Institution: The University of Edinburgh

Unit of assessment: 1

a. Overview and Context

Overview:

Impact Results: The significance and reach of our research impact is evidenced by our 22 case studies, which demonstrate impact in more than 100 countries on all continents of the world, benefitting millions of individuals. Moreover, for the case studies with a measurable health economic impact, the underpinning grant funding has generated *annual* cost savings for the NHS alone of £294M, representing an *annual* return on public funding of a minimum of £147 for every £1 of grant income awarded. We have influenced and defined practice for: a) those delivering patient care, b) healthcare delivery organisations, and c) national governments and global bodies - including the World Health Organization (WHO). This has resulted from a comprehensive strategy to deliver impact from the work of our multidisciplinary research Centres and Institutes (see REF5). Our focus is on impacting the health and welfare of patients, translating and commercialising research output, and outreach through public engagement.

1. **Translation to improve health and welfare** is delivered through the development and implementation of new services into NHS-Lothian and national practice. We influence policy at the highest levels, and address major unmet need all over the world, including in developing countries.

2. **Translation to healthcare industries** has been transformed by our approach of funding an Entrepreneur in Residence, initially via one of the first Medical Research Council (MRC) Translator Awards in the UK, ultimately leading to the establishment of the **Edinburgh BioQuarter** (EBQ) Commercialisation Team in 2009. EBQ, is an £18M, 6-year partnership with Scottish Enterprise (SE), NHS-Lothian (NHS-L) and the leading USA-based bioparks developer, Alexandria Real Estate Equities (Alexandria), which has brought expertise through the EBQ team and Executive Board. It has resulted in valuable partnerships with pharmaceutical partners, such as one of the first 10 GlaxoSmithKline (GSK) “Discovery Partnership with Academia” (DPAc) partnerships worldwide. Our proactive strategy for biomedical innovation has led to an influx of venture capital (VC) funds to Edinburgh of over £36M of new funds in the last 3 years; notably the £25M Rock Spring Ventures fund (http://www.rockspringventures.com), representing the first new biomedical venture fund in Scotland for over 10 years.

3. **Engagement with the public** is vital, and we actively encourage all research staff to relish fruitful two-way dialogue with the public, explaining research value and impact at every opportunity. As a result, our public engagement is vibrant and extensive. Major contributions include UK Science Festivals, and many other outreach programmes - for example in topical and controversial areas such as new cancer drug treatments and availabilities, stem cell research, use of genetic information, genetic modification, and regenerative medicine (researchers returned in both UoAs 1 and 4).

Context:

The major Impact Statements from our Unit of Assessment relate to Health and Welfare, the Economy, Public Policy and Services, Practitioners and Services, and International Development. Our non-academic user groups and beneficiaries include the public (through developments in healthcare, translational medicine and media/outreach), the NHS and regional and national healthcare policy and delivery agencies i.e., Scottish and UK government, and international organisations, i.e. WHO and global pharmaceutical and biotechnology industries.

b. Approach to Impact

1. Translation to Improve Health and Welfare: Impacts on health, welfare and policy are catalysed by the long-held partnership between clinician scientists and NHS-L, a £1.3 billion health system employing 28,000 staff and providing primary, secondary and tertiary care to a population catchment of around one million. Integration is facilitated by a number of high-level joint University of Edinburgh (UoE)-NHS appointments including, for example, **Iredale** (Regius Professor of Medical Science, Clinical Dean, non-Executive Director of NHS-L), **Newby (Impact Statement (IS):B)** see list at end of REF3a) (Professor of Cardiology and Director of NHS R&D) and

Cameron (IS:C) (Professor of Oncology and Head of NHS-L Cancer Services). Clinical academics design, execute and manage research innovation and service development, linking these across a wide range of clinical services provided by NHS-L. This includes, and extends beyond, hospital and general practice settings. Examples include: **Turner** (Medical Director of the Scottish National Blood Transfusion Service), **Clegg** (Academic Lead of Scottish Ambulance Service Advisory Group) and **Eddleston (IS:D)** (Director of Scottish National Poisons Inflammation Service). The close partnership and integration is evidenced by our joint enterprises that optimise access to patient records and clinical material, and, crucially, the development and efficient deployment of new therapeutic interventions. Key clinical leads in NHS-L are also active members of the UoE College of Medicine and Veterinary Medicine (CMVM)'s Research and Strategy Committees, ensuring that our medical research planning and progress feeds into NHS-L services. Importantly, we have linked NHS-L with entrepreneurial opportunities beyond that of traditional NHS research and development (R&D), by the appointment of NHS-L Chief Executive **Davison** and NHS-L Medical Director **Farquharson** to the EBQ Board (see below). In both UoE and NHS-L, clinical academics and NHS Consultant colleagues work together to deliver patient-based translational studies and clinical trials **(IS:A-C, E-L)**, efficiently implementing changes to clinical practice.

UoE has a strong track record of delivering major healthcare innovations. These include the UK's first renal transplant in 1960, through to the introduction of islet cell transplantation in Scotland, and the UK's first adult living donor liver transplant, which was carried out during the REF census period. Recently, acute myocardial infarction and 'out of hospital' cardiac arrest care has been revolutionised by **Clegg,** working with the Scottish Ambulance Service, who has developed innovative monitoring of 'out of hospital' resuscitation in situ. Consequently, changes in training for paramedical staff have been adopted, resulting in a doubling in the recirculation rate (to the second highest in the UK), saving 15 lives in Edinburgh alone in 2012. This work represents one of a series of game-changing practices that has impacted on patients' lives, spanning multiple care settings. Others include establishment of one of the UK's first direct admission units for Percutaneous Coronary Intervention, developed from a Chief Scientist Office (CSO) and UoE-funded pilot study in 2006–2008 **(Boon, Newby)**, the introduction of post-arrest patient cooling and oesophageal temperature monitoring **(Clegg, Gray)** and a stringent analytic approach to monitoring quality of care on intensive care units (led by **Walsh** and supported by a Wellcome Trust (WT) Health Innovation Challenge fund grant of **£1M**). The latter has identified new approaches to ventilation complications and to novel biomarkers for ventilation-associated pneumonia, which are expected to have significant future impact. These examples of new clinical developments exemplify our "joined up" approach to strengthening the pathway in acute medicine, from 'points of crisis' through 'on site' resuscitation and transfer to lesion-limitation and post-admission care, so as to relentlessly drive improvements in the quality and outcome of clinical interventions that require seamless management of multi-disciplinary teams. All are research-led.

We are particularly strong in community-based medicine, with impact extending to resource-poor healthcare settings and neglected diseases. Indeed, the Centre for Population Health Sciences hosts the Medical Research Council (MRC) Trials Methodology Hub, whose researchers are setting standards in community-based guidelines for end-of-life care in non-malignant chronic disorders worldwide **(IS:M)**. The long-standing collaboration between NHS and UoE groups working across community and secondary care settings is exemplified by the development and adoption of robust new cervical cytology methods, which directly influenced establishment of the national HPV vaccination programme and national policy on allergy and asthma **(IS:N)**. We have also delivered major impact in the fields of phthalate and nanotube exposure **(IS:O, P)**, in WHO policy in the medically challenging area of childhood pneumonia **(IS:Q)**, in global policy regarding therapeutic intervention in organophosphate poisoning in South East Asia **(IS:D)** and in the treatment of onchocerciasis in Africa and South America **(IS:R)**.

Clinical Trials: UoE and NHS-L R&D clinical trial management are fully integrated and co-localised in a "one stop shop" joint office (ACCORD: Academic and Clinical Central Office for R&D), providing support on indemnity, material transfer agreements and ethics. This facilitates translational research and rapid execution of clinical trials, permitting efficient adoption of changes to clinical practice. The Edinburgh Clinical Trials Unit (ECTU) provides fully equipped adult patient care facilities in the Wellcome Trust Clinical Research Facility (WTCRF) at the Western General Hospital and at the Royal Infirmary of Edinburgh Clinical Research Facility (RIECRF). Both are

Medicines and Healthcare Products Regulatory Agency (MHRA) phase I-accredited units and both oversee phase I and 'first-in-human' trials; ECTU was the first UK academic unit to achieve such accreditation. Paediatric facilities are established in the Children's Clinical Research Facility (CCRF) at the Edinburgh Royal Hospital for Sick Children.

The WTCRF also performs an outreach function in hospital wards and the community, in particular via extensive research nursing support. Facilities include in-patient bedrooms, consultation rooms, gene therapy suites and intensive studies rooms. In 2012, the WTCRF contributed to over 350 studies from over 200 investigators, and there were over 8000 study visits; during 2012 alone, nearly 200 papers were published from work conducted under its auspices. Especially important for the genetic studies at the Institute of Genetics and Molecular Medicine (IGMM) is the WTCRF Genetics Core, which can perform large-scale genotyping and next-generation sequencing. It has sophisticated procedures for storing DNA from "bio-banked" population cohorts of many thousands, including Generation Scotland (see below). Critical to delivering impact is integration of the WTCRF Genetics Core with the NHS Clinical Genetics Service. The service employs 80 people, links genetic counselling, cytogenetics and molecular genetics and biology, and is co-located with IGMM, resulting in scientists sharing space and research goals. This provides a vital link between scientists in the IGMM (including the MRC-Human Genetics Unit) and clinicians in the NHS, and has led to several important examples of new gene discovery underpinning inherited disorders, bringing these to the clinic through the NHS Clinical Genetics Service **(IS**:**G)**.

Our Cancer Research (CR)-UK-funded clinical trials team provides infrastructure for cancer-specific clinical trials. Like ECTU, it is MHRA phase 1-accredited. This is pivotal to the clinical testing of new anti-cancer drugs, with at least one new anti-cancer drug (lapatinib) tested here now used globally in the treatment of breast cancer **(IS:C)**. The Experimental Cancer Medicine Centre (ECMC), which is co-funded by CR-UK and the CSO (£2.2M) collects, annotates and distributes (with full tissue governance compliance) all clinical cancer samples. These are available to UoE researchers for genetic, histologic, pathologic or pathway analysis, and are vital to on-going clinical and translational studies.

2. Translation to Healthcare Industries: To enhance entrepreneurial activity, UoE has embedded experienced pharmaceutical industrialists within research centres to drive translation and commercialisation. Initially, an 'Entrepreneur in Residence' (Marriage) was funded through one of the first two MRC Translator Awards in 2007. Supported by SFC knowledge-transfer funds, the Entrepreneur in Residence team grew rapidly. An early success was the granting of an MRC Development Pathway Funding Scheme (DPFS) award: a pilot portfolio of £2.0M (plus a further £0.3M), one of only five in the UK. Robust processes identified milestone-based projects, with innovation as the driver. These included projects on devices **(IS:T, U)**, drug discovery, novel imaging agents, and repositioning of clinically-approved drugs. Four of the projects had significant collaborative input from industrial partners. Multiple projects, including lung molecular imaging agent development (**Haslett** and **Bradley**, School of Chemistry) and pancreatitis drug discovery (**Iredale** and **Mole**), have already leveraged significant additional funds of over £18M from MRC, Wellcome Trust (WT) and the Engineering and Physical Sciences Research Council (EPSRC), and of £3M from GSK. All DPFS-funded projects successfully met key milestones and we expect future impact from them. The tangible success of the original 'Entrepreneur in Residence' programme led to rapid expansion of commercialisation capacity, and EBQ was formed in 2010 (www.bioquarter.com).

Edinburgh BioQuarter (EBQ): EBQ was formed in response to the increasingly difficult environment for University-led spinout companies, and to foster interactions with the pharmaceutical sector, which is now keenly engaging with our academic research centres. EBQ is supported by a Board, comprising senior representatives from UoE, NHS-L, SE, Alexandria and international entrepreneurs and venture capitalists, and is chaired by the serial entrepreneur Prof Simon Best OBE (previously CEO of Zeneca Plant Sciences, Roslin Biomed, Ardana and Aquapharm Biodiscovery). The EBQ team has four broad roles: (1) to identify commercially relevant R&D programmes and to work with UoE academics to maximise commercial potential, either by creating spinout companies or via out-licensing opportunities; (2) to work with prospective company spinouts to ensure that they achieve early investor readiness; (3) to actively encourage

and facilitate wider collaboration between academics and industry; and (4) to foster an entrepreneurial culture amongst CMVM academics. EBQ was initially funded for 6 years at £3M per year, and now has an experienced commercialisation team of 12, including EBQ Director (**Capaldi**) and the Entrepreneur in Residence. EBQ led a successful bid for a Confidence-in-Concept award in 2012 from the MRC (£700K per annum), specifically focusing on devices and diagnostics, and incorporating bio-engineering and fabrication excellence at Heriot-Watt University (Edinburgh). Crucially, EBQ supports a growing NHS-L entrepreneurial culture; for example, the co-creation with the NHS-L Metabolic Unit of the company ipSOX, a private company that designs and sells "socks" (covers) for insulin pumps. ipSOX is a company limited by guarantee that is dedicated to returning its profits to research; as such, it made its first donation to the Edinburgh branch of Diabetes UK in 2012 as a result of successful entry to market. Such philanthropic companies are an alternative approach to capturing income from academic innovation, and demonstrate EBQ's qualities in entrepreneurship and commercialisation.

EBQ is exerting exciting commercialisation benefits. In the 5 years prior to the inception of EBQ, there was a single spinout company from CMVM; during the past 3 years, EBQ has spun out seven companies (ipSOX, Cytomos, NeuroOrg, Pharmatics, Coolgenics, Aquila BioMedical, i2eye Diagnostics). Indeed, CMVM disclosure activity has increased by 230%, in part because of a newly introduced 'Innovation Competition', and collaborative research agreements with industry have increased by 32%.

The success of EBQ is also evidenced by the alliance with GSK via the DPAc. GSK has taken the unique approach of entering into a limited number of agreements with leading academic centres of research excellence, intending to sign only 10 such agreements worldwide. Brokered by EBQ, CMVM signed one of the first agreements with GSK, namely a collaborative project with **Iredale, Webster** and **Mole** (Academy of Medical Sciences/Health Foundation Intermediate Fellow) to develop a novel therapeutic entity for multi-organ failure in acute pancreatitis. Such collaborations are intended to take new therapeutics all the way to market launch, with academic clinicians providing biological and clinical insights and GSK providing chemical, regulatory and product development. Early promise has been fulfilled following the Edinburgh £3M award and, in addition to future impact, we expect new therapeutic indications for malaria and Huntington's disease to result from this alliance. Including the GSK DPAc alliance, EBQ has signed 81 collaborative research agreements with industry in the last 3 years, accounting for over £15.5M of new funding.

Policy-makers and Funders: Our academic researchers are frequently solicited to inform and guide both national and global approaches to major healthcare issues. CMVM researchers contribute to evidence-led policy-making and legislative change through publication and their participation on national and international committees. These include Scottish Intercollegiate Guidelines, National Institute for Health and Care Excellence (NICE) guidelines, other UK, European, North American and Australasian Guidelines, and WHO policy **(IS:D, N-Q)**. UoE researchers influence policy on translational research and wealth generation, through contribution to biomedical science-funding organisations charged with knowledge-based implementation and translation of academic findings. These include: **Savill** (Chief Scientist, Scotland 2008–2010, Chief Executive Officer of the MRC from 2010), **Seckl** (MRC/Technology Strategy Board Biomedical Catalyst Major Award Committee Member) and **Frame** (Member of CR-UK Science Strategy Advisory Group). Other examples of our influence are provided in **REF5e.**

3. Engagement of the Public: We have engendered ambitious **public outreach** programmes supported by MRC, WT, CR-UK and the EU; for example via scientists in the MRC Human Genetics Unit, the MRC Centres for Reproductive Health and for Regenerative Medicine, working with MRC-funded science communication officers based in our Institutes. The outreach and media programmes at the MRC Centre for Regenerative Medicine (impact statement submitted to UoA4), is funded through the core MRC grant, two EU FP7 streams (total > €2M) and a WT award (£190K). These programmes included major contributions to the Royal Society Centenary Science Exhibition (2009, 10,800 visitors), the Glasgow and Edinburgh Science Festivals (2011–2012, 18,000 visitors), the design of secondary school teaching materials, and the making of an award-winning feature-length documentary "Stem Cell Revolutions", together with a "graphic" book and other teaching materials, the former translated into five European languages. High-level

contributions to science festivals and public debate on regenerative medicine include **Wilmut (IS:V)** appearing at the Edinburgh Science Festival (2010–2012) and **Iredale** appearing at the Times Cheltenham Science Festival (2012). At a more local level, **Dorin** was instrumental in setting up the Dunbar Science Festival, which was winner of the National Science and Engineering Week best community event award in 2012. In the last 5 years, our outreach and science festival events relating to organ remodelling and regeneration have attracted a cumulative audience in excess of 35,000. Highly successful public engagement lecture series such as the "Edinburgh Medical Detectives" are provided regularly for national and international audiences through podcasting and via YouTube (>35000 hits to date). Regular strategic engagement with patient groups, for example, from the Multiple Sclerosis Society, the British Heart Foundation, Children's Liver Disease Foundation, CR-UK, Arthritis Research Council and Maggie's Cancer Centre, ensures our researchers are in touch with their patient 'user groups' and funders, promoting and delivering information relating to research output, impact and care.

Research staff regularly participate in wide-ranging science outreach and public engagement activities; for example, primary school visits, laboratory tours, dialogue with biology teachers and secondary school pupils, public lectures, debates on issues of science ethics and engagement with local and national political fora, including politicians, as exemplified by regular visits by the Scottish Parliament Cross Party Group on Cancer to both the Edinburgh Cancer Research Centre and the NHS-L Cancer Treatment Centre. Major discoveries, such as mammalian cloning, including "Dolly the Sheep" **(IS:V)**, have become established as part of the scientific mainstream in public perception, with recurrent media references, museum exhibits and inclusion in the secondary school science curriculum.

The Media: Experienced Press and Media Officers undertake responsible reporting of important scientific facts and new developments on behalf of the UoE, in close liaison with research funders and scientists. We have been successful in science writing competitions, including the award of the MRC Max Perutz Science Writing Award to Clinical Lecturer and early career researcher **Maybin** in 2009, writing about menstruation, a direct result of involvement in studies underpinning the development of progesterone receptor modulators **(IS:S)**. Examples of broadcast media output by Edinburgh scientists includes **J Pollard's** contribution to the Emmy Award-winning ABC documentary "TV Special Breast Cancer: New Options and New Promise" and contributions to the Japanese public television "Journalist Takashi Tachibana's Fight against Cancer", which was viewed by 26 million people in 'prime time'.

c. Strategy and Plan for Supporting Impact:

Infrastructure investment: The UoE has invested over £160M in new translational infrastructure, including buildings and major equipment relevant to UoA1, in the past decade. Potential for impact across UoAs1, 4 and 6 has been directly enhanced by this investment, which is strategically aimed at 'embracing innovation'. The basement of the £50M Queens Medical Research Institute (QMRI) building (opened in 2005) has been fully equipped through success in the 2nd WT clinical research facility competition to form the £20M Clinical Research Imaging Centre (CRIC; Director **Newby)**, which was commissioned in 2011. This comprises 3T-MRI, ultra-high-resolution computerised tomography (CT), a CT-positron emission tomography (PET) camera and cyclotron integrated in the same facility, uniquely in the UK. With seven research-dedicated shielded radiation containment chambers ('hot-cells'), and a team of talented radio-chemists, the cyclotron is now generating bespoke reagents, derived from QMRI research, for PET imaging of patients from the adjacent Royal Infirmary of Edinburgh (RIE). In another example, the £52M Scottish Centre for Regenerative Medicine building (opened 2012) includes a Good Manufacturing Practice (GMP) cell manufacturing facility that is run collaboratively with Roslin Cells (lead partner in a 2013 £40M induced pluripotent stem cell resource-based Innovative Medicines Initiative) and the Scottish National Blood Transfusion Service (Medical Director **Turner**), to expedite new impact arising from the exciting potential utility of stem cell-based therapies. A third example is the £10M Anne Rowling Regenerative Neurology Clinic (Directors **Chandran** and **ffrench-Constant**). Opened 2012, this clinical research facility is co-located with QMRI at RIE. It will hugely enhance translation of neuroregenerative research associated with the MRC Centres for Regenerative Medicine and Inflammation Research, benefitting local patients with neurological inflammatory disorders such as multiple sclerosis, in a state-of-the-art research-healthcare setting.

Plans are at an advanced stage to relocate Edinburgh Neuroscience to the RIE site, bringing together all clinical and basic neuroscience and physiology research teams. This is being facilitated by over £20M investment in new buildings on the QMRI/RIE site, and £3M planned investment in a further 'hot' MRI research scanner, which will be placed immediately adjacent to the Accident and Emergency Department within the hospital. This will hugely increase capacity for research in acute and critical care. Furthermore, NHS-L, co-supported by UoE and the Scottish Government, is about to begin construction of a new Children's Hospital at the RIE site, at a cost of £184M. Academic and clinical research space, including a state-of-the-art child radiology facility, will be an integral part of the new build and this will facilitate future impact in paediatric medicine (£3M funded by UoE, Scottish Government and NHS-L in partnership). Meanwhile, the establishment of the £5M MRC-funded Scottish node of the Farr Institute (a UoE- and University of Dundee-supported initiative) will establish an NHS-linked Informatics Centre on the same campus.

Drug Discovery: Drug discovery comprises both target-based screening and medicinal chemistry activities at QMRI (led by **Webster**, jointly funded by £5M Wellcome Seed Drug Discovery funding, MRC-DPFS and GSK-DPAC, £3.0M) and a complementary biology-based drug discovery activity (Edinburgh Cancer Discovery Unit (ECDU) at IGMM (led by **Carragher**, recruited in 2011 from AstraZeneca plc). ECDU takes innovative approaches to cancer discovery science, focusing on phenotypic mechanisms and pathway analysis to place biological evidence-led approaches at the top of the discovery agenda, thereby enhancing the predictability of success in the clinic. This approach is being expanded to other bio-medical disease areas, such as neurodegenerative diseases using induced pluripotent stem cells. ECDU is funded from various sources, including multiple EBQ-brokered pharmaceutical alliances between IGMM scientists and major pharma or biotech companies (e.g., AstraZeneca, Galapagos NV, GSK, Aquila BioMedical and Eli Lilly and Company), totalling over £1.5M to date. We recently united these distinct but complementary drug-discovery activities in the QMRI and IGMM to form a single Drug Discovery Unit, sharing reciprocal techniques and innovative technologies, adding value and anticipating future impact across multiple disease areas, very much in partnership with EBQ.

Links with Chemistry and Engineering: The innovative discovery science underpinning the generation of spinout companies requires chemical biology and medicinal chemistry, producing research tools and 'model therapeutics'. This has been a major strategic drive for researchers in UoA1, largely through excellent links with the School of Chemistry that have been forged by the creation of the Centre for Translational and Chemical Biology (CTCB; Director **Walkinshaw**), and the joint appointments of leading 'high-throughput' chemists (**Bradley** and **Auer**). Bradley, Walkinshaw and Auer were involved in successful, collaborative MRC-DPFS projects. Their physical co-location with biologists in QMRI is catalysing interdisciplinary 'bench to bedside' translational research, exemplified by the generation of a new series of optical probes for molecular imaging.

Interaction of biomedical scientists with engineers and chemists has a long track record of success in Edinburgh. One such is the invention of Optical Projection Tomography, first developed by the **Hastie** group (**IS:U**), which resulted in significant income for MRC Technology (£2.3M) and has had far-reaching technical impact, influencing, for example, the development of more recent developments in microscopic techniques. Although it is too early for impact to be included in this REF, **Haslett, Dhaliwal** (respiratory physicians), **Vendrell** and **Bradley** (chemists), have brought together a team of chemists and biologists to begin to reap the translational dividends of the optical molecular imaging revolution. This was supported initially by a £1M MRC Capacity-Building Award, a £7M award from WT and the MRC (including an MRC Developmental Clinical Studies grant), and an EPSRC interdisciplinary research centre award (jointly with Heriot-Watt University) of £11.4M.

Population and family health genetics: Conceived and led by **Porteous,** Generation Scotland (GS) was established in 2001 (supported by £11M in grant funding from the Scottish Funding Council (SFC), CSO, MRC, SE and Pfizer, Inc.), and is hosted by UoE on behalf of the Scottish Medical Schools and the NHS in Scotland. GS is a population- and family-based health genetics programme including 31,000 participants representing 0.6% of the population (7000 families), richly phenotyped for measures of clinical, mental and cognitive health. GS capitalises on the unique universal health record system in Scotland, in which every individual has a unique identifier so that patients can be tracked through periods of illness. GS has led to over 150 collaborative research proposals with academic and industrial partners across a wide spectrum of complex

diseases, and has created access to phenotyped and genotyped volunteers and donors; for example, in an HLA-typed stem cell banking initiative. We expect significant future impact will emerge from such studies.

d. Approach to Impact: Relationship to Case Studies:
As described above, our strategy has been to target three broad areas for delivering impact of reach and significance: health and welfare; translation to healthcare industries; and public engagement. Below the impact statements are listed according to context:

Translation to improve health and wellbeing (including policy change):

A. The GRACE risk score: a reference standard for the management of acute coronary syndrome.
B. Avoiding ineffective statin use in aortic stenosis.
C. Detailed analysis of trial of lapatinib in combination with capecitabine in advanced, HER2+ breast cancer leads to marketing authorisation worldwide.
D. Preventing deaths from pesticide self-poisoning in rural Asia – pralidoxime is hazardous and banning organophosphorus insecticides is beneficial.
E. Uterine artery embolisation is superior to surgery in the short term, for the treatment of symptomatic uterine fibroids.
F. By defining the minimum liver remnant required, volumetric analysis is now the pre-operative standard of care in liver cancer surgery worldwide.
G. Diagnosis from gene discovery – developmental disorders of eye, brain, nerve and skeleton.
H. Ovarian cryopreservation can restore fertility in women following cancer treatment that would otherwise irreversibly deny them children.
I. Reducing blood transfusions in intensive care and surgery saves precious blood, reduces costs and decreases patient risk.
J. Elective delivery of pregnant women reduces perinatal mortality, particularly in mothers over 40 years of age.
K. Progesterone does not prevent preterm birth in twin pregnancy (STOPPIT study).
L. Pharmacological and interventional therapies for acute coronary syndromes improve patient outcome.
M. Defining patient needs and delivering evidence-based palliative and end-of-life care for non-malignant disease, through services that can be delivered in developed and low-income countries.
N. Detailed epidemiological studies of people with allergy have triggered policy developments and catalysed service innovations to enhance care.
O. Making technological advancement safer by defining the specific attributes of carbon nanofibres that are detrimental to human health.
P. Testicular Dysgenesis Syndrome is linked to endocrine-disrupting phthalate exposure; specific phthalates are now banned from children's mouth toys.
Q. Accurate epidemiological pneumonia incidence and mortality estimates have influenced child health policy to reduce global child pneumonia mortality.
R. Community-directed delivery of doxycycline in Cameroon demonstrates effectiveness as a treatment for onchocerciasis (river blindness) in Africa that avoids adverse effects associated with ivermectin.
S. Progesterone receptor modulators are effective in emergency contraception and therapy of heavy menstrual bleeding/fibroids.

Translation to Healthcare Industries

T. Commercialisation of ScreenTape™ - a microfluidic tool for genomics, next-generation sequencing and proteomic analysis.
U. Invention, licensing and commercialisation of optical projection tomography microscopy.

Engagement of the Public

V. Dolly the sheep - the first cloned mammal and a public icon for regenerative medicine.