Institution: University of Leeds

Unit of Assessment: UOA3 (Allied Health Professions, Dentistry, Nursing & Pharmacy)

a. Overview

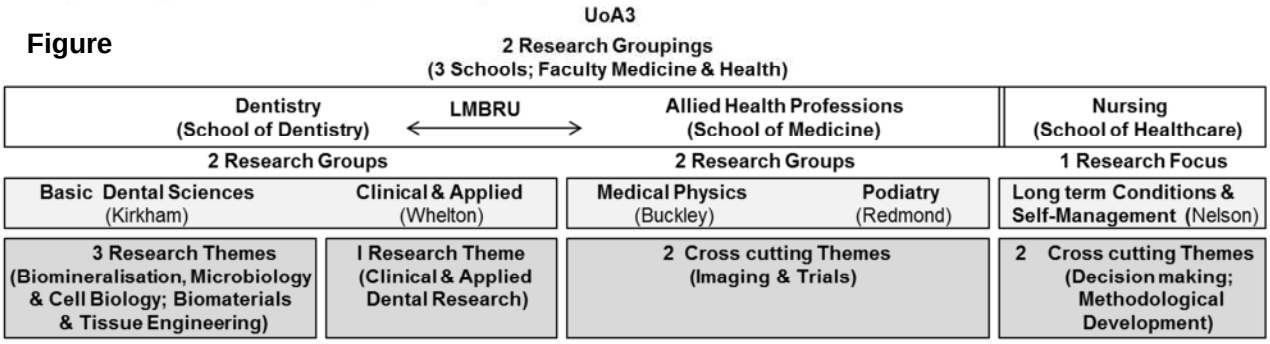
This UOA comprises two Research Groupings within the **Faculty of Medicine & Health** (FMH), linked through integrated research processes and FMH infrastructure (Figure). Their strategies sit within the wider University of Leeds (UoL) Biomedical Health Research Strategy, which involves significant interdisciplinary collaboration between researchers across the UoL and the NHS. Our key partner in delivering patient focused research is the Leeds Teaching Hospitals Trust (LTHT), the UK's second largest NHS Trust with an annual budget of over £1 billion.

(1) Dentistry and Allied Health Professions (AHP) comprises staff in the **School of Dentistry** (**SD**; 20.2 fte) and **AHP staff** (7 fte) in the **School of Medicine** (**SM**). **"Musculoskeletal (including Dentistry)"** research is a priority area in the UoL strategy, which has enabled investment in quality research in both dentistry and allied health. Dentistry and the AHP are linked through the NIHR Leeds Musculoskeletal Biomedical Research Unit (LMBRU), a £12.7M centre of excellence for translational research into individually targeted, patient-focused therapies across the musculoskeletal diseases. SD & AHP staff actively contribute to other key cross-disciplinary initiatives addressing significant healthcare challenges: the £11.2M Wellcome/EPSRC Centre of Excellence in Medical Engineering ("WELMEC") and the strategically aligned £7.3M EPSRC/TSB/ BBSRC Medical Technologies Innovation and Knowledge Centre (IKC; REF3a). All clinical and many basic science SD and AHP academic staff hold honorary contracts with the LTHT.

Dentistry has two collaborating research groups, reflecting strengths and leadership in research at international level and each containing basic science and clinical academics. **The Basic Dental Sciences research group** undertakes research in three themes: Biomineralisation; Biomaterials & Tissue Engineering; Microbiology & Cell Biology. **The Clinical & Applied Dental Sciences research group** includes the UoL and Wellcome Trust–funded Dental Translational & Clinical Research Unit (DenTCRU). **The Allied Health Professions** undertake translational, patient focussed research centred in Medical Physics and Podiatry (in the Foot and Ankle STudiEs in Rheumatology programme; FASTER).

(2) Nursing: Situated within the multidisciplinary **School of Healthcare** (SH), this Research Grouping (17.2 fte) generates applied research to underpin policy, practice and education for the direct benefit of patients and the public. Research centres on **Long-Term Conditions and Self-Management** (LTC&SM), particularly among older people, and includes: wound management; pain and cancer care; stroke, mental health and medicines information and management. Two themes run through LTC&SM projects; Decision-making and Methodological Development. The SH is organised according to professional groups and research activity cuts across these, strengthening interdisciplinary working.

Figure



b. Research strategy **(1) DENTISTRY & ALLIED HEALTH PROFESSIONS**

Our goal from RAE2008 was to underpin high quality translational research for patient benefit with world class basic and applied science. In SD, our focus was to use dentally based problems and research tools as accessible models for studies of broader biomedical relevance; for AHPs, the focus was to exploit emerging technologies to support targeted therapies for musculoskeletal disease. The integration of clinicians and basic scientists with a shared vision to deliver patient benefit in our research and in collaborative programmes such as WELMEC and LMBRU, has ensured development of a common core strategy predicated on effective translational research. Investment in infrastructure has been a key priority: we have established DenTCRU and the NIHR

funded LMBRU Imaging Centre, which are integral to our research. We achieved our targets of increasing research funding, including industrial partnerships (section d, REF3a), and investing in developing emerging researchers, as evidenced through increased postgraduate research student (PGR) supervision and successful fellowship applications (section c). We provide a vital and sustainable research culture and collaborate extensively. Internal investment from the FMH and central UoL has provided essential equipment, updating of infrastructure (section d) and employment of staff to build capacity in key areas (section ci). The SD provides strategic funding for PhD students (section cii), pump-priming (≤£10K), publication and conference costs, international staff/student exchange and internal seminars and lecture series (section c). Research strategy is reviewed formally at a local and at Faculty level. Key to the development of our strategy is engagement with our research collaborators, industrial partners and patient advocates.

Achievements of the Dentistry & AHP Research Grouping:

Basic Dental Sciences. Biomineralisation research produced paradigm-shifting data, including the first elucidation of the molecular mechanisms underpinning Amelogenesis imperfecta (Ai) (Kirkham:2-4), and dissection of the mechanisms regulating enamel formation and repair (Brookes:1-4; Kirkham:1). Collaboration between SD clinicians and UoL geneticists (UoA1), with state of the art gene sequencing (NExGen), has identified more new genes involved in Ai than the rest of the world together, including genes responsible for Jalili syndrome (causing Ai and sight loss) and nephrocalcinosis (Mighell:1-4). Atomic force microscopy (AFM) has provided ultra-high resolution imaging of cells and bacteria, and revealed the fundamental structure and function of clinically important biomolecules including collagen and DNA (Bonass:1,2; Thomson:1-4). Biomaterials & Tissue Engineering research is developing novel restorative dental materials (Bubb:1; Wood:1,2), scaffolds for tissue engineering of bone and cartilage (Raif:2; Wood:3,4; Yang:2,3), and is devising non-invasive approaches to control the growth and differentiation of stem cells for regenerative applications (Churchman:1,2; Feichtinger:1; Yang:1). The aims of this theme, the Biomineralisation theme and AHP converge in WELMEC. WELMEC is investigating degeneration of bones and teeth in an ageing population, delivering innovative regenerative therapies and novel diagnostic methods, in musculoskeletal (and cardiovascular) diseases. Dentistry & AHP staff (Kirkham, Wood, Yang, Redmond, Buckley) contribute to three of seven work streams. The SD has supervised six WELMEC post-doctoral Research Assistants (PDRAs) and we work with a further six in other departments. Our Microbiology and Cell Biology research has revealed strategies used by commensal and pathogenic bacteria to manipulate host responses (Devine:1,4) and the functions and evolution of microbial communities (Do:1). Proof that prions are transmitted from oral tissues (Marsh:1) changed Department of Health guidelines (REF3a). We have shown the potential for NExGen sequencing in diagnosis and understanding of virus-associated cancers (Chengot:1). We have expanded understanding of oral innate defences (High:1,2; Meade:1,2), and applied mathematical modelling to cellular processes (Kang:1).

Clinical & Applied Dental Sciences. The OSTEODENT trial has linked dental radiographs and tooth loss with mainstream approaches to osteoporosis screening (Pavitt:1-4). Dental public health (PH) research has addressed oral disease prevention and health promotion, focussing on measures for use at the population level (Whelton:1-4). DenTCRU has increased PGR clinical research activity and leveraged significant funding (£24M award value linked to DenTCRU). It has enabled the translation of our research and the launch of two products (REF3a and Case study 2).

Allied Health Professions. Magnetic resonance imaging (MRI) has contributed to a better understanding of musculoskeletal conditions (Rhodes:1) and dynamic contrast-enhanced MRI has improved broader biomedical diagnostic and therapeutic applications from musculoskeletal medicine to cardiology, oncology and neurology (Buckley:1-4; Sourbron:1-3; Tsoumpas:1). LMBRU Podiatry research has developed novel outcomes for foot posture (Redmond:2) and osteoarthritis (Keenan:2-4). Clinical trials have been focused on targeted treatment in rheumatoid arthritis, spinal stenosis ankylosing spondylitis (Keenan:1; Ndosi:2; Siddle:1; Redmond:1,4; Case study 1).

Future strategic aims and goals of Dentistry & AHP Research Grouping: Our shared vision is to use interdisciplinary expertise to understand the fundamental mechanisms of disease, particularly musculoskeletal (including dental), to identify and treat early, improve outcomes, restore function and address the needs for prevention. We seek to extrapolate the findings and tools developed for dental and AHP research across to biomedicine in general and position our research at the forefront of biomedical and health sciences research. To deliver these and to continue to grow as a vibrant centre of research excellence, over the next five years we will:

- **Integrate excellence in basic, clinical and AHP research**. Continued participation in large collaborative projects following from WELMEC and LMBRU will integrate further our research expertise in challenge-led research. New collaborations bringing together dental, medical and AHP researchers will capitalise on our joint expertise and the large patient base in Leeds and the wider region to enable research in outcomes of care and co-morbidities. Building on a collaboration with Computing (Head, UoA11), we will use mathematical tools and modelling to expedite transition from laboratory to clinic, and to extrapolate our work to the population.
- **Increase our research impact**. Our strategy continues to be driven by our existing capabilities, which are internationally competitive and respond to the national research economy. DenTCRU, and collaboration with the UoL Clinical Trials Research Unit and Leeds Institute of Health Sciences (UOA2), places Leeds in an excellent position to deliver its translational research strategy. We will continue to invest in infrastructure to facilitate research that is meaningful in the context of clinical practice and expand expertise beyond clinical trials to include, for example, Registry studies. We will use our new capabilities (infrastructural and leadership in PH), increased capacity (via new appointments, section c) and strategic partnerships across the region to position Health Services Research firmly within the translational pipeline at Leeds, accelerating our research impact for patient and population benefit.
- **Increase the proportion of research active staff and numbers of PGRs**. We will build capacity by developing a critical mass of researchers who are supported in cross-disciplinary research collaborations. We will capitalise on opportunities such as the NIHR Fellowship schemes for AHP researchers and the new SD Dental Education Research theme, to increase research opportunities for clinical staff. The Professional Doctorate, Integrated PhD, internal PhD funding, joint PhD and staff exchange programmes will further increase these opportunities.

Research strategy **(2) NURSING**

Our distinctive focus is the improvement of direct patient care, enhanced through tailored service user involvement throughout the planning, execution and dissemination of our research. Our work capitalises on inter-disciplinary collaborative partnerships with academics and clinical staff; the broad, eclectic use of research methods; and integrated knowledge transfer. The central RAE2008 strategic aim of research growth has been achieved through staff capacity building and support, and improved student recruitment mechanisms. A 44% reduction in academic staff levels due to cuts in funding during the REF period necessitated the focusing of research support on our most talented staff. Ten SH staff have been awarded PhDs in the REF period and we have appointed new research staff at a range of levels (section ci). PGR numbers, particularly international, have increased (section cii) and we have increased internal investment and external funding for studentships (section c). We have increased service user involvement, research funding quality and international recognition and profile (section e). We have been awarded 17 NIHR grants, including three programme grants (section d). In 2009, Social Work was integrated into the School, providing a strong platform for expanding the social aspects of health research. Topic and methodological expertise available in the school is complemented by cross-Faculty collaboration when appropriate, particularly in statistics and health economics. Research teams span Schools and Institutes within the UoL and other UK and international universities (section e). Research activity and research culture have been actively promoted. Strategic support for research is provided through funding to facilitate pump-priming for substantive externally funded projects, international staff/student exchange and for novel projects promoting integration of research and education. Two SH research away days per year and a biennial research showcase inform colleagues in the SH, NHS, UoL and Yorkshire universities of our research activity.

Achievements of the Nursing Research Grouping: Our research into Long Term Conditions & Self-management (LTC&SM), in particular wounds, pain and medicines management are recognised internationally (evidenced in section e). Methodological and decision-making themes crosscut LTC&SM. Expertise in different types of systematic reviewing has expanded rapidly (e.g. Cochrane systematic reviews of trials, qualitative research reviews and mixed method research reviews) and we have an international profile in mixed methods (section e).

Long Term Conditions and Self-management: Three large wound management trials of leg ulcer care showed that larval therapy was more expensive and no more effective than topical gel for ulcer healing (Nelson:2), and that local ultrasound was not clinically or cost-effective in healing (Nelson:4). The Canadian Bandaging trial was the largest ever of its kind, demonstrating that the correct pressure application rather than the type of bandage used improved healing (Nelson:3).

Systematic reviews have shown the effectiveness of bandaging for leg ulcers and dressings for foot ulcers (O'Meara:1,2,4) and how pressure ulcers impact on quality of life in older people (Nixon:1,2). Nelson is Co-director of the new Centre for Textile Materials Innovation, funded by the Worshipful Company of Clothworkers. Pain research is funded mainly through NIHR and includes assessing pain in people with dementia, which has informed national, European and American guidelines. We have deepened understanding of the experiences and expressions of pain in under-represented groups (Closs:2,3), studied the self-management of cancer pain and identified the positive impact of education on self-management (Closs:1,4) and developed internationally adopted quality of life measures for cancer survivors (Harley:1,2; Wright:1-3; 5). Mental Health focuses on psychological therapies (Cahill:2,3) and empowerment (Fisher:1,2). Stroke research has advanced both physical and psychological rehabilitation (Bhakta:1; Clarke:1,2; House:3,4). Medicines management and information research (section e), has identified the impact of written information on patient knowledge and how to clearly communicate risks of drug side-effects and benefits (Raynor:2,3). Findings have improved written medicines information, including clinical trial patient information sheets and alternatives to the European template for medicine leaflets (Raynor:4), work that informs our spin-out company, LUTO. We have increased understanding of medication error prevalence and causes, particularly in care homes (Raynor:1; Case study 3).

Crosscutting themes: Decision-making centres on developing and evaluating new tools to assist health and social care practitioners with decision making. This includes electronic decision support systems (Randell:1,4), health records and bespoke algorithms, the impact of organisational influences (Dowding:3), as well as patient narratives (Bekker:1,4). Methodological Development includes outcomes research in stroke (Long:2-4), diabetes (Long:3), cancer (Harley:1; Wright:2; Case study 5), pressure ulcers (Gorecki:1), and interventions such as IVF (McGowan:3,4) and Shiatsu (Long:1). Our novel self-report outcome measure COAST (Communication Outcome After Stroke) for patients and carers (Long:2) has been translated into Swedish, French and Korean; our Electronic Patient Reported Outcomes from Cancer Survivors (ePOCS) Scale and Social Difficulties Inventory are used internationally (Wright:2,3; Case study 5).

Future strategic aims and goals of Nursing Research Grouping: Our vision is to grow as an internationally leading centre of excellence in applied health and social care research, education, innovation and knowledge transfer. This will be achieved through continued generation of a strong evidence base which translates into excellent health care provision for people with long term conditions. We will expand our focus on complex issues related to long term conditions and self-management, centred on co-morbidity and symptom clusters, common problems within the expanding global population of older people. To achieve this we will strengthen our strategic focus on research growth in terms of quality, quantity and sustainability. Central to this is our target of increasing our international research profile through an increased volume of high quality research activity together with more effective dissemination and impact activities. This will be supported by:

- **Continued expansion of research capacity and activity**. Increase the proportion of research-active academic staff by 10% per annum funded through internal investment, research fellowship awards and grant income. To complement this we aim to increase research student numbers and increase international research collaborations.
- **Increased number, value, duration and diversity of research grants**. Diversify research grant sources to ensure a balanced portfolio of charitable and blue-chip sources and ensure planned increases in research grant income each year. Increase the number of 5-year programme grants to ensure stability, sustainability and knowledge focus.
- **Further integration of research and knowledge transfer activities.** Ensure rapid, significant and far-reaching impact. This includes further strengthening the role of service users, empowering them to participate as fully as they wish in planning, critiquing, conducting, disseminating and implementing research and its findings.

c. People, including:

i. **Staffing strategy and staff development.**

The two Research Groupings in UoA3 share common approaches to staff development, while implementing local strategies to support individual professional development.

Staffing Strategies. Local Workload Models provide oversight of research capacity, equitable spread of responsibilities and transparent policies for allocating protected research time, in balance with student education, NHS service provision and external professional activities. Succession

planning is integral to all key activities in order to ensure continuity, capacity building and sustainability of research programmes and delivery of research strategies.

Dentistry & AHP: The SD staffing strategy has recognised the need to strengthen clinical research leadership and maintain excellence while broadening expertise in the basic sciences. Strategic clinical leadership for SD was assured through the appointment in 2013 of a new Dean (Whelton), funded as part of a UoL £23M investment in **Leadership Chairs**. We will also recruit a Chair of Applied/Translational Research and linked new Lecturer in Statistics; with central UoL investment, we will recruit a new clinical Professor with a linked clinical Lectureship. In the basic sciences, Meade (Lecturer, **ECR**) was recruited to provide expertise in molecular immunology, essential for advancing research in cancer and oral disease linked to systemic diseases. Additional strength in tissue engineering has been provided by Raif (Wellcome Trust/UoL funded Fellow; **ECR**) and Feichtinger (Wellcome Trust Institutional Strategic Support Fund Junior Fellowship, **ECR)**; Kang (Lecturer; **ECR**) was appointed to maintain expertise in biostatistics and extend into mathematical modelling, and Do (Lecturer, **ECR**) to provide metagenomics and transcriptomics expertise, essential to microbiology research in the SD and across FMH. These appointments, plus a Personal Chair in Microbiology (Devine) and promotion of tenure-track fellows (Thomson, Reader; Yang, Senior Lecturer), assure continuity and leadership for dental research. In Medical Physics, the appointment of Buckley (Chair) and new lecturers (Sourbron, Rhodes, Tsoumpas; **ECRs**) has ensured continued development of this group. Similarly in Podiatry, Siddle and Ndosi (**ECR**) work under the guidance of Redmond (promoted to Chair, 2013; Head of the Section of Clinical Biomechanics & Physical Medicine, SM Institute of Rheumatic & Musculoskeletal Medicine; joint lead of LMBRU Joint Replacement Technology Group) and Keenan (LMBRU Assistant Director; pivotal in securing £12.7M for LMBRU since 2008).

Nursing: The SH has supported research strengths through directed strategic investment at all levels of appointment, including **ECRs** (Gorecki, Clarke). Three Chairs were appointed in Applied Health Research; Dowding, Anthony and McGowan, the latter being a UoL **Leadership Chair**. Alongside these were three Research Fellows to extend existing research groups, through internal investment (Harley, Randell and O'Meara) to take forward interdisciplinary research at the highest level. Our success in developing research leaders has led to key researchers taking Chair promotions within other institutions (UK: Cheater, Tovey, Briggs and Astin - US: Dowding 0.8FTE).

Equality and Diversity. The UoL is committed to delivering a supportive and professional working environment for our staff and addressing equality and diversity issues is central to this. In the FMH, the proportion of staff with a declared disability, or an ethnicity other than "White" is higher than for the UoL as a whole. Women comprise 50% of those returned in UOA3, and eight of the 16 Professors. An Athena SWAN Bronze award to the UoL recognises its programme to support the conditions and progression of women's careers in STEM disciplines. The SH and SM have been awarded Athena SWAN Bronze awards in recognition of their positive support for women at key career transition points and changing the culture and the gender balance in decision-making.

Arrangements for the Effective Development and Support of the Research Work of Staff, including PGRs. In 2010 the UoL was one of the first UK HEIs to be awarded the HR Excellence in Research Award by the European Commission, in recognition of our commitment to ensuring good working conditions and career development for researchers. The UoL monitors its progress through participating biennially in national surveys: Postgraduate Research Experience Survey; Careers in Research Online Survey; Principal Investigators and Research Leaders Surveys. The UoL **Employment Policy for Research Staff** and the **Next Generation Researcher programme** have been developed in line with the Concordat to Support the Career Development of Researchers and the Researcher Development Framework (RDF). The programme provides a Researcher Pipeline with guidance on activities commensurate with each stage of the research career. Our **Staff and Department Development Unit** (SDDU) provides training in all aspects of the research process, and a range of sand pit events to encourage peer interaction, as well as training and development for those in leadership roles; ten UoA3 researchers have benefitted from participation in the competitive "**Leaders of the Future"** programme, which includes working with senior Mentors and peer groups. **Faculty training hubs,** in collaboration with SDDU and other central services, provide training and development for PGRs and staff at cognate Faculty level in subject-specific and transferable skills. FMH and the Faculty of Biological Sciences have a joint training hub, with dedicated staff to provide professional training for ECRs and PGRs.

The annual **Staff Review and Development Scheme** (SRDS,) provides a two-way review of

achievements and aims for all staff, supporting developmental needs in line with the requirements of the School/Institute and University. In SH, this review process uses a research performance framework with clear activity benchmarks, with individualised support to help staff meet them. SD and SH each have systems for rapid, supportive, peer review of grant applications. **New staff** are provided with both School-specific and general UoL induction processes and undergo a structured probationary period, allowing them to set objectives to meet their developmental needs and the strategic needs of the School. Support for new appointees has included pump-priming funds of £10K for new SD lecturers. The UoL **New Lecturers' Network** provides an informal forum and information source for newly appointed academics from across the campus. **ECRs** work with an experienced Mentor to optimise personal research career training and development. In SH, there is also an independent ECR-led career development group and a three month bridging fund for new doctoral graduates to help them submit publications and grant applications. FMH has a training and support group for NIHR clinical academic trainees. Staff without PhDs are encouraged to register for a PhD and apply for external funding (five SD and 10 SH staff attained PhDs in the REF period and SH gained external funding for two Doctoral Fellowships and four Doctoral Studentships). **Enhanced support for Fellowship applications** is provided at central University and Faculty (led by Pavitt) levels, providing close mentoring from the earliest stages, peer support and mock interviews. Funder-specific workshops, including representation from the funding body (MRC, Wellcome Trust, NIHR, EPSRC, Leverhulme) are routinely held to raise awareness and associated surgery sessions with funders arranged on a one-to-one basis. The SH hosts a regular event to support NIHR Fellowship applications for delegates from across the UoL. Dentistry & AHP supported four external applicants for Fellowships, including Feichtinger, and 12 of our own staff, with success in five. Support for ECRS and PGRs to expand their research expertise and develop collaborations is central to our strategy and five PDRAs and two PGRs were visiting researchers in laboratories in the Universities of Michigan and Osaka and at ILL, Grenoble.

Costing and pricing of awards is supported by the FMH Research Office team. SD and SH Research Administrators and Business Managers support the strategic alignment of research activities, building relationships with key funders, advising researchers in the award process, liaising with the NHS R&D offices, horizon scanning for funding opportunities and facilitating development of cross-Faculty/cross-organisational bids. The UoL on-line research support system (KRISTAL) provides cradle-to-grave process and document management.

ii. **Research students**

UoL policies and practices for the support of researchers (section ci) include PGRs, reflecting our view that, as our earliest career stage researchers, they are central to a vibrant research environment. PG Research Tutors (PGRTs) meet regularly with PGRs and oversee all aspects of admission, allocation of supervisors, progress and examination. Elected PGR representatives sit on School committees including the SH Research Committee, the SD PGR Committee and PG Framework Committee. Increased PGR numbers, together with improved research training, monitoring and student support are core strategic objectives. More doctoral degrees were awarded across the UOA than in RAE2008 and Nursing increased the proportion of international candidates. Of PGR graduates whose destination is known, 67% entered academia. SD PGRs were awarded 13 prizes for conference presentations and six international travel bursaries.

PGRs are vital to our research activity: 70% of the outputs submitted for REF in Dentistry & AHP were co-authored by PGRs. 188 PGRs were supervised in UOA3; 63 in Nursing, 125 in Dentistry & AHP. A further 48 students registered in other departments were supervised by UOA3 staff. Joint supervision was undertaken with colleagues from across the FMH, as well as Transport Studies, Chemistry, Computing, Physics & Astronomy, Mechanical Engineering, Materials Science, the Astbury Centre for Structural Molecular Biology, Engineering, Mathematics, and other Universities (including Bournemouth, London, Sheffield, York, Sydney). This has promoted integration of our Research Groupings within the wider research community while benefiting the student experience through access to state-of-the-art facilities and high quality, multidisciplinary research.

The SH funds 2-3 internationally advertised PhD studentships each year and the SD provides matched and top up funding for externally funded students and supports all of its PGRs through its policy of not levying laboratory access charges. External funding sources for UOA3 PGRs included: Research Councils (including four Dentistry & AHP CASE awards), NIHR (including two Doctoral Fellowships in SH and four for AHPs in the FASTER group), White Rose, charities, industry, overseas scholarship schemes, overseas governments, UoL and self-funded. An **EPSRC**

Doctoral Training Centre in Regenerative Medicine was awarded to the School of Medical Engineering with SD Co-applicants (Kirkham, Wood, Yang) and the Universities of Sheffield and York. The DTC has supported 50 students; 20% of these elected to study tissue engineering in the SD. To meet the needs of dentists for clinical training alongside research development, the SD introduced the 4y Integrated PhD in Oral Sciences and the Professional Doctorate in Clinical Dentistry, which allows clinicians to carry out research in their normal clinical environment.
Supervision and Training: All students have ≥two supervisors, who must undertake SDDU training, and provide ≥10 formal supervision meetings each year (five for part-time students). A structured training plan is created in the first month of registration and reviewed six monthly. In line with the *Next Generation Researcher* programme and the RDF, the UoL provides an extensive programme of research and transferable skills training and personal development opportunities (**www.sddu.leeds.ac.uk/sddu-post-grad-research_students.html**). The UoL's Postgraduate Development Record System (PDRS) facilitates this through provision of a training needs analysis tool based on the national RDF, and it records candidates' supervision meetings and training courses attended. The latest QAA Institutional Review highlighted the PDR system as an example of good practice. Each PGR is provided with £1K pa by the Faculty (topped up to £1.5K in the SD) to support training and conference attendance. In addition to hosting regular Research Seminars with UK and international speakers, the SD, SH, FMH and UoL hold annual PGR events that allow our students to present to audiences from the UoL, wider academia and industry.

d. Income, infrastructure and facilities

Research Governance: The FMH provides central support to ensure and assure UoL values of academic excellence, community, integrity, inclusiveness and professionalism, underpinned by high ethical standards. FMH has a Quality Assurance team, jointly funded with LTHT, providing support for trials within the FMH and ensuring MHRA compliance. The Head of Faculty Research Support (Sponsor under governance for NRES applications) is responsible for UoL compliance with the Human Tissue Act. SD and SH each have internal Ethics Committees, in the SD supporting the Research (skeletal) Tissue Bank (below) and advising PGRs on NRES applications. Research governance across the FMH and the LTHT is provided by the **Joint Partnership Board**, allowing executive input from both organisations. Research governance issues sit with **the FMH Research and Innovation Committee (FRIC)** and local research governance and strategy are the responsibility of the SD Research Board or the SH Research Committee, which meet bi-monthly.
Income: Staff in UOA3 are participants in grants with a total award value of £61M (UOA3 REF share £22.5M). Our strategies have been to ensure sustainability through a balanced portfolio of research in terms of funding sources and project duration. Experienced researchers aim to overlap ongoing projects, to sustain momentum in developing knowledge and creating a stable environment for ECRs and others on fixed term contracts. We have built upon smaller projects to gain longer term, NIHR Programme funding (e.g. Closs, IMPACCT; Harley, eRapid). The Wellcome Odontogenesis Programme grant and the successful initiative to establish tissue engineering and stem cell research in the SD, and the advanced imaging research in Medical Physics, resulted in our participation in the WELMEC initiative and the IKC (sections a and b). Total research expenditure in UOA3 was £16.8M (£8.1M Dentistry & AHP; £8.7M Nursing). Nursing shows significant strength in funding from NIHR and NHS HTA; Dentistry & AHP in funding from Research Councils (particularly EPSRC for Dentistry), the Wellcome Trust (Dentistry), Industry, and NIHR (particularly the FASTER group). Other charitable funders included Arthritis Research UK, British Heart Foundation, Cancer Research UK, Dunhill Medical Trust, Kidney Research UK, Macmillan Cancer Support, Multiple Sclerosis Society, Smith & Nephew Foundation, Stroke Association and Yorkshire Cancer Research.
Infrastructure and Facilities: All staff have dedicated office space, high quality computing facilities and IT support, and library access to 2.8M print and 500,000 online books, and >37K print and online journals. The SD and SH each has a dedicated PG Suite, providing a high standard of accommodation for PGRs, including PCs and printing facilities. The SD additionally provides basic science PGRs with laptops to facilitate laboratory working. All PGRs have access to Information Systems Services, Careers Centre, Language Centre, SDDU, the Faculty Training Hub, and other University facilities. A common room facility in the SD and a new SH 'Student Zone' with two dedicated work and social spaces, promote interaction between PGRs.
The SH has an established, vibrant community of **Service Users** (for whom we provide training) who are involved in research, knowledge transfer and teaching. A database of c60 such

individuals is a research resource for SH staff. The landmark SH Patient Learning Journey (**http://www.healthcare.leeds.ac.uk/enterprise/cpd4healthinnovation/patient-led-innovation.htm**) was devised in collaboration with the SM to support service users and carers in informing educational and research developments.

Equipment purchase and renewal is planned in a 5-10 year framework, and Dentistry & AHP collaborate extensively, ensuring access to the highest quality research facilities and strategic investment. The UoL, with the N8 universities (Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York) has developed a web-based searchable database to encourage new research collaborations through equipment sharing. Medical Physics collaborate in imaging research with the LMBRU and cardiac MRI groups to access state-of-the-art MRI scanners (2 x 3 T and 1 x 1.5 T MRI), and also with staff at LTHT to access MRI (5 x 1.5 T MRI) and the latest clinical research PET-CT system. Collaborations between SD and the SM, Medical Engineering, Physics & Astronomy and the Astbury Centre for Structural Molecular Biology have provided access to state-of-the-art facilities including fluorescence spectroscopy, flow-cytometry and next generation sequencing. SD recently led (Thomson) a successful cross-Faculty bid to the Wellcome Trust to purchase a fast scan AFM platform. SD has refurbished tissue culture and bioengineering facilities and a surface plasmon resonance Biosensor, imaging suite with scanning and transmission electron microscopes (with elemental analysis) and confocal scanning laser microscope, and dedicated technical support. SD microbiology laboratories provide constant depth film fermenters, anaerobic culture facilities and chemostats. Materials Science laboratories house equipment accredited to UKAS standards. We have in-house proteomics capabilities and protein purification equipment (FPLC, preparative gel electrophoresis). Hard tissue histology includes quantitative microradiography and SD recently purchased, with FMH co-investment, a high-resolution micro-CT for biological applications. Facilities for translational research have been transformed by DenTCRU (section b), funded by a £1M Wellcome Trust Capital Award and £500K from the UoL. This is a high specification clinical facility (6 Chairs, with sample preparation/ analysis rooms, reception and waiting area). We have recruited permanent DenTCRU support staff with expertise in trials management and statistics, technical support in microbiology and tissue culture and two research nurses. DenTCRU works closely with the UoL Clinical Trials Research Unit (UOA1). SD recently invested £1.2M in state-of-the-art Virtual Reality 3D Dental haptic simulators, providing critical infrastructure to underpin research in Dental Education and new collaborative links with other UOAs (e.g. UOA4). This infrastructure was a strategic investment to enable multidisciplinary translational research and effective collaboration across the UoL and the NHS. It maps to an additional UoL and LTHT investment of £13.5M (Biomedicine & Health Research Centre) to support capacity building in translational research and adds capacity in the priority area of surgical technologies. SD hosts a unique Research (Skeletal) Tissue Bank, which operates the highest standards of clinical governance and adherence to the Human Tissues Act. It stores skeletal tissue samples for disbursement to researchers and our collaborators, precluding the need to obtain project-specific consent and greatly facilitating research in stem cell therapy and tissue engineering. A HTA inspection in 2013 highlighted a number of aspects of good practice in the operation of this Tissue Bank.

e. Collaboration or contribution to the discipline or research base

Both UoA3 Research Groupings recognise the importance of inter-disciplinarity to deliver their research strategies and respond to national and international priorities.

Dentistry & AHP. In WELMEC (www.welmec.leeds.ac.uk), >200 engineering, physical science, life science and medical researchers from the UoL and LTHT collaborate with clinicians and industrialists to deliver to clinical innovation challenges, focused on improving the quality of life of older people with musculoskeletal and cardiovascular disease. Within WELMEC, we participate in research that delivers to the strategic priorities of Research Councils UK (lifelong health and wellbeing in an ageing population) and the Department of Health and the Wellcome Trust (translation of research to improve patient health and care). Our participation in LMBRU has led to a new collaboration to understand mechanisms underlying links between arthritis and periodontitis. In the LMBRU (www.lmbru.ac.uk), the AHPs are integral to the research activities, contributing to the Clinical Rheumatology, Imaging and Bioengineering and Surgical Solutions workstreams. The LMBRU's strategy is underpinned by early identification and targeted solutions to musculoskeletal conditions: both imaging and physical therapeutic approaches are key to delivering this. Buckley, Keenan, Kirkham and Redmond, have senior roles within the LMBRU.

National and international collaborations are vital to our research and 63% of our REF outputs are co-authored by colleagues from other UK or international institutions. Mighell has established worldwide collaborations resulting in outputs (1-4) co-authored by 23 colleagues from 18 institutions in the UK, Europe, Middle East, Pakistan, USA and Australia. Brooke's expertise in enamel protein biochemistry and amelogenesis resulted in successful, longstanding collaborations (including hosting of international researchers at Leeds) with scientists in the Universities of California, Oslo and Paris/Centre de Recherche des Cordeliers (INSERM) (Brookes:1-4). The Wellcome Trust programme grant (Kirkham, Brookes) with the University of Manchester, resulted in further Wellcome funding. We actively foster international relationships to promote collaboration. The UoL is a member of the Worldwide Universities Network (WUN), which has provided support for collaborations and researcher mobility. Formal agreements between SD and Universities of Michigan, Nanjing and Osaka have promoted staff and student exchange, and SD has organised and hosted three tissue engineering symposia with Osaka. The SD has hosted 19 visiting researchers in the REF period, including 10 ECRs, for periods ranging from days to a year from Universities in the UK and EU, South and North America, New Zealand, China, Japan, Middle East and India. SD staff have been visiting researchers at the Universities of British Columbia, Otago, Costa Rica, Washington, W Australia, Sydney, Chinese and Japanese Universities including Nanjing, Shanghai, Osaka, and Tokyo.

Nursing. Raynor leads the WUN collaboration "Supporting patients to make best use of their medicines" with Sydney and Wisconsin and has led collaborations with the Universities of Aarhus, Aalborg and Utrecht, focussed on medicines information for patients. Dowding established an international network for improved patient care via nursing informatics with colleagues from the Universities of Leeds, Harvard, Kaiser Permanente (US), British Columbia and Victoria (Canada), New South Wales (Australia), the Vienna University of Technology (Austria) and CICESE (Mexico). Randell collaborates with UCL, University Health Network (Canada) and Harvard developing methodological approaches to health technology evaluation. Nelson has a wounds research collaboration with Queen's University, Canada.

Collaboration with external bodies (NHS R&D, Government, Industry)

Dentistry & AHP. In 2011, LTHT 's strategic goals included integration of research, innovation and clinical care via four priority clinical areas, including musculoskeletal (incorporating dental), and a commitment to raising £2M for DenTCRU. LTHT Charitable Foundation has funded five pump-priming projects in the SD and NIHR W Yorkshire Comprehensive Local Research Network Responsive Funding has provided research nursing support to DenTCRU. Pavitt is on the Board of INVOLVE (Patient and Public Involvement in Research), and LMBRU runs an active Patient and Public Advocacy Group, ensuring participants help to shape future research. We work extensively with industrial partners, including GlaxoSmithKline, Colgate Palmolive, Depuy UK, Philips Healthcare and AstraZenica as well as SMEs: GABA Int, AedStem, Geitschlich Biomaterials, [text removed for publication].

Nursing The SH Service User and Carer Involvement Advisory Group (IAG) informs educational and research activities. The SH is the home of 'CPD4 Health Innovation', bringing stakeholders together to produce innovations which have a positive impact on patients and carers. Through CPD4 Health, NHS clinicians and managers help inform our research agenda. Our Medicines Information research spin-out company (LUTO) has provided readability advice and testing for Pharma and other companies since 2007.

Contribution to wider research base

Dentistry & AHP. **Professional bodies, expert advisory and peer review roles:** These include the NCRI Imaging & Biomarkers Clinical Studies Group and Clinical & Translational Radiotherapy Research Working Group (Buckley); the NIHR EME Board (Pavitt); Chair of the Research and Development Committee of the College of Podiatrists and EULAR Health Professionals Standing Committee (Redmond); NIHR Training Forum AHP National Lead (Keenan); the MRC Panel of Experts (to 2010) and the BBSRC Pool of Experts (Devine). Redmond is Nominated AHP clinical expert for podiatry to the Chief Health Professions Officer, has been Chair of the Arthritis and Musculoskeletal Alliance (the UK umbrella body for musculoskeletal disease), was on the NICE panel for OA and RA guidelines development and the All Party Parliamentary Advisory Group for Inflammatory Arthritis. Keenan is the Musculoskeletal Research Lead for the LTHT. Whelton is President of the International Association for Dental Research (IADR); Chair of the SAG for Dental Public Health RCS Ireland; on European expert advisory boards for P&G, GSK and J&J; advises

WHO as director of a collaborating centre, has consulted with CDC (Atlanta); is advisor on UK water fluoridation, a consultant to the Ministry of Health in Kuala Lumpur; is grant reviewer for NIHR (UK), Hong Kong Research Council, Finnish Research Council for Health, Health Research Board, Ireland and Enterprise Ireland; reviewer for the HRB and R&D Office (NI) Cochrane Fellowships (2008-12) and scientific programme chair for the World Congress of Preventive Dentistry (Budapest, 2013). **Editorial boards:** including ISRN Dentistry (Brookes); Magnetic Resonance in Medicine (Buckley); Journal of Oral Microbiology (Devine), Oral Oncology, Oral Diseases, British Journal of Oral & Maxillofacial Surgery (High); Journal of Microbiology, Oral Microbiology & Immunology, Biofilms, Biofilm Journal (Marsh); American Journal of Biochemistry and Bio-technology, Open Tissue Engineering and Regenerative Medicine Journal (Yang); BMC Musculo-skeletal Disorders (Keenan), BMC (Whelton), Arthritis Care & Research (Redmond). **Conference organisation:** SD organised two international WUN Oral Health Symposia; in Leeds in 2011, focussed on translational dental research. **Awards and invited keynote lectures:** Kirkham is an EPSRC Chair in Translational Research, delivered the Charles Tomes prize Lecture, RCS, (2012); gave keynote lectures at annual conferences of the British Society for Dental Research, IADR, American Association for Dental Research and Medical Innovation Forum (UK). Marsh received the Lifetime Achievement Award from the World Congress in Minimally Invasive Dentistry (WCMID, 2012), gave the Robert-Frank Lecture (IADR-CED) and keynote lectures for the IADR, American Society for Microbiology, Finnish and Danish Societies for Periodontology, EuroPerio 6 and the WCMID. Whelton received IADR Distinguished Scientist (2011) and Oral Health Research Group (2010) awards, the European Organisation for Caries Research Zsolnay Prize (2009); gave invited keynote lectures at conferences of the IADR (2012), Continental European Division of IADR (2012), Indian Division of IADR (2013); Inaugural Conference, University of Osaka (2013) and the British Association for the Study of Community Dentistry, (2012). Redmond was named in the Times Newspaper's top 100 UK doctors (2010). Keenan received the Arthritis Research UK Silver Medal for the most outstanding AHP paper at the British Society of Rheumatology Conference (2008). Redmond and Keenan are Fellows of the Royal College of Physicians and Surgeons.

Nursing. **Policy and expert advice** provided to the British Pain Society's Science and Research Committee (Closs); DoH/Macmillan National Cancer Survivorship Advisory Group (Wright), the US NIH Agency for Healthcare Research and Quality and expert panel on pelvic pain (McGowan). **Professional bodies:** Deputy Chair, National Nursing Informatics Strategic Task Force (Dowding); Chair, RCN Scientific Committee for their International Nursing Research Conference and Deputy Chair, External Devices and Physical Therapies Panel of the NHS HTA programme (Nelson); UK representative, International Medical Informatics Association: Nursing Informatics (Dowding); Chair, 'Patients as Partners' Working Group of the World Pharmacy Federation and the Royal Pharmaceutical Society Expert Advisory Group on Pharmaceutical Science (Raynor). **Grant awarding panels:** NIHR HS&DR (Dowding); Yorkshire and Humber RfPB and expert member of the Patient & Public Engagement Expert Advisory Group for the Commission on Human Medicines (Raynor); HTA Commissioning Board, Deputy Chair of the HTA EDAPT Panel (Nelson); NIHR Doctoral and Post-doctoral awards (McGowan). **International dissemination**: SH hosted the annual International Mixed Methods Conference 2009-2012, attracting delegates from 20 countries. In 2012 we hosted the International Philosophy of Nursing conference and the National Custody and Caring Conference. Raynor organised and chaired at the Centennial World Pharmacy Congress 2012. **Editorial Boards** including: European Journal of Oncology Nursing (Closs); BMC Implementation Science (Dowding); BMC Complementary and Alternative Medicine (Long); Health Informatics Journal (Randell); International Journal of Pharmacy Practice (Raynor); Journal of Forensic Nursing (Walsh). **Invited keynote and plenary lectures:** 4th International Conference on Pain and Impaired Cognition, Leiden 2012 (Closs); 2013 Swedish Nursing Informatics Association (Dowding); the European Parliament, Brussels 2012 (Long); the European Committee on Environment and Public Health Workshop, Brussels 2010, the Norton memorial Lecture, MHRA 2012 and the Rennebohm Lectures, University of Wisconsin 2012 (Raynor); International Custody and Caring Conference, Canada 2011 (Walsh); WHO 2012 meeting of BFHI Co-ordinators (Woolridge). **Awards:** Harkness Fellowship in Health Care Policy and Practice 2009 (Dowding); US 'Healthy Children Project' lifetime award (Woolridge); Fellow of the Royal Pharmaceutical Society in 2011, (Raynor); New Investigator Award for Best Oral Presentation, International Society for Quality of Life Research 2010 and the 2011 Clay Award for the most

highly cited paper in Optometry and Vision Science over 5 years (Harley).