Institution: Newcastle University

Unit of Assessment: 3

a. Overview

Research returned in this UoA, undertaken in two linked Research Centres, focuses on some of the most significant and costly health challenges faced by our society, namely obesity, poor oral health and ageing. **The Human Nutrition Research Centre (HNRC)** and the **Centre for Oral Health Services Research (COHR)** have a shared history. Each Centre has its own focus, but both use the same multi-disciplinary approach. The "*molecules to public health*" concept developed by HNRC applies equally to COHR and drives the mission to improve human health through research. Both Centres start with basic molecular mechanisms and epidemiological patterns and apply their findings to develop and test interventions, to inform the management of common risks and to use services to improve health. The Faculty of Medical Sciences (FMS) Research Institutes provide outstanding physical and methodological support for both Centres, however our work crosses Institutes and Faculties, and draws methodological support from many disciplines. The work of the two Centres also overlaps around a 19-year programme of research at the interface between nutrition and oral health.

The HNRC was established in 1994 to serve as a focus for research in Human Nutrition and has quadrupled in size in the subsequent two decades. Nutrition and Oral Health researchers have been partners in Newcastle over this period, and we have hosted the World Health Organization Collaborating Centre for Nutrition and Oral Health since 1996. The cross-disciplinary 'Centre' approach that works well for nutrition was adapted for oral health, and the COHR was established early in 2010 using the HNRC model. In view of the common model, shared history and philosophy, this submission considers Human Nutrition and Oral Health research together. The academic team for HNRC is based in both the Faculty of Science, Agriculture and Engineering (SAgE) and in the Faculty of Medical Sciences (FMS). Colleagues in SAgE (focussed mainly in the Food Quality and Health Theme) are returned within UoA6 and two others are returned in UoA1 and UoA2, whilst the remaining eight academics in FMS working in Molecular Nutrition and Public Health Nutrition, are returned here. Similarly, in addition to the 12 core PIs returned here under Dentistry, 16 other scientists from across the University make major contributions to oral health research but will be returned under several other Units of Assessment. The two centres have their own areas of work but two PIs (***Moynihan*** and ***Valentine***) work comprehensively across both Centres.

b. Research strategy

HNRC has a sustained focus on some of the major public health concerns i.e. obesity and ageing and on common age- and obesity-related chronic diseases including diabetes, cardiovascular disease and colorectal cancer. Our **primary strategic aim** is to focus on these dominant issues and to play to our strengths in translational research to extend understanding of mechanisms and to develop and test nutritional interventions to improve public health - our '*molecules to public health*' approach. This matches well the priorities of our major funders including the Research Councils and NIHR. The two nutrition-specific themes reported in UoA3 are '**Molecular Nutrition**' and '**Public Health Nutrition**'.

COHR was established in 2010 in recognition of the need for a tightened focus and multi-disciplinary research approach if we are to address the problem of poor oral health, particularly in an ageing population. Our **primary strategic aim** is to build excellence around two themes, both aimed at preventing poor oral health; **Translational Oral Biosciences,** which is predominantly research at the laboratory-clinical interface and concentrates on two important conditions (periodontal diseases and oral cancer) and **Oral Health Care and Epidemiology,** with a public health and services focus. To ensure methodological excellence, COHR members are drawn from across the University, whilst collaborating with other dental institutions means we contribute to high quality, multi-centre studies. We are developing our research programme in a third area (oral health, biomaterials and biological interfaces) and progress in this area represents a major strategic goal over the next REF period.

b1. Nutrition (HNRC)

a) Molecular Nutrition

Mechanistic nutrition research has been transformed by the application of molecular tools. We

have increased greatly our capacity for, and expertise in, basic research on diet-gene interactions through the EU FP6 Centre of Excellence in Nutrition Genomics (NuGO; euros 17.2M) (***Ford***, ***Hesketh***, ***Mathers***, ***McKay*** & Relton (UoA1)). This research includes the application of post-genomic technologies (transcriptomics, proteomics, metabolomics and epigenomics, and associated bioinformatic tools) to reveal the mechanisms through which nutrients and other food bioactive compounds influence gene expression and cell function. Our major focus has been on micro-nutrients e.g. folate, selenium and zinc and we have initiated several productive collaborations with colleagues across Europe. This has led to the development of the international *Micronutrient Genomic Project* (founding Chair, ***Hesketh***) and to participation in other EU-funded consortia including *MICROGENNET* and *GEoCoDE* (***Hesketh, McKay*** & Relton). Our strategy also embraces investigation of the impact of individual genotype on responses to foods and nutrients where our expertise has led to new collaborations with i) systems biology experts (Kirkwood & Shanley (UoA1)) in innovative BBSRC-funded systems biology research on selenium use (***Hesketh*** & ***Mathers***) and ii) European colleagues in the EU FP7 project *food4me* which is investigating the utility of providing genotype-based dietary advice in personalised nutrition (***Mathers***). We collaborate widely with industry in keeping with our translational goals. Examples include ***Ford'***s work on nutrition and epigenetics funded by Unilever and ***Mathers'*** collaborations with Phillips and DSM Nutrition (in *food4me*) and with DuPont/Danisco (in a BBSRC-funded project on gut health).

We have invested in expansion of capacity to undertake fundamental research in epigenetics which we consider to be a major mechanistic link between nutrition and cell function and health. This has included purchase of a Pyromark™ MD system for quantification of DNA methylation by pyrosequencing and investment in researcher training (***Mathers*** with ***Ford*** & ***McKay***). This has produced new methodological advances (Lisanti *et al.* (2012) *Epigenetics*) and new collaborations resulting in high-profile publications (Zeybel *et al.* (2012) *Nature Medicine*). Much of our work is undertaken in humans but we also use model systems including cells and mice. ***Ford*** recently initiated a novel line of research using honey bees as a model for epigenetics-based studies of the impact of nutrition on the ageing process.

b) Public Health Nutrition

Changing lifestyle behaviours and, in particular, eating habits to improve health is an international public health priority and we are contributing significantly to the evidence base. Our strategy is to develop interventions which are stratified (appropriate for the individual or group), scaleable (suitable for use at community, region or national levels) and sustainable (sustainable long-term by the provider and delivering sustained behaviour change). Our research includes development and testing of behavioural interventions to treat obesity and maintain weight loss (including use of digital technologies in collaboration with Olivier (UoA11) and the Centre for Translational Research in Public Health (FUSE) (Sniehotta (UoA2 funded by MRC-NPRI)) and to reverse Type 2 Diabetes (in collaboration with Taylor (UoA1) and Sniehotta (***Adamson*** (**NIHR Research Professor in Translational Research**) & ***Mathers***). The appointment of ***Siervo*** strengthens our expertise in the assessment of body composition and on mechanistic links between adiposity and metabolic health and ***Brennan*** (recruited from Ireland) enhances collaboration between Molecular and Public Health Nutrition. In addition, we are undertaking a major collaborative project *The LiveWell Programme* (£2.1M, funded by the cross Research Councils' LLHW initiative) to develop and pilot lifestyle-based intervention to enhance healthy ageing (PI ***Mathers*** with ***Moynihan***, *Sniehotta*, *White* (UoA2) & ***Adamson***). *LiveWell* includes research on the development of outcome measures to assess the Healthy Ageing Phenotype in collaboration with colleagues in Birmingham, Cambridge, Edinburgh and UCL (***Mathers***). Our work also includes evaluation of national policies and working with policy makers e.g. research on effects of OfCom's TV food advertising regulations and evaluation of the School Food Policy (***Adamson***) and evidence synthesis on sugars and dental caries to inform WHO guideline development for population nutrient goals (***Moynihan***).

Over the assessment period we have addressed the challenging issue of measurement of dietary intake using two novel and complementary approaches. In multi-disciplinary research with colleagues expert in human-computer interactions (Olivier UoA11), we have developed a prototype computer-based self-completion 24 hour recall system INTAKE24 (***Foster*** with ***Adamson***). INTAKE24 is being adapted for web delivery for young adults using funding from the Food Standards Agency (Scotland) (***Foster***) and for older adults via *The LiveWell Programme* (***Mathers***

& ***Adamson***). In parallel, in collaboration with colleagues in Aberystwyth (***Draper***), we have used a metabolomics-based approach to discover metabolites in urine which are characteristic of consumption of specific foods (*Metabolomics* 2011, *Am J Clin Nutr* 2011) (***Mathers***). This proof-of-principle work is being extended in a new MRC-funded project (with Aberystwyth and Imperial College) to develop novel biomarkers of food intake. In the next period, we aim to integrate the outcomes from the metabolomics- and computer-based approaches to produce novel, objective, acceptable and cost-effective approaches to dietary assessment with wide utility.

b2. Oral Health (COHR)

a) Translational Oral Biosciences

Preshaw and ***Taylor*** lead clinical and laboratory research in periodontal disease, built on foundations of contemporary immunology and working with the Institute for Cellular Medicine. Their work focuses on the important bi-directional relationship between diabetes and periodontal diseases (*Diabetologia 2012, J Clin Periodontol 2013*) with new trial findings in preparation, and on early stage detection of periodontal disease by using salivary biomarkers, increasingly working with industrial partners. This includes recent support from Phillips and a £1.1M EPSRC/TSB-funded project to develop technology platforms for early diagnosis. Preshaw also links across to the Oral Health Care and Epidemiology group on trials and clinical research. ***Jakubovics*** is a young researcher in microbiology appointed at the beginning of the REF period. He has a very active collaboration with marine biologists and their team has developed a unique nuclease enzyme capable of dispersing plaque biofilms (key to the development of periodontal disease and caries). Initial results have been published (Shields *PLoS ONE* 2013) and we have several Confidentiality Disclosure Agreements in place with industrial partners in view of its many commercial applications in health. We have an emerging programme of work in the molecular genetics of oropharyngeal cancer, specifically related to the role of *PAX9* and other development genes (***Robinson***, Kist (UoA1)), combining expertise in oral cancer (***Robinson***) with long standing published molecular genetic research on oro-facial development (Kist, ***Peters***) to characterise specific cancer development pathways whilst ***Thomson*** provides the clinical research link with the Oral Health Care and Epidemiology theme.

b) Oral Health Care and Epidemiology

Steele*'s** work on health trends underpins the current dental services reform programme in the NHS. Funding of approximately £0.45M has been secured over the period from the DH Information Centre (via the Office for National Statistics as part of a £6M funding package with several collaborators). ESRC is supporting secondary econometric analysis (Steele*** with Newcastle Business School and UCL) to aid understanding of the major age-related oral health inequalities that are clearly evident in oral health and the structural reasons for these (*Comm Dent Oral Epidemiol,* 2013). The unique *Thousand Family* birth cohort, which has included oral health data since 1997, is the focus for an NIHR Doctoral Research Fellowship (***Steele*** and ***Preshaw*** as supervisors) investigating why people find themselves on different oral health trajectories in old age with a view to targeting interventions, particularly around periodontal health.

To complement the epidemiology we have developed considerable expertise in mixed methods health services research related to better care pathways and economics, with a number of significant health economics outputs in the REF period. ***Durham***'s emerging research on chronic pain (*J Dent Res,* 2010) has led to a highly sophisticated study of the economics associated with managing chronic pain (£0.95M NIHR Clinician Scientist Fellowship). ***Heasman***'s publications on the economics of periodontal diseases are the first of their kind, whilst the economics research of Holmes and Vernazza (early career Academic Clinical Lecturers (ACLs)) will see outputs outside the current assessment period. ***Moynihan*** directs the WHO Collaborating Centre for Nutrition and Oral Health and her mixed methods research addresses shared concerns around nutrition and oral health of global significance (for example evidence synthesis on sugars and dental caries to inform WHO guidelines and research on childhood dental erosion). ***Maguire*** (with ***Moynihan***) also works at the oral health and nutrition interface, as evidenced by a strong body of published work on fluoride metabolism.

Clinical trials are an important activity of COHR, delivered in-house only where a generalisable trial question can be set and answered. To develop the capacity to answer more complex, difficult and expensive questions, our strategy is to work with partner organisations and to develop the capacity

to deliver the trials in primary care. A programme of clinical trials in pain management with local analgesia (***Meechan***) has delivered clear global clinical impacts over the REF period, described in REF3a, whilst ***Preshaw***, with ***Heasman***, has linked his laboratory research to clinical trials, with clinically important findings around smoking and diabetes. On a larger scale, in the last five years we have been involved with four large NIHR portfolio trials operating in primary care and are developing a thriving infrastructure for clinical research. The DEEP study is Newcastle led (***Durham***), the £3M FiCTIoN trial is split between Dundee and Newcastle with ***Maguire*** as a PI, whilst IQuAD (£2M) is led by Dundee but with Newcastle as the major partner. We now have 25 dental practices trained and experienced in research and ready for future trials.

Future Research Plans & Research Strategy

Human Nutrition Research Centre: Ageing and obesity will remain major public health priorities for the foreseeable future. In the next five years the HNRC will continue to focus on these priority areas. We will undertake multi-disciplinary research building on our existing strengths in two areas. Firstly, research on underlying mechanisms that may offer new insights into the ways in which nutrition modulates health, focussing on epigenetic regulation (via DNA methylation, histone modifications and microRNA) of gene expression and cell function. Here our primary focus will be on the ageing gut and brain for which we have developed effective experimental approaches, appropriate tools and key collaborations and where there is significant opportunity for health benefit through nutritional modulation of the risk of age-related diseases such as bowel cancer and dementia. Secondly, research on the evidence base for intervention development and testing including innovations in measurement of dietary behaviours (testing the utility of biomarkers in the National Diet and Nutrition Survey) and in assessment of the Healthy Ageing Phenotype. This will include novel approaches to prevent/manage obesity in children and adults and for the sustained reversal of Type 2 Diabetes in obese adults – the latter newly-funded by Diabetes UK (£2.4M) in collaboration with MJ Lean and colleagues (University of Glasgow) and Taylor (UoA1). We will also test the utility of an innovative, integrated platform for behaviour change, developed within *The LiveWell Programme*, to motivate and support lifestyle changes in those in the peri-retirement period which is aimed at enhancing healthy ageing. Both areas of research will include use of model systems and birth cohorts including the Gateshead Millennium Study (***Adamson*** PI**)**, Thousand Families Study (***Adamson*** & ***Mathers)*** and the Newcastle 85+ Study (***Adamson, Mathers*** & ***Siervo)*** (all managed by Newcastle University) and the National Survey of Health and Development, in collaboration with UCL. A key strategic goal for HNRC is to be in a position to make a competitive application for an NIHR Biomedical Research Unit in the Nutrition, Lifestyle and Health field in the next national competition.

Centre for Oral Health Nutrition: A feature of our work in Translational Oral Biosciences is the speed to potential commercial and/or health impact. Over the next five years we will develop and refine reliable diagnostics for periodontal risks (***Taylor*** and ***Preshaw***) funded under the EPSRC/TSB, and work with our commercial partners to see this through to viable products. ***Jakubovics***'s nuclease work has been pump primed by COHR through its early stages: In the next period we will strengthen relevant clinical links using our clinical fellow scheme (see c i below) with a view to larger scale commercial funding. To do this we aim to build an oral biofilm model to facilitate *in vitro* testing of a range of commercial applications. This will ensure that we can strengthen existing partnerships and seek new applications for the technology and new partners. With translational opportunities emerging in personalised medicine, COHR will seek to build the area of molecular genetics of oral cancer. To do this COHR will provide pump priming if necessary, and clinical fellow support. We anticipate that this area will be ready for competitive Research Council funding proposals in the near future.

We will extend the work initiated over the REF assessment period by ***Durham*** and apply the resulting knowledge and experience in developing this approach to services beyond chronic oro-facial pain by forming collaborations with clinicians in other linked areas such as chronic fatigue and headache. We will seek to maximise the learning from national oral health datasets (Adults 2009 and Children 2013) by working with our academic partners (e.g. UCL) on secondary analyses. We will complement the work on national data with the unique Newcastle cohort studies (Thousand families and Newcastle 85+). For all of our population research we will focus on trends, health economics and econometrics and in Vernazza (ACL), Holmes (ACL) and O'Connor (NIHR Fellow) we now have the next generation of early career clinical scientists training in the

appropriate skills to take this forward. Alongside O'Connor's five year NIHR Doctoral Fellowship we will work with epidemiology colleagues in the Institute of Health and Society in Newcastle to consolidate our expertise in this area of strength, with a view to applying the methods to new datasets as they emerge. We aim to both lead and partner applications for large scale primary care clinical trials which we expect to be developed in the next five years, and have put in place the primary care network to support this. To do this we will form strategic partnerships with other UK dental academic institutions. We will exploit ***Valentine***'s expertise on molecular mechanisms of micro-nutrient function to develop new initiatives focussing on the roles of micro-nutrients in oral health, including chronic pain, periodontal disease and tooth development by seeking opportunities with existing PIs (e.g. ***Durham, Preshaw***).

Development of the research programme in our nascent third COHR area of **biomaterials and biological interfaces** is a key strategic goal for COHR. The science of biological surfaces and interfaces is critical in oral health and links both to our work on biofilms and periodontal diseases. It is also an area where there is ready translation into other areas of health. The research programme will be applied in nature and will focus on practical solutions to key clinical problems developed through a high quality research programme. German has already attracted funding in the area from BBSRC/EPSRC in the form of CASE studentships, from the EU FP7 funded 'Restoration Project' (£0.5M) and from several industrial collaborations. The opportunity to develop a focussed new research theme area, and to make supporting appointments, has arisen following the retirement of a senior academic. This has allowed us to concentrate our focus on projects specifically in the area of surfaces and interfaces. Over the next five years we aim to secure high quality outputs from this 'Restoration Project' and consolidate emerging work with industrial partners particularly where there is synergy with the two existing oral health themes. Our goal is for the work developed and undertaken by this theme to be returnable in the next REF.

c. People, including:

i. Staffing strategy and staff development

A critical factor in our future development, and in particular in delivering our growth strategy, will be the development of our research teams. Our goal is to sustain and grow a critical mass of highly motivated, well-resourced and productive researchers who undertake leading edge research in line with our research strategy. Both HNRC and COHR are committed, with host Faculty support, to recruiting the highest quality established researchers in relevant fields from around the world, whilst retaining and developing our own talented researchers, nurturing them in a positive and supportive environment so that they reach their full potential. Newcastle University meets many of the expectations contained within the Research Concordat and has developed an implementation plan to ensure all requirements are met.

Staffing strategy: Both elements of our twin-track staffing strategy have proved successful in the REF period. In terms of internal development, over the REF period HNRC appointed ***McKay***, trained in Newcastle, to a Lectureship in Molecular Epidemiology (in 2011). In terms of international external appointments ***Siervo***, a clinician with expertise in metabolic research, was recruited from the NIH (USA) to a Lectureship in Nutrition and Ageing in 2011. Additional appointments to strengthen obesity research will follow the award of an ***NIHR Research Professorship*** to ***Adamson*** who is a product of the Newcastle career development structures. In COHR three non-clinical external appointments were made immediately prior to the REF period, in 2007 and two are returned in the REF (***Jakubovics*** & ***Valentine*** in this UoA) and Kist was appointed in 2010 (returned in UoA1), the latter on the basis of outstanding outputs in developmental genetics from earlier work. Over the assessment period five PIs returned in this UoA were promoted to personal chairs (***Adamson, Ford, Maguire, Moynihan*** and ***Preshaw***). Four of these five personal promotions related to women, reflecting our strong commitment to equal opportunities. The value of our approach to development, aimed at nurturing talented staff and developing their full potential is illustrated by two case studies. ***Durham*** (COHR) was appointed to our internal clinical fellows scheme (see below) in 2002, obtained a PhD, was appointed as an NIHR ACL, was mentored to expand and develop his skills and won a five year NIHR Clinician Scientist Fellowship at Senior Lecturer level in 2012 working on health economics and care pathways. In nutrition, ***Adamson*** completed a PhD in 1993 (working with dental researchers on the diet of school children), was appointed Lecturer in the HNRC (1995), was promoted in 2005 (Senior Lecturer) and in 2009 (Chair) and was awarded an **NIHR Research**

Professorship in 2013 focussing on obesity.

In oral health research, the international recruitment pool is shallow, so, to build capacity from within, we developed a novel five year 'clinical fellow' programme a decade ago, comprising a PhD and teaching experience (with clinical training later). Subsequently, this has been complemented by the NIHR Integrated Academic Training (IAT) pathway (clinical training and research) and our progression rates for Academic Clinical Fellows (ACF), Academic Clinical Lecturers (ACL) and our own fellows to NIHR fellowships have been very high. In the assessment period we have appointed seven clinical fellows to our scheme (five in the last two years) and three ACFs, five PhDs have been awarded, three previous fellows have been appointed Lecturers in the School of Dental Sciences whilst two fellows and one ACF have progressed to NIHR Academic Clinical Lecturer level (***Durham,*** Holmes, Vernazza). Holmes and O'Connor won NIHR Doctoral Fellowships whilst ***Preshaw*** moved from a DH/NIHR Clinician Scientist Fellowship to a Chair and ***Durham*** was awarded an NIHR Clinician Scientist Fellowship. In all cases, our fellows are assigned to work only with established PIs in one of our three key areas, sustaining our focus.

All staff have access to training in a wide range of skills provided by the University Staff Development Unit and training needs are considered as part of the annual Performance Development Review (PDR) process. All staff members have received Equality and Diversity training. We help newly recruited staff to establish independent research careers by managing their teaching loads, by provision of start-up funds, and through mentoring by a senior colleague (e.g. ***Mathers*** mentors ***Siervo*** and ***Adamson*** who, in turn, mentors ***McKay*** and ***Foster***, ***Steele*** mentors Holmes, O'Connor and ***Durham***). FMS has developed a Careers Pathways Scheme to support early career researchers (to consider their career options in a timely manner) including annual PDR, careers advice workshops, and support through the fellowship application process for non-clinical and clinical researchers.

ii. Research students

Recruitment and completion: Since 2008, the entrance requirement for PhD students has been increased to include both an excellent first degree (at least upper second class honours) and a relevant master's degree (or equivalent). The proportion of clinically qualified dental PhD students is 24%. The number of PhD students across the UoA has increased in the assessment period with 56 students successfully completing their PhDs in the period and 58 currently in training.

Training and satisfaction: HNRC and COHR provide a strong multi-disciplinary research environment and culture of research excellence for our PhD students and co-supervision policies (e.g. COHR PhD students have one supervisor from an institute outside dentistry) ensure exposure to research excellence beyond the disciplines of nutrition or dentistry. Students may undertake part of their research in leading units elsewhere in the University but are brought together and embedded in the ethos of their research centre. PhD students present their research in our weekly seminar series and attend presentations by external speakers and annual research days.

PhD candidates receive the equivalent of ten days formal training in transferable and generic skills each year by selection from 155 courses including compulsory and elective modules. These courses are fully compliant with the QAA Code of Practice and UK Research Councils Joint Statement on Skills Training, and receive excellent student feedback. Performance monitoring, mentoring and attendance at appropriate taught courses by both PhD students and supervisors means that failures to complete a postgraduate research degree are rare both in the Faculty overall and in the two Centres (e.g. only one since 2008 in dentistry/COHR).

Research outputs: The recruitment and support of high quality postgraduate students contributes directly to overall research productivity, with 27% of REF returned papers co-authored by our students. High profile journals publishing papers first authored by students in the UoA include: Dromanraju *Gut* 2009 & Jaedicke *J Leukoc Biol* 2013. All PhD students are expected to present data to at least one major international conference during their period of study; to enable this, travel grants of up to £800/student are made available. In 2012, Newcastle PhD students (Gorniak and Tyrrell) organised the first Nutrition Society conference for PG students held in Great Britain which proved so successful that the Society is taking this forward as an annual event. The success of our students is also recognised by their career progression (e.g. Foster and McKay are now Lecturers in Newcastle, Lake in Durham and Craigie in Dundee) and awards e.g. PhD Gorniak was awarded a MRC Centenary Early Career Award (£20k). We have two CASE studentships in

collaboration with GSK and two industrial funded studentship grants from DENTSPLY (supervised by German, ***Preshaw***). Jaedicke is now applying information and expertise derived from her PhD to a TSB/EPSRC project.

d. Income, infrastructure and facilities

The diversity of our funders reflects the multi-disciplinary nature of our work and illustrates our ability to bring together very diverse types of research. The major sources of research income for Human Nutrition PIs include BBSRC and MRC, with significant income from cross-council initiatives including Lifelong Health and Wellbeing (through the *Centre for Brain Ageing and Vitality* (CBAV, £4.5M) and *The LiveWell Programme* (£2.1M, ***Mathers***)) and the New Dynamics of Ageing Programme (through the MAPP-MAL project, £1.0M ***Moynihan***). In addition, we have attracted substantial funding from the Wellcome Trust, MRC-NPRI, NIHR, UKCRC, government bodies (including Department of Health and the Food Standards Agency) and the EU FP6 and FP7 programmes. This focus on major funding streams will continue through our participation in the MRC/ARUK *Centre for Integrated Research on Musculoskeletal Ageing* (CIMA, £2.5M), through MRC funding for CBAV renewal and the NIHR School for Public Health Research whilst we also target specialist funders including the British Heart Foundation, CRUK and the WCRF. Oral Health Researchers have received external income in the period from a similarly diverse group of funders, again reflecting the multi-disciplinary nature of the work. These include NIHR (e.g. the DEEP study, (£853K, ***Durham***), the HTA funded FiCTION (£1.1M, ***Maguire)***, and IQuaD trials (£206k, ***Heasman***)), MRC; (ISODS study (£180K, Exley/Ellis/***Steele***)), ESRC (e.g. the MAPP-MAL project, ***Moynihan***, see above), EPSRC (EPSRC/TSB (£704k, ***Taylor***)), NIH (NIDCR RO21 grant), EU FP7 (e.g. the Restoration Project (£120k, ***German/Meechan***)) and Government (e.g. Children's Dental Health Survey 2013 (£248k of £3M, ***Steele***)). The HNRC and COHR provide pump priming and bridging support for early career researchers for strategically important projects. These include a contribution from the Faculty and resources from consultancy work and other activities. Staff and students also target the Faculty's competitive fellowships and studentships.

PIs enjoy access to specialist facilities in the seven Faculty of Medical Sciences Research Institutes (which also line manage researchers) and in the other Newcastle University Faculties, accessing additional research support as required (for example Kist (UoA1) and ***Peters*** use specialist mouse facilities in the Institute of Genetic Medicine and oral health researchers use systems set up in the Institute of Health and Society for interviewer safety in the field). Moreover, PIs benefit from using major facilities including our dedicated **Clinical Ageing Research Unit** for invasive studies using human participants (e.g. endothelial function and insulin sensitivity measurements) the **Comparative Biology Centre** for animal model (mainly mice) studies the NIHR **Clinical Research Facility (CRF)** (used for intensive investigations with human participants e.g. our metabolomics-based studies) and its linked **Dental Clinical Research Facility**. The dental CRF was funded by the University and the Newcastle Hospitals NHS Trust and opened in 2011 and was built specifically to allow us to conduct high intensity clinical research in a customised and properly equipped dental setting. Molecular Nutrition researchers have excellent access to faculty platforms for transcriptomic and proteomic research as well as our own platform for DNA methylation and genotyping using Pyrosequencing. The broader approach to understanding key lifestyle behaviours in the public health nutrition theme, and development of behaviour change interventions, are enhanced through collaboration with the MoveLab, colleagues in FUSE (Sniehotta (UoA2)) and Computing Science (Olivier). There are also three well equipped specialist research laboratories located in the School of Dental Sciences: a Level 2 containment molecular biology laboratory, a materials science laboratory equipped with a high standard of equipment including an Atomic Force Microscope (used by the whole University) and a dedicated fluoride research laboratory.

e. Collaboration or contribution to the discipline or research base

Collaborations

Collaborations using local and regional cohorts: The underpinning concept of both Centres is that their research is multi-disciplinary in nature, drawing expertise from across the University to address our strategic targets in ageing research. In addition, PIs are collaborators in research using biological samples and data from the landmark Newcastle 85+ Study (***Mathers, Siervo, Steele***) and other regional cohorts including the Thousand Families Study (***Adamson, Mathers, Siervo, Steele***) and the North Cumbrian Community Genetics Project (***Mathers, McKay***).

Major National and Newcastle-based collaborations: HNRC PIs play leading roles in several prominent multi-institutional centres e.g. ***Adamson*** is a member of the UKCRC £1.7M Centre for Translational Research in Public Health (FUSE), the Department of Health £4.2M Policy Research Public Health Research Consortium and the NIHR School for Public Health Research. ***Mathers*** is co-Director of the MRC/BBSRC £4.2M Centre for Brain Ageing and Vitality (CBAV), a PI on the MRC/ARUK £2.5M Centre for Integrated Research on Musculoskeletal Ageing (CIMA) and collaborates with the BBSRC/EPSRC £6.2M Centre for Integrated Systems Biology in Ageing and Nutrition (CISBAN). COHR PIs actively collaborate with nine other UK Dental Schools. Examples include ***Steele*** with an established collaboration with a consortium of 4 UK dental schools, ONS and NatCen on the £3M National Survey programme, and a Co-Investigator role with UCL on a recently awarded ESRC grant and work with Dundee University on two very large primary care HTA trials; ***Maguire*** is co-PI on FiCTIoN and ***Heasman*** is a key collaborator on the IQuAD trial.

International collaboration: ***Siervo*** is an investigator in the InCHIANTI Study (population-based study of ageing in Italy) and work with the **National Institute on Ageing** in the USA. Through the GEoCoDE study, ***McKay*** collaborates with colleagues in China, India and Brazil. In the EU FP7 '*food4me projec*t', ***Mathers*** collaborates within a consortium of 25 European academic institutions and companies. COHR researchers have published or undertaken funded projects with five Universities in the US, three groups in Asia and four in Latin America (e.g. ***Maguire*** has productive working links with institutions in Japan and Brazil which have led to significant outputs). ***Moynihan***, who directs the only *WHO Collaborating Centre for Nutrition and Oral Health*, shares her nutrition and oral health expertise with a range of collaborators around the world, leading to important outputs (e.g. Iwasaki et al J Dent Res, 2009,). In total, 66% of the outputs submitted in this return include co-authors from our national and international collaborations.

Honours: In the assessment period ***Adamson*** received a Fellowship of the Faculty of Public Health and an NIHR Research Professorship. ***Mathers*** received the highly prestigious Nutrition Society Gold Medal and an Honorary Fellowship of the Association for Nutrition. Three COHR members received Distinguished Scientists Awards from the International Association of Dental Research in the return period (***Steele, Moynihan*** both for 'Geriatric Oral Health Research' and ***Preshaw*** in 2008 (Young Investigator Award)). In 2011, ***Meechan*** won the Medical Futures Innovations Award (the overall award). ***Steele*** was awarded the CBE in 2012 for services to dentistry and oral health and has received two honorary Royal College Fellowships.

Membership, Chairmanship and Contribution to the Disciplines of Nutrition and Dentistry

National bodies: ***Adamson*** served on the Food Standards Agency Front of Pack labelling independent project management panel, was an invited expert panel member for the Secretary of State's School Food Plan and is a member of the Public Health England (PHE) Obesity Priority Programme Board. During the review period, ***Mathers*** was a member of several Research Council strategic bodies including: the Advisory panel of the RCUK Lifelong Health and Wellbeing Research programme; the BBSRC's Diet and Health Research Industry Club (DRINC); the BBSRC's Basic Bioscience Underpinning Health Strategy Advisory Panel; the ESRC's "*Understanding Society*" Governing Board: the ESRC's Biosocial Research Committee, and the MRC's Physiological Systems and Clinical Sciences Board. We have panel members on four NIHR fellowship panels (***Preshaw, Steele, Adamson***) and ***Steele*** serves as national chair (since 2008) of the NIHR Oral and Dental Speciality group which manages the portfolio of all of the UK clinical portfolio studies. ***Girdler*** is a member of the NICE Advisory Group on paediatric sedation.

International bodies: ***Steele*** was a member of the advisory panel on the research evidence-based Canadian Academy of Health Sciences report on oral health care in Canada (to be published 2013). ***Moynihan*** served as an expert advisor to the WHO's Nutrition Guideline Advisory Group on Sugars and Dental Health, updating global population guidelines on dietary sugars.

Editorial duties: In addition to regular peer-reviewing for over 40 journals, HNRC and COHR staff served on the editorial boards of 33 journals e.g. *British Journal of Nutrition* (***Mathers***), *Clinical Obesity* (***Siervo***), *Journal of Trace Elements in Medicine and Biology* (***Ford***) and *Community Dentistry and Oral Epidemiology* (**Steele**).