Medical Research Foundation*: Grant Panel – Dockrell
- *Wellcome*: Science Interview Panel – Burton; Basic Science Interview Committee – Mostowy; Sir Henry Dale Fellowship Interview Committee – Wren; Pathogen Biology and Disease Transmission Expert Review Group – Blackman

4.7.4. Advisory roles

During the assessment period there were many examples of staff acting as advisors for UK, international and other national agencies, including the following:

- *WHO Advisory Groups*: Croft, Ferrand, Jarvis, Kranzer, Mabey, Mayaud, Roy
- *International government agencies*: Uganda Ministry of Health NTD Technical Committee – Elliott; Uganda COVID-19 Laboratory Quality Assurance Committee – Kaleebu; Uganda Ministry of Health Scientific Advisory Committee – Kaleebu; Uganda SARS-CoV-2 National Vaccine Access Committee – Kaleebu
- *COVID-19*: Zimbabwe National COVID-19 Expert Advisory Panel – Ferrand; Zimbabwe Ministry of Health and Child Care Infection Prevention and Control Adviser – Kranzer; Botswana Minister of Health COVID-19 Technical Advisor – Jarvis; Botswana Ministry of Health and Wellness National HIV and TB Guidelines Development Group – Jarvis
- *The Global Fund*: Technical Review Panel – Ayles
- *Drugs for Neglected Diseases Initiative*: Scientific Advisory Committee – Croft
- *Medicines for Malaria Venture*: Scientific Advisory Committee – Croft
- *Genome Canada*: Genomics in Medicine – Wren
- *African Academy of Sciences*: Open Research Advisory Board – Elliott
- *Armauer Hansen Research Institute*: Scientific Advisory Board – Dockrell
- *Royal Society of Tropical Medicine and Hygiene*: Trustee – Grant
- *Scientific Foundation Ireland* – Wren

4.7.5. Journal editorships and editorial boards

During the assessment period at least 20 UOA1 staff held Editor, Editor-in-Chief and Section Editor roles, including:

- *BMC: Immunology* – Helmby (Associate Editor); *Infectious Diseases* – T Walker (Editorial Board); *Medicine* – Fletcher (Editorial Board)

- *FEMS Microbiology Reviews* – van Ooij (Editorial Board)
- *Genes* – Alford (Editorial Board)
- *Infection and Immunity* – Dockrell (Editorial Board)
- *International Journal of Molecular Sciences* – Holland (Editorial Board)
- *Journal for Antimicrobial Chemotherapy* – C Sutherland (Editorial Board)
- *Journal of Adolescent Health* – Ferrand (Editorial Board)
- *Journal of Infectious Diseases* – Dockrell (Editorial Board)
- *Malaria Journal* – Drakeley, Walker, Helmby (Associate Editors)
- *PLoS: Neglected Tropical Diseases* – Lewis (Editor); *One* – Ferrand (Editorial Board); *Pathogens* – Blackman, Lewis (Editors)
- *Scientific Reports* – Stresman (Editor); Furnham, Beshir, Cortez (Editorial Board)
- *Tropical Medicine and International Health* Fletcher (Editor).
- *Tuberculosis* – Fletcher (Editorial Board)