I am enormously proud of the achievements of the PHG Foundation in 2019, our busiest year yet – perhaps not surprising, since the importance of ensuring that good science makes healthcare better is clearer than ever before.

Over the last decade we have kept pace with medical innovation, identifying the best opportunities for implementation and paving the way for policy to support what are now healthcare realities.

Looking ahead, as health systems around the world grapple with expanding technological opportunities and growing demands, we will keep addressing the questions new science poses for health policy, and working with experts to find the solutions that ensure that more people can benefit from improved, personalised care.

Dr Mark Kroese
Director
PHG Foundation is a health policy unit that is a linked exempt charity of the University of Cambridge.

We analyse evidence and issues to provide practical insights and advice to policymakers, health systems and professionals, supporting them in making the most of scientific opportunities to improve health.

With particular focus on genomics, our multidisciplinary team analyses biomedical developments, identifying the policy issues that must be addressed for effective uptake in health services.

Our work brings together researchers, health professionals, policymakers and regulators, along with patients and wider publics.

Through providing practical policy solutions and guides we shorten the journey from science to effective healthcare, and from research to human health benefits.
The link between genes and health is well established, with modern developments in DNA sequencing making the diagnosis of diseases arising from rare, high-risk variants easier than ever before. However, we all possess many variations in our DNA that influence our risk of developing more common diseases; individually, these have little effect, but collectively they may be more significant.

Polygenic scores are a relatively recent scientific development that allow us to test many DNA variants to calculate a single combined assessment of genetic risk for a given disease. Combined with information about conventional risk factors, such as age, lifestyle, or medical data such as blood pressure or blood sugar levels, they may offer more accurate assessment of disease risk. Some believe polygenic scores are the key to personalised disease prevention – but others fear they are a dangerous distraction from other causes of ill-health.

We have always believed that genomics can aid disease prediction and prevention, as well as diagnosis and management. There is an urgent need for evidence-based appraisal for the clinical use of polygenic risk scores. Our ongoing programme of work in polygenic risk is filling in the gaps to distinguish hype from hope.
Our first major report on polygenic scores and disease risk focused on cardiovascular disease, which in the UK alone affects over seven million people and accounts for over a quarter of deaths. More accurate prediction of cardiovascular disease risk could underpin targeted prevention to those in greatest need, making polygenic scores an area of significant interest. But what is the evidence?

Whilst there is considerable potential in this area, we found that the field remains some years away from clinical application. In particular, there is a need for robust mechanisms to generate polygenic scores and for validated tests with clear evidence of clinical utility.

We are now working with a range of experts to define accurately what clinical utility for polygenic scores would look like – and the types of evidence that will be needed to evaluate polygenic tests before use by health systems.

In addition, we are examining the potential personal, social and ethical impacts of using polygenic scores for disease risk assessment – and what actions might be needed to genuinely reduce risks.

“Polygenic scores, risk and cardiovascular disease provides an excellent summary of the basis, use and appraisal of polygenic scores for disease risk that anyone working in common disease prevention will find helpful”

Prof John Newton (Director of Health Improvement, Public Health England)
The long-term future of healthcare has received considerable attention over the last year, with the role of science and technology a recurring theme. Ambitions to harness the benefits of science feature strongly in recent health policy.

Foresight projects often try to look ahead and anticipate what new science may arise, especially those technologies that will have the greatest transformational effects on healthcare.

The *My healthy future* project took a broader view to understand not only how emerging technologies are likely to be used for health and care, but also what their potential impacts on health systems, populations and people may be.

We delved into a host of emerging technologies with health applications at different stages of life to identify cross-cutting issues, around person-centred healthcare, overdiagnosis, health technologies and social impacts, and privacy and autonomy. This resulted in a series of detailed reports and discussion papers.
We want people to enjoy the benefits of science and technology for health, whilst avoiding the possible harms.

Irrespective of the scientific breakthroughs and new technologies that may emerge in the next twenty years, we believe that a holistic, data-driven, trusted and person-centred healthcare system will make the best use of them.

*Our healthy future* describes what policy makers need to do to realise this vision and adapt to any surprise developments. We set out critical actions for success, bringing together diverse ‘innovation allies’ to improve the design and delivery of health innovations through:

- **Constructive co-development** – including with patients, citizens and communities
- **Smart systems** – flexible, interoperable systems for health information and care
- **Equitable access** – planning to ensure everyone benefits from health innovations
- **Responsive regulation** – proportionate mechanisms to keep pace and maintain quality
Genome editing shot to prominence with the advent of new and easier techniques for manipulating the human genome. The many ethical, legal and social controversies posed by the potential to edit the germline genome – to make genomic changes that will be inherited by future generations - dominate the headlines, overshadowing the steady advance of therapeutic genome editing.

Our work has focused on the potential, progress and policy implications of somatic (non-heritable) genome editing for the treatment of existing diseases. Clinical trials are in progress for a range of diseases, including rare eye conditions and blood disorders, alongside exciting developments in the use of genome editing for new cancer diagnostics and immunotherapy. Though expensive, these new tools offer enormous hope for patients.

These less contentious applications still pose questions – will new therapeutic options change public perceptions of certain diseases? What regulatory challenges may they pose? And how and where should lines be drawn between therapeutic, preventative and non-therapeutic applications, such as physical or cosmetic enhancements? Our policy briefings offer clarity on emerging applications and issues.
Data science and artificial intelligence (AI) are the driving forces behind future digital health systems, with innovations in techniques such as machine learning having many exciting potential applications in healthcare. Our enthusiasm must be tempered with an awareness of the many issues to be resolved before widespread use.

Regulating algorithms in healthcare examined the legal basis of the mathematical functions that underpin all software, and the implication for regulation of medical applications. We offered insights for both digital health developers, regulators and policy-makers to help them work together in designing these medical devices of the future in ways amenable to regulation as well as function, and in creating adaptable regulatory mechanisms.

We have also been commissioned by the Wellcome Trust to investigate the legal issues and ethical dilemmas posed by medical applications of ‘black box’ machine learning systems that may make decisions in ways that humans cannot easily interpret. We are also examining the application of data protection laws to human genomic data for the UK Information Commissioner’s Office.

Unpacking the black box
We have always believed that genomics has a role to play in offering more accurate disease risk prediction and prevention. This potential is finally reaching realisation, as modern tools for genome sequencing and analysis reach mainstream application. Previous work has examined the possible impact of genomic information on risk prediction, and the policy implications.

This year, as part of our contribution to a major EU research collaboration on breast cancer risk prediction and stratification, we held a multidisciplinary workshop on the future for personalised breast cancer prevention. Working with a variety of international experts, we outlined opportunities and policy issues for individual women, health systems and societies and strategies to support future implementation.

The scientific evidence that will underpin personalised prediction of breast cancer risk – and the type and likely nature of breast cancers that may appear – to improve prevention and care is still emerging. Making policy preparations now will maximise the speed at which this evidence is put to practical use for the benefit of millions of women.
With a new UK government in place, we looked back at our 2015 Health Innovation Manifesto policy goals.

Regarding information, we called for better data sharing within the NHS, including a national genomic database and improved understanding of issues and uncertainties. On infrastructure, we sought integration of genomics and digital health technologies in mainstream medicine, including workforce education. Considering individuals, we advocated for personalised disease prevention alongside traditional public health.

Four years on, we have a new national NHS Genomic Medicine Service, plans to sequence five million human genomes are rapidly advancing, and Genomics England has completed a major public dialogue on genomic medicine, including the use of data, with a National Genomic Healthcare Strategy expected imminently.

The 2019 NHS Long Term Plan led to the launch of NHSX to lead digital transformation; the Topol Review recommended expansion of workforce and patient education in genomics and digital health; and the Prevention Green Paper set out plans for ‘proactive, predictive, and personalised prevention’.

While there are plenty of fresh policy challenges ahead, this is impressive progress towards using science for better, more personalised health and care.
We were delighted to welcome leaders in science, health and policy to the 2019 PHG Foundation conference. This was a chance to listen and learn from skilled delegates and fabulous speakers, generously supported by Roche.
Whilst our talented staff span across science, medicine, law, ethics, communications and engagement, policy development relies on input from a host of external experts. We involve academic and commercial researchers and innovators, healthcare professionals and scientists, regulators, policy makers and a range of others in our work, and we are very grateful to them all.

This year we were delighted to introduce a new form of recognition for a select group of people who over the years have shown outstanding eminence in their own fields – as well as being great supporters of our mission to make science work for health.

Our new Senior Fellows are:

**Prof Tim Aitman**  
Director, Centre for Genomic and Experimental Medicine, University of Edinburgh and Consultant Physician, NHS Lothian

**Prof Bartha Maria Knoppers**  
Director, Centre of Genomics and Policy, McGill University

**Prof Dennis Lo**  
Li Ka Shing Professor of Medicine, Chinese University of Hong Kong

**Prof Anneke Lucassen**  
Professor of Clinical Genetics, University of Southampton and Consultant Physician, University Hospital Southampton

**Dr Eric Meslin**  
President and CEO of the Council of Canadian Academies

**Prof Sir Munir Pirmohamed**  
Director, Wolfson Centre for Personalised Medicine, University of Liverpool; Consultant Physician, Royal Liverpool University Hospital; and non-executive director, NHS England
We receive generous donations of the Hatton Trust and the Wyng Foundation, along with income from academic grants and collaborations, commercial and public sector consultancy, and a modest investment portfolio.

We are not funded by the University of Cambridge.

**2018-2019 income: £998k**

- Charitable activities: £93k
- Grants: £47k
- Investments: £25k
- Donations: £832K

**2018-2019 outgoings: £1294k**

- Charitable activities: £1155K
- Governance: £24k
- Support: £113k
- Other: £2k

Our expenditure in the 2018-19 financial year was greater than our income. This was a planned overspend and covered by funds from our strategic reserves.

Most of our spending is on charitable activities, including our programme of work and staff costs.