**Institution: University of Glasgow**

**Unit of Assessment: Unit 1; Clinical Medicine**

## a. Context

Since RAE2008, the University of Glasgow has radically restructured, creating the College of Medical, Veterinary and Life Sciences (MVLS). Restructuring has brought together research-intensive clinical academics and life scientists to undertake world-class science. Our research is primarily directed at understanding major global diseases of the 21st century and translating discoveries into new therapeutics and diagnostics that benefit patients, taking new therapies through preclinical and clinical trials, and providing economic benefit to Scotland and the UK. The new inter-disciplinary College environment has been instrumental in facilitating and enhancing research impact. The 183 staff returned in UoA1 derive predominantly from the 3 largest of 7 research Institutes in MVLS, namely the Institutes of Cancer Sciences, Cardiovascular & Medical Sciences, and Infection, Immunity & Inflammation. Research across these disciplines now benefits from increased academic mass, enhanced infrastructure, and opportunities for cross-disciplinary interactions.

Our mission is to translate our biomedical and clinical science into real world impact on global health in chronic diseases and co-morbidities. The impact of our research, beyond academia, is targeted to the following key user groups:

1. Clinical trial organisations and clinical guideline developers
2. Health care policy makers
3. Health service organisations and health care professionals
4. Research funding bodies, including charitable organisations and the voluntary sector
5. Life sciences, pharmaceutical and medical device industries
6. The public and patients

## b. Approach to impact

The University of Glasgow provides a strong platform to facilitate impact across disciplines and Institutes. In 2012, the University launched a Knowledge Exchange (KE) strategy and established a £1 million fund to develop and foster KE. The University's support for impact is delivered through a central Research Strategy & Innovation Office that provides specialist commercialisation expertise working closely with the embedded research & business development and public engagement teams and the researchers returned in UoA1. MVLS has also invested >£2 million annually in support of KE activities. As part of this investment, our first 'entrepreneur-in-residence' was appointed to develop an entrepreneurial environment for identifying and enabling impact. This approach resulted in a 2012 spin-out company, Clyde Biosciences Ltd (**Smith**). Using funding from the EPSRC Knowledge Transfer Account and investment from the IP Group, this company is helping to streamline cardiotoxicity testing and novel compound development using induced pluripotent stem cell derived cardiomyocytes. Our KE activities promoting economic impact are many and varied. For example, the Industrial Partnership PhD is an innovative programme, with costs shared by the College and industry, to facilitate companies and academics working on collaborative projects of mutual benefit for business development and research advancement. Industry partners range from large pharma (e.g. Novartis, UCB Celltech) to small and medium sized enterprises (SMEs) (e.g. US-based United Therapeutics); without this cost-sharing support, such research projects would be unaffordable for many SMEs.

UoA1 researchers have made major contributions to clinical trials and data analyses that have impacted significantly on global medicine through guidelines and best clinical practice. Examples of the major contributions via landmark studies include: best treatment in heart failure; primary prevention of cardiovascular disease via statins; risk factor and cardiovascular disease associations, acute treatment of stroke; the development of xeloda and oxaliplatin as standard treatment of advanced colon cancer. This work is complemented by fundamental science that spans genetic, molecular and cellular research in experimental models of human disease.

Through the approaches described above for ensuring impact of our pre-clinical and clinical research we have had a major impact on the following key user groups:

**1) Clinical trial organisations and clinical guideline developers**

UoA1 staff have contributed nationally and internationally to clinical trial design, guideline development and clinical practice through key leadership roles (Chairs, Presidents) in clinical trial organisations and guideline committees as evidenced by: National Cancer Research Network, Clinical Studies Groups for individual tumour types (**Biankin, Chalmers, Copland, Evans, Holyoake, Jones, MacPherson, McNeish, Oien**); British Society of Rheumatology Guidelines Group on Biologics in Spondylo-arthropathies (**Siebert**); British Society of Rheumatology Guidelines Group on Psoriatic Arthritis (**McInnes**), Intercollegiate Guidelines Network and the European League Against Rheumatism Guidelines for Management of Cardiovascular Risk in Inflammatory Arthritis (**McInnes, Sattar**); World Health Organisation Guidelines for Hepatitis C (**Thomson**); National Institute for Health Research Stroke Research Network, European Stroke Organisation, Virtual International Stroke Trials Archive and Virtual International Cardiovascular and Cognitive Trials Archive (**Lees**); Scottish Stroke Research Network; Stroke Guidelines of the American Heart Association (**Walters**); Heart Failure Guideline Committee of the European Society of Cardiology, American College of Cardiology/American Heart Association Heart Failure Guidelines Committee; National Institute for Health and Care Excellence (NICE) Acute Heart Failure Guidelines Committee and Health Technology Appraisals Committee A; Kidney Disease: Improving Global Outcomes Anaemia Guidelines (**McMurray**); Canadian Hypertension Education Program Hypertension Guidelines (**Touyz**), European Societies of Hypertension and Cardiology Hypertension Guidelines (**Dominiczak**); American Diabetes Association/European Association for the Study of Diabetes (**Petrie, Sattar**); Scottish Intercollegiate Guidelines Network on Obesity (**Sattar**).

Through directorship of the Robertson Centre for Biostatistics and the UK Clinical Research Collaboration (UKCRC) Glasgow Clinical Trials Unit (GCTU), **Ford** has made leading contributions to the development of informatics approaches to clinical research, particularly the use of record linkage. **Ford** also influences the design of clinical trials nationally and internationally through his chairmanship of the National Institute of Health Clinical Trials Fellowship and the UKCRC Clinical Trials Unit Directors' Industry Committees. Our researchers have had a major leadership impact in the international hypertension community as evidenced by the unique situation where both the President of the European Society of Hypertension (**Dominiczak**) and the in-coming President of the International Society of Hypertension (**Touyz**) are from Glasgow.

***Summary of impact: Pioneering pre-clinical and clinical research led by staff in UoA1 has impacted on new therapeutics and management strategies in cancer, chronic inflammatory and cardiovascular diseases. The work has contributed significantly to the reduction in morbidity and mortality associated with these conditions, e.g. death from: all cardiovascular disease (reduced by 25% through lipid lowering); acute stroke (reduced by 25% through use of anticoagulants); heart failure (reduced by 24% due to use of mineralocorticoid receptor antagonists).***

**2) Health care policy makers**

Glasgow researchers have acted as expert assessors or advisors nationally and internationally. These include NICE Assessment Committees; US Food & Drugs Administration (FDA) Standardized Definitions for End Point Events in Cardiovascular Trials Task Force; Canadian and German Governments Cardiovascular Research Panels (**McMurray**); Scottish Medicines Consortium (**Walters**: lead assessor, New Drugs Committee); chaired Cochrane groups (**Stott**: Health Care of Older People; **Langhorne**: Stroke), and have been members of the Expert Advisory Group in Cardiovascular, Renal & Metabolic Disease, Committee for Human Medicines (**Jardine**), all-party parliamentary groups (House of Commons) on cancer (**McNeish**), ovarian cancer (**McNeish**), and diabetes (**Sattar**); International Cancer Genome Consortium Scientific Steering Committee, (**Grimmond**); Emerging Science & Biotechnology Advisory Committee (**Baker**), European Medicines Agency (**Sattar**).

***Summary of impact: Through our clinical research and leadership we have impacted on health policies and clinical care, resulting in improved care of patients with stroke, heart failure, hypertension, and cancer (particularly colon, ovarian cancers and chronic myeloid leukaemia).***

**3) Health service organisations and health care professionals**

Clinical academics returned in UoA1 have a close strategic relationship with the NHS Greater Glasgow and Clyde (NHSGGC), which includes 41% of Scotland's population (2.3 million).

**Dominiczak** is a non-executive director of the NHSGGC Board and is leading the planning of >£70 million investment in clinical academic and research infrastructure at the £1 billion New South Glasgow Hospitals Campus, which will be one of the largest hospitals in Europe when it opens in 2015. Glasgow Biomedicine, a partnership between the University of Glasgow and NHSGGC (Chair: **Dominiczak;** Members: **Evans, McInnes**), is responsible for all clinical research involving the Health Board including co-sponsorship of clinical trials. Glasgow Biomedicine links to its pan-Scottish equivalent, Health Science Scotland, where **Dominiczak** is a member of the Board and **McInnes** is a deputy. The Scottish Public Health Network report 'Health Care Needs Assessment of Services for Adults with Rheumatoid Arthritis' commissioned by the Scottish Government, provides a framework for delivery of rheumatology services across Scotland (**Porter**). The Scottish Infection Research Network informs policy and innovation for Hospital Acquired Infection in NHS Scotland (**Evans, Leonard**). Glasgow researchers have taken leading roles and responsibilities in Professional Organisations, including UK Royal College of Physicians Intercollegiate Stroke Working Party (**Langhorne**) and Chief Scientist Cardiovascular Disease/Stroke Portfolio Steering Group and Advisory Group to Scottish Department of Health on Research strategy (**McMurray**).

***Summary of impact: Glasgow researchers have major influence on Health Board policy, planning, and activities for implementing clinical guidelines and health care policies to impact on the health of Scotland and beyond.***

**4) Research funding bodies, including charitable organisations and the voluntary sector**

We influence the strategy of numerous funding organisations through leadership roles on funding committees. For example, the Union for International Cancer Control (UICC) includes over 770 organisations across 155 countries and features the world's major cancer societies, ministries of health, research institutes and patient groups. It is the pre-eminent organisation concerned with improving outcomes in resource-constrained settings. Glasgow researchers (**Jones, Keith**) have been instrumental in driving the success and credibility of the UICC's flagship clinical training portfolio through leadership (Chairs and Co-Chairs) of the 3 UICC Fellowships committees. In 2008-2013, the combined value of the UICC awards was approximately $3.5 million. A total of 31,425 days of training was provided to 541 recipients from more than 90 countries. Fellows have subsequently become leaders in diverse areas of clinical cancer control, including epidemiology, tobacco legislation and screening.

***Summary of impact: The input of UoA1 investigators to prioritisation of funding areas and policy by both government and charities is broad, as exemplified by the UICC Fellowships scheme.***

**5) Life sciences, pharmaceutical and medical device industries**

We play key roles in collaborative projects with the life sciences, pharmaceutical and medical device industries which directly benefit from our expert knowledge, skills and international network of scientists and clinicians. For example, since 2008, licensing of 'The Glasgow Program' (automated interpretation algorithms of electrocardiogram, or ECG data) [confidential text removed] and has been incorporated into some of the market-leading medical devices approved by the FDA. Over 40,000 devices containing the Glasgow Program have been sold worldwide (**Macfarlane**). We led a Cancer Research UK (CR-UK) consortium grant (**Keith**) that resulted in the founding of Senectus Therapeutics (http://www.senectustherapeutics.co.uk/). Spin-out companies include Pathfinder LLC (http://www.pathfindercelltherapy.com/), created in 2009, which is a Boston-based company established using IP generated at Glasgow University (**Shiels**).

Further recognition of our ability to work with key industry partners to achieve major economic impact is evidenced by the Stratified Medicine Scotland Innovation Centre (SMS-IC), a new public-private consortium hosted by the University of Glasgow on behalf of four Scottish medical schools, the NHS and industry partners. It has attracted £20 million in funding, including £6 million from industry. The value to the economy attributed to SMS-IC by independent consultants has been estimated at £68 million over five years. MVLS held an inaugural 'Industry Day' in 2012, which attracted >250 participants and secured additional pharma and SME partners for the SMS-IC.

In addition to leading roles and responsibilities in industry-sponsored clinical studies (current commercial clinical trial portfolio of >200 studies; total clinical research income >£13 million annually), Glasgow researchers, based on their expertise, impact and international reputation, have performed key roles as advisors or consultants for life sciences and pharmaceutical

companies. This, in turn, enables our researchers to directly impact the research direction and development of novel therapies and diagnostics. Exemplars of leading roles include membership of the AstraZeneca – the Experimental Cancer Medicine Centre (ECMC) Combinations Alliance Steering Committee (**Evans**), of external Scientific Advisory Boards for AstraZeneca (**McInnes**: Chair, global), Novartis (**McMurray**), Regeneron Sarilumab (**McInnes**: Chair), Consortium for Parasitic Drug Development (Gates Foundation: **de Koenig**), and Karus Therapeutics (**Evans**).

***Summary of impact: via licensing of novel and improved technologies, the establishment of spin-out companies and direct interactions with the pharma industry based on our global leadership in clinical insight and understanding of disease mechanisms, UoA1 staff have impacted substantially on the development of novel therapeutics and use of medical devices.***

**6) The public and patients**

***Glasgow Science Centre:*** This centre (http://www.glasgowsciencecentre.org/) is a major public venue for the promulgation of science with ~280,000 visitors per year. Our researchers play key leadership roles in the Centre's activities through membership of the Scientific Advisory Board (**Graham**). The Medical Research Council (MRC) Centre for Virus Research (CVR) regularly delivers 'Meet the Expert' and 'hands on' events which stimulate engagement between researchers and the public. To celebrate the MRC Centenary, CVR scientists worked with renowned Glasgow artist Murray Robertson to develop a visual timeline that explores key discoveries in virology over the last century (www.virusesacenturyofdiscovery.org.uk). 'Rheumatomics' represents a major public educational initiative (**McInnes**) within the Glasgow Science Centre and now represents an ongoing recurrent exhibition informing the community of mechanisms and treatment of inflammatory disease.

***Glasgow Café Scientifique:*** Founded in 2004 (**MacLean**), this monthly event is free and open to the public of all ages, providing a forum to engage with the community on science and technology in a non-academic environment. In 2012, in celebration of the Olympic Games, Café Scientifique ran a series of interactive events (Knowing Sport) in various community locations across Glasgow; this enabled communities to discover the science behind exercise and sport and its relevance to everyday life. Knowing Sport was granted the London 2012 Inspire mark, recognising exceptional and innovative projects inspired by the 2012 Games. **MacLean** was awarded the MBE (2010) for Services to Science for her work related to Café Scientifique. She has hosted events run by the Royal Society e.g. public lectures for the Royal Society at the Edinburgh International Science Festival (2013).

***Cancer-specific engagement activities:*** Researchers in the Institute of Cancer Sciences (ICS) work with CR-UK's Research Engagement Manager to extend and enhance our well-established engagement activities, which form part of the objectives and reporting metrics for the CR-UK Glasgow Centre, GCTU and ECMC. The number of supporters/public reached by cancer researchers exceeded 500,000 in 2012-2013. The ICS includes a panel of former patients/carers as members of its Trials Advisory Board and Clinical Trials Executive Committee, which reviews clinical trial protocols for the GCTU and the ECMC. Presentations to local fundraisers, patients and the public include 'open-days' at the CR-UK Beatson Institute (**Vousden**), the Paul O'Gorman Leukaemia Research Centre (**Holyoake**), and the Beatson West of Scotland Cancer Centre (**Evans, Jones**).

***Cardiovascular-specific engagement activities:*** We have led fund-raising and public awareness campaigns on cardiovascular health issues including diabetes and obesity. We work locally, using open-days, school visits, and public talks, and internationally through our senior roles in international societies. We work closely with the British Heart Foundation (BHF) through our PhD student-led public outreach programme to engage with BHF volunteers and fund-raisers. Examples of international outreach are: **McMurray**, while president of the Heart Failure Association of the ESC, introduced a 'Heart Failure Awareness Day' (currently involves 22 counties) and a website for patients and care-givers about heart failure (http://www.heartfailurematters.org/EN). **Walters** hosted the Scottish Stroke Association's 'World Stroke Day', attended by a rich diversity of stakeholders (2010). Community-targeted activities include public symposia and lectures at the University to highlight the importance of hypertension prevention and treatment, as part of the World Hypertension Day of the World Health Organisation (**Padmanabhan**) and **Sattar** has helped to increase public awareness, prevention and treatment of diabetes and obesity with Diabetes UK.

**Baker** has a leadership role (President) in the Annual British Society of Gene & Cell Therapy public engagement day. We have been an active participant in the Nuffield Research Placement programme, which provides the opportunity for students to work alongside professional scientists, technologists, engineers and mathematicians.

***Infection-specific engagement activities:*** The Wellcome Trust Centre for Molecular Parasitology (WTCMP) schools engagement was highlighted in the Wellcome report 'Working with Schools in STEM Public Engagement', while the WTCMP David Livingstone Symposium (2013, **Barrett**) contributed significantly to the 'David Livingstone 200th Anniversary' public events. **Stewart** (WTCMP) led the 'Host with the Most' parasitology activity designed by postdoctoral researchers at the Glasgow Science Centre 'Bodyworks' Exhibition 2013. WTCMP has pioneered intelligent comics that convey the problems and goals of their research areas in highly accessible graphic comics that are eye-catchingly illustrated (http://www.malariacomic.com/Home.html).

***Other engagement activities:*** Making a difference to improve health at the public level is a College-wide priority, with many of our staff engaged at various levels. We promote the health implications of our research to the public and policy makers through TV, radio and print media. For example, a television advert for CR-UK (**McNeish**), interviews on stratified medicine (**Dominiczak, Evans**), prostate cancer (**Jones**), fatty liver disease, obesity, and sugar addiction (**Logue, Sattar**), exercise, health and disease (**Gill**), gene therapy of vein grafts (**Baker, Berry**), live webcasts including research strategies to address pancreatic cancer; 'East meets West: Global perspectives on the treatment of gastric cancer' (**Evans**); and treatment of hypertension (**Touyz**), to multiple countries.

**Graham** served on 'Gengage' a Scottish Government committee to prosper knowledge of genetic methods and potential, and was the Higher Education Representative for Biology on the Scottish Qualifications Authority Assessment Panel. The Glasgow Science Festival is run annually by MVLS staff and postgraduate students. This mechanism takes our research in clinical medicine and disease to the wider community, including primary and secondary schools, to enhance knowledge of medical advances and encourage biomedicine as a choice subject at schools. Glasgow Science Festival surveys indicated a doubling of attendees between 2010 (23,830) and 2012 (40,387).

***Summary of impact: Through our outreach programmes there is greater public awareness of clinical medicine and disease, which has impacted on increased engagement and interest in STEMM by school children, volunteers and communities at large.***

## c. Strategy and plans

MVLS has an impact strategy in place to develop and deliver impact through activities aligned to our four key themes of **Understanding**, **Enabling**, **Identifying** and **Publicising** impact, with the aim of embedding the necessary knowledge and skills within our academic and non-academic communities. The College is a participant in the Biotechnology and Biological Sciences Research Council Excellence with Impact competition (2013-15). Examples of current activities aligned to our strategic themes include:

**Understanding Impact:** Introducing impact sessions for research students that give them 'credits' as part of a wider skills training programme; offering funding for staff and students to run their own impact seminars and away-days; including impact as a formal research activity to be captured as part of the University's new workload modelling methodology; utilisation of the entrepreneur-in-residence to help researchers engage in opportunities for commercialisation.

**Enabling Impact:** Identifying mechanisms to reward impact and ensure the value of impact is recognised, including through promotion and performance review; introduction of a competition and prize for impact; providing support to our researchers to develop strong 'pathways to impact' proposals; facilitating industry placements for postgraduate research and taught masters students; developing mechanisms to enable early interactions with industry through researcher exchanges and seminars; promotion and enhancement of PhD joint supervision with industry; incorporating patient/stakeholder engagement in clinical research; actively engaging with the local SME community.

**Identifying Impact:** Utilising new scientific writer posts to compile a comprehensive record of impact and a mechanism to track outcomes of our research.

**Publicising Impact:** Providing opportunities for researchers to undertake media training; embedding a media professional within UoA1; development of impact web pages, covering the diversity of our research impact; expansion of current exemplars, including talks, seminars, demonstrations, in public venues (museums, schools, shopping centres, gym clubs).

Our **future plans** for impact are wide-ranging and world-leading. As an example, we plan to develop significant impact from our leadership of the New South Glasgow Hospitals Campus (SGH), which will incorporate the Stratified Medicine Scotland Innovation Centre, an additional incubator space for SMEs and the first 7 Tesla MRI scanner (for very high resolution imaging) in a clinical setting in the UK. By bringing together clinical academics, industry and the NHS within state-of-the-art facilities at the SGH, we will provide a collaborative environment to expedite translation to clinical practice/patient benefit, support partnership with pharma and imaging companies for the development of stratified clinical trials, and support health innovation by SMEs and supply chain companies. Similarly the new Wolfson-Wohl Translational Cancer Research Centre brings together clinical academics and the NHS to facilitate world-leading precision medicine across a number of priority cancers, including pancreas, brain, ovarian, prostate and leukaemia. We have recently partnered with AstraZeneca to create the pioneering GLAZgo Incubator Centre, an embedded £4 million alliance to elicit novel targets in the inflammation field. Similarly we are collaborating with GlaxoSmithKline on proposals to develop new molecular targets for hypertension and rheumatoid arthritis. These developments represent leading examples of our wider strategic plan with the City-wide Glasgow Economic Leadership, including Glasgow City Council, BioCity Scotland (http://www.biocity.co.uk/) and Scottish Enterprise, for maximising the economic potential of biomedicine in the wider Glasgow 'Bio-corridor' region.

## d. Relationship to case studies

Our submitted cases highlight the impact of our research beyond academia, focusing on best practice clinical care, health of society and health economic benefits. Impact on clinical guideline development includes clinical trials directly leading to revision of national and international clinical guidelines (Europe, US, UK, Australia, Canada) on the management of heart failure (**McMurray**); informing UK, European and international hypertension guidelines (**Walters**) that have contributed to the observed reduced incidence of primary and recurrent stroke by around 25% and reducing the number of lives devastated by stroke, and the consequent economic and societal burden; stratifying patients in the general population for statin therapy (**Sattar**) and guiding statin use in patients with rheumatoid arthritis (**McInnes**); the use of a novel oral anticoagulant agent for control of atrial fibrillation (**McMurray**); the development of xeloda (capecitabine) as monotherapy and in combination with oxaliplatin in colon cancer (Europe, US) (**Evans**).

Impact on NHS organisations and healthcare policy makers is exemplified by several of our impact cases. **Nelson** developed a highly accurate, multivariate prediction model for live birth outcome following *in vitro* fertilisation (IVFpredict). This online, personalised calculator has been completed by >5 million users worldwide. **McMurray** was instrumental in the introduction of specialist heart failure nurses, saving the NHS in the region of £8 million yearly. **Langhorne** drove the implementation of evidence-based evaluation of the quality of stroke care, with annual savings to the NHS of around £6 million. **Sattar** and **Preiss** identified statin-associated diabetes risk which prompted the European Medicines Agency and the US Food & Drug Administration to revise safety labelling for all classes of statin medications, which has been communicated to 27 million patients in the UK and US. Our combined expertise in clinical and biostatistical studies (**Sattar, McMurray, Ford**) has altered treatment standards with major impacts. For example treatment of high cholesterol in men without heart failure with a statin saves the NHS approximately £1 million over 15 years for every 1000 patients treated. **Wright** developed and designed a growth chart that is used for every child born in the UK (around 750,000 per year) to monitor growth. **Macfarlane** developed the automated ECG, which has impacted on international guidelines for ECG-based diagnosis of cardiac disease. The impact cases on ustekinumab in psoriatic arthritis (**McInnes**) and the paradigm shift in the treatment of chronic myeloid leukaemia by eliminating a small population of treatment-resistant cells (**Holyoake**) demonstrate impact on pharmaceutical industry strategy.