HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Genomics and genome editing in the NHS, HC 349

Tuesday 28 November 2017

Ordered by the House of Commons to be published on 28 November 2017.

Watch the meeting

Members present: Norman Lamb (Chair); Vicky Ford; Bill Grant; Darren Jones; Stephen Metcalfe; Neil O'Brien; Graham Stringer.

Questions 97 - 234

Witnesses

I: Dr Hilary Burton, Consultant in Public Health, PHG Foundation; Professor Sian Ellard, Clinical Programme Director, South West NHS Genomic Medicine Centre; and Fiona Murphy, Director, National Services Division, NHS National Services Scotland, and Member of the Scottish Genomes Partnership.

II: Lord O'Shaughnessy, Parliamentary Under-Secretary of State, Department of Health; Professor Dame Sally Davies, Chief Medical Officer for England; and Professor Patrick Chinnery, Professor of Neurology, Cambridge University.

Written evidence from witnesses:

- PHG Foundation
- Scottish Genomes Partnership
- Department of Health

Examination of witnesses

Witnesses: Dr Burton, Professor Ellard and Fiona Murphy.

Q97 **Chair:** Welcome, all three of you. Thank you very much for your time in coming to give evidence to us. Perhaps we could start by each of you telling us briefly who you are and where you are from.

Dr Burton: I am Hilary Burton. I am a consultant in public health medicine at the PHG Foundation in Cambridge, which is a health policy think-tank concerned with the implementation of genomics in health systems.

Fiona Murphy: I am Fiona Murphy, director of the national services division in NHS Scotland. We commission specialist services in Scotland, in particular the Scottish genetic laboratories. I am here today on behalf of the Scottish Genomes Partnership, which is a partnership between our universities and clinicians in the NHS to consider genomic medicine for Scotland.

Professor Ellard: I am Sian Ellard, a clinical scientist. I head the regional genetics lab at the Royal Devon and Exeter Hospital. I am a clinical academic at the University of Exeter Medical School, and since 2014 I have been the clinical programme director for the South West NHS Genomic Medicine Centre.

Q98 **Chair:** Thank you very much. Incidentally, do not feel that all of you have to answer every question. If you feel you have something to add, please do so, but don't feel obliged.

What is your view of the chief medical officer's report "Generation Genome"? I am interested in opinions across the panel. What do you particularly support and what might you perhaps have difficulty with in the report?

Dr Burton: PHG Foundation welcomes the report and the fantastic spotlight that it has brought on genomics and the potential to improve population health. It is extremely aspirational; it builds on a huge amount of research in various areas of rare disease, cancer and pathogens. We think there is a gap between the outputs of research and embedding new technologies, whether they are diagnostics or treatments, in health services. This is something we at the PHG Foundation have been focused on over the last 20 years. We need to try to ensure that the new technologies are available in an equitable manner wherever people live across the country, and are not dependent on whether they are near a teaching hospital where a particular technology has perhaps been piloted. With our public health focus, we are thinking about high-quality, effective and equitable services.

With respect to the CMO's report, she talks a lot about the 100,000 Genomes Project, which has been hugely important and has set up a lot of the infrastructure and learning that will be helpful in mainstreaming

genomics into the NHS. Lots of processes have been put in place that will be extremely useful, but undertaking whole genome sequencing, as they are doing, is very much a pilot study in a sense; it is a proof of principle, and we need to make sure we learn from that how we would use whole genome sequencing and a range of other technologies in mainstream services within a whole patient pathway. One of the issues is how you know when to use it, when it is cost-effective and how we bring a range of other health professionals to be able to use genome sequencing and other technologies in a competent way.

Q99 **Chair:** Do you think the building blocks are in place to realise the ambition to move from the pilot to implementing it across the system, or are there big challenges that cause you particular concern?

Dr Burton: Some of the building blocks are now in place. Some of the processes are in place as to how patients are consented, how the actual sequencing is undertaken and how the interpretation is done. We have a lot of those processes well worked out, but what is not there is how eventually whole genome sequencing will be embedded into normal patient pathways. Coming from East Anglia, I always say that the cardiologist in—

Chair: Norwich.

Dr Burton: In Great Yarmouth needs to know how to use it effectively for their patients, because this is very different. The 100,000 Genomes Project has recruited patients in particular clinical categories.

Q100 **Chair:** It requires a very substantial training operation.

Dr Burton: It requires a lot of training and commissioning. Health service commissioners need to understand the cost-effectiveness of the whole pathways using genome testing and what that can achieve for clinical decision making. That information will not necessarily come out of the 100,000 Genomes Project because, although we have heard quite a bit about specific diagnoses made for individual patients, we have not seen the aggregate of that information. What patients were tested, and in general what were the results? How does that influence the clinical decisions and, if embedded, would it be cost-effective? That information is not necessarily forthcoming from the 100,000 Genomes Project.

Q101 **Chair:** Do you think we are right to be very excited about this, or is the jury out as to the extent of its application?

Dr Burton: We are right to be very excited. The potential is huge. If we look at where we imagined five years ago we would be, the ability to do sequencing at scale to that quality is a fantastic achievement. The way all the genomic medicine centres have been set up, so that they all have the facility to recruit patients, get the necessary clinical information together and submit them for sequencing, with the processes for doing the sequencing and interpretation and feeding back diagnostic information, has been a fantastic leap forward and will set the way for how we

eventually use it. Our point is that there is still a long way to go and we still have to put substantial resources into making it happen across the whole country for all the specialties where it is relevant.

Chair: Understood.

Professor Ellard: We are hugely excited. From the laboratory perspective, in the past we could provide testing only for patients who had the most common rare diseases, because you had to set up a test for each specific condition and it was only feasible to do those tests where there was sufficient volume. This technology means that potentially we can diagnose any rare disease for which the genetic basis is known. That is really exciting. We have seen a huge increase in the number of patients for whom we can provide a diagnosis. Many of them have waited a number of years and perhaps have had a number of misdiagnoses along the way. For cancer, from the early days—in the late 1990s—we understood the genetic basis of chronic myeloid leukaemia, and a drug was developed to target that disorder. It is now extremely effective. We have seen more and more targeted treatments being developed—the idea that we can take a patient's tumour and identify the cause of it and which drugs work most effectively—and that will increase over time.

Fiona Murphy: I agree with both speakers. Excited and cautious at the same time is probably how I would sum it up. We are also taking part as a genomics medicine centre in Scotland. We intend to supply 1,000 genomes to the 100,000 Genomes Project. We are set up slightly differently, in that we are sequencing the data in Scotland and trying to set up the infrastructure to be able to do this ourselves within Scottish universities. We have a slightly different starting point, in that we have had a long-term consortium of genetic labs in Scotland, so we do not have quite the same issues of access and equity that you heard about from NHS England colleagues at your previous session. We have huge challenges, which Hilary alluded to, in infrastructure and the ability to interpret, analyse and store data—the data files are enormous—and in taking the workforce with us. Education and training are needed for both the specific workforce for genomic medicine and the wider NHS workforce to make sure that they know how to use the technology, and can take patients and the public with us as we go forward.

Q102 **Chair:** The issues about the scale of the challenge, the investment needed and so forth bring me to the timescale for this. There were media reports of the chief medical officer talking about a five-year timescale for embedding it in the NHS. NHS England said that its genomic medicine service will be operational by the summer of 2018 and mainstreamed by the summer of 2019. What is your view of the timescale?

Professor Ellard: In terms of the laboratories, the plan is that from October next year we will have a new NHS genomic medicine service, and that will be delivered by a national network of seven genomic laboratory hubs. For the first time, we will have a single directory of tests and an IT infrastructure that allows us to link those centres to a central database.

Q103 **Chair:** Have they all been identified?

Professor Ellard: No. On the procurement process, I think the official invitation to tender will be issued in December this year. There is a huge amount of work to do between now and then. We have a clear vision of what we want to deliver, but there is a lot to do to create infrastructure where it does not exist. Each of the genetics laboratories in England already has an IT system, and what we will need to do is link those systems to central databases and to hospitals' pathology laboratories, and then have a way of delivering the results back to the clinicians through electronic patient records, while also having systems in place where those are not yet embedded across the country.

Q104 **Chair:** What you have described is quite a substantial undertaking.

Professor Ellard: Yes.

Q105 **Chair:** When is it achievable? You say that you will have it up and running by next autumn, but what does that mean? What will actually be happening by autumn next year?

Professor Ellard: My view is that we need a system that is ready to go on 1 October, so that it will be possible to order tests through an online ordering system, but we are delivering tests to a huge number of hospitals and GP practices across the whole country. We need to work towards a completely connected infrastructure, but it is unrealistic to expect it to be there on day one. We need a mechanism whereby the driver is to ensure that we have interoperability, but we can still get results out on 1 October. For example, we currently send out reports by email and some still go by hard copy in the post, so it is about creating a structure where we have the electronic capacity and can drive that forward across the whole health system, but we need to be realistic that that will not be achievable by 1 October next year.

Q106 **Chair:** Hilary, what is your view on timescale?

Dr Burton: Technically, the ability of laboratories and the actual genetic testing will be as Sian says. I am concerned about the medical workforce, for example—the people who need to be connecting and identifying the patients, engaging with whole genome testing and using those clinical diagnoses. That will not be in place by next October; we will not have that capability.

Q107 **Chair:** We will have further examination of issues relating to training in due course. Fiona, in your submission you warn that targeted sequencing panels will be more appropriate than whole genome sequencing for the foreseeable future. Should NHS England be cautious in taking forward the 100,000 Genomes Project?

Fiona Murphy: I think we are talking about two slightly different things, in that we anticipate an iterative process towards whole genomes, moving from single genes to panels to exomes to genomes. My understanding is that NHS England will not move to whole genomes for

every test; it will be for a proportion of tests where there is evidence that it already makes sense. It is in cancer in particular that we use targeted sequencing and panels and exomes. That is because at the moment that is where we can deliver to scale. We get good depth of coverage; we can do analysis on older samples that we cannot do with whole genome sequencing very easily. Our particular research arm for cancer is concentrating just now on exomes, but it will be interesting to see, as the results start coming through from the 100,000 genome cancer cohort, which is the best way to go. This will develop as time goes on. We are not going to do a split from day one to day two, moving to different tests; we will pick them up as evidence becomes available that they are both cost-effective and getting the best diagnosis for patients.

Q108 **Chair:** It is a step-by-step approach.

Fiona Murphy: Absolutely.

Q109 **Chair:** Patients in the 100,000 Genomes Project were guaranteed standard NHS care alongside whole genome sequencing to ensure their welfare did not suffer, so in a way there were two parallel systems. Is there a case for ensuring that whole genome sequencing complements existing diagnostics when it is first introduced into the mainstream NHS? Is that the way it will work?

Professor Ellard: Whole genome sequencing will be the most comprehensive genetic test we can do, but there are some types of variants where we need to do more work to validate the methodology, to show that the sensitivity and specificity of the test equals the current tests before we replace those.

Q110 **Chair:** Ultimately, the objective is to get rid of diagnostics tests that can be improved upon.

Professor Ellard: Absolutely, and to do this as the first test. We see many patients who have had sequential tests, which delay their diagnosis and are not cost-effective. In terms of the changeover from current testing methods to whole genome sequencing, obviously we need health economic data; we need a health economic model that works out at which price point it makes sense to move from current methods to whole genome sequencing. Of course, that is dependent on the price drop of whole genome sequencing, but our expectation is that in time more tests will be replaced with whole genome sequencing. The other advantage is that those data are stored, so you can revisit them; for example, if a new genetic cause of your very rare disorder is published, you can go back to the data and potentially make that diagnosis.

Q111 **Chair:** Dr Burton, you have called for a formal evaluation of the 100,000 Genomes Project. Do we just get on with establishing the NHS service even though we have not had the formal evaluation, or should there be an evaluation before we start to roll out the NHS application of it? Why do you think an evaluation is so important?

Dr Burton: From the PHG Foundation point of view, we had hoped to be able to undertake evaluation of the 100,000 Genomes Project as it was going on, so that we would prospectively collect information, for example, about the patients being recruited—their age, sex, clinical conditions and clinical backgrounds; the results of the testing; and the clinical impact of that in an aggregate form. If you did that, you could also collect information about the processes involved, such as how tricky the consent process was, how long it took, the things that were of concern to the patient, the process of interpretation and how the clinician was involved in it.

Q112 **Chair:** You are learning as you go.

Dr Burton: We hoped that that would have been done prospectively because obviously you have to set up that collection of information right at the beginning; you cannot just go in at the end.

Q113 **Chair:** But you do not think there has been that ongoing evaluation.

Dr Burton: Our understanding is that that has not happened. It would have been nice if the cost-effectiveness information had been collected alongside. Partly that was due to the way funding of the so-called research streams was going on. There was no funding up front to set up those things, so there was no mechanism through which we could have set that up. We would have liked to make an independent evaluation.

Q114 **Chair:** Shouldn't Government always ensure that new programmes are evaluated thoroughly as they progress? Should that not be a matter of course as substantial sums of public money are spent?

Dr Burton: That is not a question for me to answer. I would have loved that to happen. It costs money to do that and it is an extra bit of the complication of setting up the whole thing.

Q115 **Chair:** But it is to ensure we get full value out of it.

Dr Burton: In our opinion, it would have been good to be clear about the questions we want to ask up front. What do we as a health service want to know about what can be achieved through whole genome sequencing for which patients, and at what cost? It is our view that that should have been set up, up front.

Q116 **Chair:** How do you feel about progressing with the application of this in the NHS without that having been done? It is too late to have done it as the project proceeded, but despite that do we just need to get on with its application in the NHS?

Dr Burton: We do. Obviously, we can get some learning from it. I suppose we have to use different means of finding out how best to implement it. Certainly, a lot of learning has been gained from it. Some of the more routine learning about how it would be implemented in normal patient pathways has not been available, but we have to get on with it now.

Q117 **Graham Stringer:** Every day, when we switch on the "Today" programme or open the newspapers, we read or hear that the staff of the NHS are under stress. It is less than 12 months before the genomic medicine service is launched. Are the workforce ready? Will they be able to cope?

Professor Ellard: The workforce, certainly in the laboratories, have been expecting this for a number of years, and the 100,000 Genomes Project has allowed us to start thinking about how it will be delivered in the NHS. With any reorganisation, there is concern among the workforce and anxiety about what the future holds, but I think I speak for all my fellow healthcare professionals when I say we really appreciate what this will mean for our patients. We are very positive about delivering the new NHS genomic medicine service.

We need more training as a workforce. We have unfilled clinical scientist posts, so we need more trainee posts and more training for the existing workforce. We are on a steep learning curve. Having said that, we are already delivering whole exome sequencing in the NHS, so we are well placed to make the transition.

Dr Burton: If I can say something about the medical workforce, this is something I have been concerned about for almost 20 years, when we first started talking about genetics, never mind genomics. It is clear that genomics will be important in every single area of clinical medicine. In 2008-09, PHG Foundation did detailed work in the areas of ophthalmology and cardiology to look at the specialist needs for those services, as we were more able to make detailed diagnoses of people with inherited conditions within those specialties. If I take cardiology as an example, it turned out to be a highly specialised diagnostic service for people with rare cardiac abnormalities—for example, abnormalities in cardiac muscle or rhythm and the sort of thing that leads to the sudden cardiac death of a young person on a rugby field that we hear about. Every year, there are 400 or 500 such deaths.

A lot can be done to diagnose people with red flag signs. Perhaps they collapse when running a marathon.

Graham Stringer: I think I might do that.

Dr Burton: As they might do anyway. They might be running or sprinting.

We looked at the availability of those specialist services around the country, where obviously you need cardiologists who understand inherited conditions and geneticists who understand cardiology. We found massive discrepancies. There were good services in London, but outside London there was a more than 30-fold variation in the availability of consultant care and understanding in that specialist area. We concluded at that stage that there was a great need to develop more cardiologists who had that specialist expertise.

Following on from that, we had a meeting at the Royal College of Physicians and invited people from, I think, 17 of the medical specialties— gastroenterology, dermatology, paediatrics—and they all said exactly the same: genomics would be really important in their specialty, but there were not enough people who understood genomics at that specialised level to be able to provide a service.

Following that, I set up and chaired a working group of the Joint Committee of the Royal Colleges on Genomic Medicine to gather together clinical champions in each of those specialty areas. We have 17 clinical champions. These are people in various specialties who are expert in genetics. All of them are concerned that there is not enough expertise within their specialty, at a general level, for example for every cardiologist to understand those red flag signs and for the development of consultants with special expertise to work in specialist centres on inherited disease. That needs to start to be embedded in the curriculum so that in particular doctors undergoing specialist training get proper, full exposure to genetics in a working environment, and some of them have special fellowship training programmes where they can become specialists and spend most of their time on inherited conditions in tertiary centres.

Health Education England has said a lot about the masters programmes and the continuing professional development programmes, and I applaud those. They are generally raising a lot of awareness and developing knowledge that genomics is going to be important, but if you want a workforce where people are able to take clinical decisions at consultant level, they need to have had that specialist training right through the curriculum and properly embedded. As you would train a cardiologist to be an imaging or a rhythm specialist, so we should be training them to be cardiology specialists in inherited disease.

Outside specialties such as oncology and haematology, which are quite genomically oriented, I do not think there is a single specialty where that is properly embedded in the curriculum, not even cardiology, even though they have been ahead of the game. It is very difficult to change curricula and the royal colleges have many other priorities, but genomics is probably sufficiently big for there to be a special request that they put in place, fairly rapidly, procedures for looking at the curriculum and making that specialist training properly embedded.

Q118 **Chair:** I am conscious that we have a lot of questions to get through, so can we keep the answers as tight as possible to make sure we cover everything?

Dr Burton: Yes. I have almost finished on that. A group has been set up by the Academy of Medical Royal Colleges and I hope they will take it forward. They need to get it into the curriculum.

Q119 **Graham Stringer:** I have a couple of questions that follow straight on from that. You are very clear that you do not think that any single

specialty is up to speed. Are there any particular specialties that are a long way behind, or where the problem of genomic-related skills is further behind than you would hope? Secondly, you said you had looked at 17 specialties. I know from campaigns and issues in other areas that, where there are 17, somebody will want to be the 18th or 19th.

Dr Burton: There were definitely more than 17.

Q120 **Graham Stringer:** What are the areas with poor genomic-related skills, and what are likely to be 18, 19 and 20?

Dr Burton: I cannot really answer that; I would not want to pick any out. I know some of the ones that are ahead, such as cardiology.

Q121 **Graham Stringer:** Tell us about the ones that are ahead.

Dr Burton: Cardiology and ophthalmology have been ahead. I think they realised the importance very early on and have some individuals who are jointly qualified and have pushed it forward. Cardiology has done a lot to try to develop the curriculum, and that is a model that could be followed.

Professor Ellard: There are different challenges for different specialties. In my own specialty of diabetes, the majority of patients have type 1 or type 2, so it has been a matter of trying to identify patients who are more likely to have a genetic sub-type that might respond to a better treatment—for example, sulphonylurea tablets rather than insulin. The challenge has been identifying the small minority, maybe 2% to 3% of patients, who have that genetic sub-type. Once we can move to a system where there is a genetic test applied, perhaps following a set of non-genetic tests, and there is a systematic approach, it will be more straightforward. The emphasis will then shift to actually managing those patients, thinking about the fact that each patient has a family, and seeing those patients not just in the setting of a person at the clinic, but in the wider family, and how the genetic diagnosis will impact on relatives as well as on the individual.

Q122 **Graham Stringer:** Does the genomic education programme provide the right level of training to a wide enough segment of the NHS workforce?

Dr Burton: It has been very good at trying to reach a wide range of health professionals, such as nurses.

Q123 **Graham Stringer:** You do not think the courses could be improved, or that they are lacking in any way.

Professor Ellard: There is always more that you can do. The University of Exeter is one of the providers of the MSc in genomic medicine. We have had excellent feedback and we have reached many people, but it is never enough. Health Education England, through its genomics education programme, for example, has created a MOOC—a massive open online course—which has been accessed by thousands of staff. Clinical staff learn through cases, and what the 100,000 Genomes Project allows us to do is to get diagnoses and use each of those cases as a learning episode

for staff, but you could never be at a stage where you had too much education or too many training opportunities.

Q124 **Graham Stringer:** Is there anything that should be done that is not being done at the present time to ensure that the NHS has the relevant expertise?

Professor Ellard: It is important that we think about multidisciplinary training. Historically, we have learned in separate professional groups. One initiative I am involved in is implementing new guidelines for interpreting rare genetic variants. We have created a regional train the trainer system whereby we have clinical geneticists, genetic counsellors and clinical scientists learning together and delivering that training locally. The future of genomic medicine requires that we work across disciplines more effectively so we bring together our laboratory skills, the skills of our bioinformaticians and our clinicians from many specialties. Having more training opportunities that embrace that multidisciplinary approach will be beneficial.

Q125 **Stephen Metcalfe:** Picking up that point, written evidence was submitted to the previous Committee by a group of Cambridge-based institutions functioning as a multidisciplinary team looking at rare cancers. Effectively, the team was held together by good will and research funding. Is that a common problem, and could it be addressed relatively straightforwardly?

Fiona Murphy: From our perspective, there are multidisciplinary teams as a way of working in the NHS, whether it is to do with genomics or other forms of medicine; it is the way teams are now looking after patients who have multiple system problems, and there are multiple sources of expertise. Many of those start from a research perspective and become more embedded as that research pays dividends, and it seems to be the way to work. In paediatrics, in Scotland there is already a countrywide MDT meeting held by PC every month. It has just become embedded as a way of working. That will evolve and other specialties will do the same over time.

Sometimes, there can be a bit of a lag moving from a research-oriented team meeting to it being part of clinical practice, but I do not see any block towards that as these things become more organised. Generally, it tends to involve some small seed funding to have a co-ordinator who holds things together and has the infrastructure to bring people together, but cancer disciplines have been doing MDT meetings like this for a very long time; it is a well-practised art.

Professor Ellard: We have MDT meetings in different formats; for example, we have case-specific MDTs. My laboratory offers a whole exome sequencing service across the country. We arrange a WebEx with the referring clinician so that we can discuss a case and reach a decision in terms of interpretation of the variant and what it means. That needs to be factored into the costing of the whole process, but it does not

necessarily have to be a room full of people discussing a series of cases live; there are different entities for different geneticists.

Fiona Murphy: They rarely are in Scotland.

Q126 **Stephen Metcalfe:** The oncogenetics review board, acting as a molecular MDT, basically said that the structure they were working under at the moment was non-sustainable. Is there a risk? We are trying to get this embedded into the NHS, and at the moment it appears that it is only through good will that we are able to do it. Do we need some structure behind that? Is there something we should be recommending as part of our report that will deliver that?

Chair: As formal commissioning.

Fiona Murphy: Part of the specific objective of one of the strands for the Scottish Genomes Partnership is to set out exactly what the infrastructure needs to be, so we are evaluating the feasibility of how we work and trying to learn both about the lab processes and the processes at the other end—the MDTs and the education requirements. We have set aside some funding to do some evaluation of that. The University of Aberdeen has been helping us with some health economic assessment.

It is very important that, when we move into commissioning this as an NHS service, all those elements are part of it, because, as Sian alluded to, the cost of doing this is not just the cost of the laboratory test; it is the change to the whole pathway for collecting samples—for example, in cancer we will need a change in how we currently practice—and, at the other end, how we make decisions for patients about drug treatments. Potentially, you need a different group of people around the table, so the whole pathway needs to be taken into account in the commissioning.

As far as I understand it, NHS England is doing the same, in that it plans to re-provision the genomic medicine centres to set out what a genomic medicine centre needs to have in its infrastructure to be able to deliver this appropriately. My understanding is that that is the next step after commissioning the laboratories for England. It certainly will be for Scotland.

Q127 **Stephen Metcalfe:** Could you say a little more about how the genomic medicine centres stay up to date with the latest research and make sure that they are all working as a network?

Fiona Murphy: In Scotland, the genetics consortium has always been a very close collaboration between our academic colleagues and clinical colleagues. Outside Cambridge, we probably have the biggest concentration of computational genome experts, and they have always worked very closely together. Our labs are associated with the four medical schools. Our leads, Professor Aitman and Professor Biankin, are leading figures in genetic research. We also have the benefit of the Scientific Advisory Board, including Sian, and other international experts to help make sure that we keep on top of what is coming out.

One of the huge benefits of the 100,000 Genomes Project has been the GCIPs, the clinical interpretation groups that have brought together experts from across the whole of the UK to help interpret what is coming through those sequences, and share learning. My understanding from genetics colleagues is that there has always been very close collaboration across the UK. Some of the societies that bring geneticists and clinical scientists together have always shared that kind of learning. It is a very evolving field, so I think there are mechanisms in place to keep people up to date.

Professor Ellard: Absolutely. The 100,000 Genomes Project has been a catalyst for the formation of the 13 genomic medicine centres in England and has enabled us to start working together much more effectively as a national network. For me, one of the pleasures has been close working with colleagues and the research collaborations that have been spun out of that.

Q128 **Stephen Metcalfe:** We have been talking about sharing learning, knowledge and best practice. What about sharing data? Is there a widely accepted scheme in place where data can be shared across all the four nations of the UK? Are there any barriers to that?

Fiona Murphy: We have addressed a lot of the barriers. For NHS Scotland, in taking part in the 100,000 Genomes Project we have set up a system for sharing encrypted anonymised data from Scotland with GeL. We do not send patient identifiable information; we hold that in a safe index in Scotland. That has been incredibly useful because it means that in the longer term we have set up the systems for that datasharing.

We had worries that the datasharing might put people off being part of the 100,000 Genomes Project. It has not. People are increasingly sophisticated about their knowledge, datasharing and control of their own data. It has taken some time to get those systems in place. We benefit from having both a technical process for protection of data as we share it and a permissions approach to make sure that we share data with the right people in a safe environment. Good work is done on datasharing in other parts of the NHS from which we can learn; we are not starting from scratch.

Professor Ellard: Currently, in the genetics laboratories, through a database called DECIPHER hosted from Cambridge, we have a mechanism whereby we can share genetic variant data across NHS laboratories, and that includes Scotland, Wales and Ireland. That is just sharing the genetic variants. If another centre finds a patient with the same very rare genetic variant, we can utilise that information, to have increased confidence in the diagnosis. Currently, those data are kept within the NHS.

In the US, the commercial laboratories have led the way in sharing data internationally. We have seen the benefits many times over of having enough evidence to get a diagnosis of a very rare disease for a family.

We are very keen that those data are shared across the international community, because it will benefit patients across the world as well as our own. We have not progressed to that stage, because of the need to have reassurance about the safeguards required to share those data in a safe way from within the NHS.

Dr Burton: Going forward, there is still a lot that needs to be done and to be achieved to make sure that we have good datasharing systems that stand up for the future. It is not only genomic data; it is clinical data as well. If you move into a mainstream service, you are talking about clinical data available in all sorts of patient notes spread in different locations around the country. There are a lot of historic databases, such as DECIPHER, but also ones held in different individual laboratories. There are barriers to sharing that have not yet been overcome—infrastructure-type things where NHS people do not necessarily have the portals that make it easy to upload data and the staff time to upload data.

Moving forward, there is a lot to do to create databases that will work, but we have to think about how they will be maintained, how the information in them will be standardised and how in the long term it will be curated; we have to think about the quality control systems for access and support for users. They are all things that will have to be built into a future proper datasharing system. We need to make sure that we have a system that works for patients and day-to-day NHS services, and is practical enough to be used. There is still a lot to be done to make sure it is created, built and then maintained.

Professor Ellard: One particular challenge is that, historically, clinical genetics notes have been separate from hospital notes. It all comes down to the fact that you are looking at a family rather than an individual. There will be a big challenge in terms of how you build into that system an ability to see just the information for which there has been consent to share it, and how you can share information effectively without breaching those family relationships.

Q129 **Stephen Metcalfe:** Is there a standard way of formatting data now? Has that been agreed? The Global Alliance for Genomics and Health had a set of standards. Is that the only one? Is everyone coalescing around one set of standards, so that the data are universal?

Professor Ellard: We are working towards an international standard, but it is early days.

Q130 **Stephen Metcalfe:** Are we leading on that international standard?

Fiona Murphy: We are certainly part of it. The SGP is a member of that file-formatting taskforce. We are lucky in the UK in that we all use the same platforms and file formats. There is work to be done. There are groups looking at international standards. The UK is certainly a big part of that. We will probably find it easier in the first instance to share among ourselves, because we are all using the same equipment.

Professor Ellard: Of course, the Global Alliance for Genomics and Health is currently chaired by Ewan Birney who is head of the European Bioinformatics Institute. It is fair to say that standards are developing. We have been doing some work on developing a standard report format so that all genomic reports coming out of the laboratories will be in the same format. We have been conscious of making sure that is established in a format that is consistent with electronic reporting, but currently we do not have the informatics systems to generate the electronic report.

Q131 **Darren Jones:** I am going to ask each of you two short questions, but if there is any burning issue that you want to jump in on, please do. At the last hearing, I asked questions about the digital infrastructure to make the systems deliver so that ultimately patients get the benefit, and I want to continue my questioning on that today. Dr Burton, you said in your written submission that you had some concerns about the infrastructure as it is today being suitable to deliver the service. Could you elaborate on that slightly?

Dr Burton: It is the things we have been touching on in the discussion: the standardisation of it; the ability of laboratories to upload the data; the portals available to them; the resources available to them; the time to do it; and the clinical information they are going to use. We feel there is still a lot to be developed to make that infrastructure standardised, high quality, usable and practical for all the laboratories.

Q132 **Darren Jones:** On the basic level of storage, I was amazed to learn from my notes that an individual's genome takes up about 200 gigabytes of data, which apparently is the size of a laptop. That is a lot of laptops for a lot of people. I am assuming that we do not have the storage capacity at the moment.

Dr Burton: I think that is being developed for the genomes in the 100,000 Genomes Project.

Q133 **Darren Jones:** But once we get past 100,000 we may need to do something else. I do not want to be accused of putting leading questions, so I will give you my point and you can tell me whether you agree or disagree. On equality of access, which you mentioned earlier, if the health service does not have the digital infrastructure to deliver this for patients because of storage, systems or uploads, are there private sector players doing this today for people who are willing to pay for access to the service?

Professor Ellard: There are many private laboratories offering genome and exome sequencing. We have patients who come to us having had a test in the private sector, and our observation is that there is very variable quality across those providers internationally.

Fiona Murphy: Are you asking whether there are private companies wishing to have access to those data who might be willing to store it for us?

Q134 **Darren Jones:** No; that is a separate question. My concern is that, ultimately, if the health service is not able to deliver this to patients across the country, only those who can afford to have access to private laboratories to get their sequencing done will have the benefits of it. That is the point I was making.

Going on to the current state of play, I have a little bit of experience of some of these issues. When I was a student, I was a clinical auditor at a GP surgery. I was given box-loads of Lloyd George paper notes. I had to understand, first, what the handwriting said and, secondly, what it meant; and, thirdly, I had to figure out what relevant coding was required to put it on to the NHS system so the GPs could get their money for measuring chronic diseases, medical auditing and things like that. It was very time-consuming. Different GP surgeries had different clinical systems, and they could add their own codes to their systems. There were lots of different codes with different headings. That was just backlog clinical information to get on to the system. You then had the problem of box-loads of emails that were printed out and all kinds of test results. Professor Ellard, earlier you mentioned that today when you order genetic testing it comes in either by email or hard copy. Is it still the same process today, where people at the other end physically have to enter this stuff into computer systems?

Professor Ellard: Yes. When a referral to request a genetic test arrives at a laboratory, currently we have a request form that ideally is completed electronically in advance and emailed to us. I had hoped that our existing system would be set up so that we could automatically bring through those data, but I do not think any of the laboratories in the UK has that today. The big advantage of a new system going forward is that the requesting clinician will enter on the electronic system exactly which tests they want to have done for their patient. They will enter those data, and the patient's name and NHS number will be pulled through from existing hospital systems, so that we do not spend as much time chasing up small details about how names are spelt, for example, which wastes a huge amount of effort and time.

Dr Burton: When we are thinking about mainstreaming, sometimes we require quite detailed clinical information that goes along with the genetic test. We had a workshop in March involving a wide range of clinicians. The interpretation process is sometimes a bit iterative. A variant may be found and a question may go back to the clinician about whether such and such a clinical factor is visible in the patient, which sometimes requires the clinician to go back and look at the records. Maybe it is a skin abnormality or something that could have fitted in with the variant (that they have identified). Their comment was that, to do that, they end up having to go through piles of records, piles of paper, to see whether that other clinical symptom or clinical finding is available. They do not have access to the sort of digital clinical records that would make it comparatively easy to add that extra bit of important information for the

interpretation. There is still a lot to be developed in the digital infrastructure to make those things happen.

Professor Ellard: But things are moving forward. Through the genomic medicine centres there has been investment in informatics infrastructure. In some places, there are quite effective systems for pulling information across different databases to make them more efficient and safer in terms of quality of data.

Q135 **Darren Jones:** Do you know whether the use of those data is envisaged to be embedded in the systems that exist today so that, if I was a GP, I would log on to my main clinical system and be able to access it, or is there going to be a separate database and a piece of software purely for the movement of this genetic testing information?

Fiona Murphy: You do not have to create a new system for the people who are inputting. In Scotland, it will draw from the referral system. We have something called Skystore that has referrals from GPs to secondary care. You would draw down the demographics Sian talked about from that. I do not think anybody would want to set up a system where you enter one system for looking after the patient in front of you and another one for sending away a test, so they will need to be integrated. They do not need to be the same. We do not need a standard IT platform; we just need platforms that are interoperable and can speak to one another. Systems are getting better at doing that, but we are a long way from it yet.

Q136 **Darren Jones:** When you refer to pulling down demographic data, do you mean from primary care or from secondary care—hospital or GP surgery files?

Fiona Murphy: In Scotland, it is based on the community health index, so it is drawn from one source index for all demographics.

Q137 **Darren Jones:** Does anybody know what it is like for England?

Professor Ellard: It is the NHS Spine, which would include both.

Fiona Murphy: It would be similar.

Q138 **Darren Jones:** You mentioned that in Scotland, when you anonymise data for data transfers, you keep the patient ID directory separate. Is that the same in England? Is that what Spine is, or is it something separate?

Fiona Murphy: My understanding is that in England you send details to GeL of a patient and their sample, and the patient information goes with it, because it is all held within England. In Scotland, our rules are that we cannot send patient identifiable information to a research system like GeL, so we have to remove all identifiers and hold an index separately. I do not think you have to do that in England because you use the NHS number, which is at Spine, to set the index, but we do not have an NHS

number; we have a CHI number, so we have to do things slightly differently.

Q139 **Darren Jones:** Who gives you the rule that asks you to do that?

Fiona Murphy: I think it is part of our legislation on data protection or data transfer in Scotland. I am not an expert on that.

Q140 **Darren Jones:** No problem. My last question is about money. In the previous hearing, we were talking about the costs of upgrading the infrastructure to allow this to work properly. Do you think it is as simple as a money question, or are there longer-term legacy infrastructure problems that pose a bigger challenge than just having a budget?

Chair: Keep your answers tight, because we have quite a lot to get through before the end of the session.

Darren Jones: It was my last question.

Fiona Murphy: The very quick answer is that it is both. We definitely need more funding for this right from the laboratory testing site through to interpretation and analysis and the long-term storage of data, but money alone is not enough to do it; we also need to redesign our pathways and how people work locally, and we need to train people, and that will take longer than simply an injection of funding.

Q141 **Vicky Ford:** We have five minutes and I have four questions. You will each have to give more or less yes/no answers, with a little bit of detail. Is the broad consent model used for the 100,000 Genomes Project suitable for routine genomic sequencing in the NHS? I think you have already said no, Hilary.

Dr Burton: It may be too complex; it is rather unwieldy for day-to-day use.

Q142 **Vicky Ford:** That is helpful. Do we all agree? Yes.

The CMO has said that genomic data should not be viewed as any more sensitive than other elements of personal or medical data and therefore should be covered by the same type of data protection regimes. Do you agree?

Dr Burton: We agree with that.

Fiona Murphy: Yes, broadly.

Vicky Ford: Broadly. That's fine.

Chair: This is brilliant. Keep going.

Vicky Ford: This is how ladies operate.

Chair: I am very impressed.

Q143 **Vicky Ford:** It's also because a lot of these topics have been covered

already. Do you think there is enough awareness of the risks and benefits of genomics datasharing, especially the benefits? We often talk about the risk, but is there enough awareness?

Dr Burton: I do not think there is enough awareness, particularly among the public and less expert health professionals, of the absolute critical need for datasharing. They think it is for future research, whereas it is actually good clinical care.

Q144 **Vicky Ford:** And for saving lives now.

Dr Burton: Yes, making the right diagnosis now.

Q145 **Vicky Ford:** I am going to send you away with a bit of homework. What more should we be doing to help inform the public about the benefits, if this is as transformational as we think it is? What more could we be doing as a Committee to enable that? I am happy to take comments on that now.

Professor Ellard: We need to talk to our children in schools about genomes, and the idea of "my genome." It is not my genome. I share 50% of my DNA with my mum and 25% with my brother, and there is significant variance across a much wider part of the population. It is about educating the public throughout of the benefits of those data and what we gain by sharing data.

Fiona Murphy: We have had some public debate in Scotland. Recently, at Edinburgh University there was a first-year medical student debate in which some of our members took part, to try to change some of the discourse around this, and to look at the benefits of datasharing, but there needs to be more public awareness. People are sometimes overly scared of the risks and not aware enough of the benefits.

Q146 **Vicky Ford:** They trust patient organisations like Alzheimer's Research and other organisations, but how can we help to promote those benefits more?

Fiona Murphy: Some of it is working with those organisations. The Genetic Alliance UK is part of our rare diseases group. There is the Healthcare Alliance and voluntary sector services. Most of the rare disease charities are very aware of the benefits of sharing data. It is about the wider public. We could use some of those trusted charities to help us with the message.

Q147 **Vicky Ford:** I think I know the answer to my next question. Is the difference between pseudonymised and anonymised data explained clearly enough? I couldn't go out there and explain it.

Fiona Murphy: Then probably not.

Q148 **Vicky Ford:** We could be doing more to put that into the discussion about what happens to your data and how it can be traced back to you.

Dr Burton: I think it is part of the trust as to how the services will use the data. Patients have to trust that it is properly secured. It can never be completely anonymised. They have to understand the benefits and stop thinking about genetic data as something extra-specially sensitive. The ideas about blueprints and so on are not really helpful; it is not usually that predictive.

Q149 **Vicky Ford:** Maybe I couldn't explain it because I have never needed to make that decision. Do you think that people making that decision, and going into a trial that involves sharing their data, understand it?

Fiona Murphy: Earlier, you asked about the broad consent model. We have found that it has not had an implication for participation compared with other more narrow consent models. We found that, if you take people through what consent means for them, that is not what puts people off taking part in the research.

Q150 **Vicky Ford:** Broad consent is not a problem.

Fiona Murphy: It might not be practical on a day-to-day basis to use the broad consent model, but the model itself has not put people off taking part.

Q151 **Vicky Ford:** Are there any specific problems for genomics in the GDPR or the UK Data Protection Bill that we should be focusing on? I know that earlier drafts of the GDPR caused great concern, but is it basically workable now?

Dr Burton: There is a working group still working on some of the finer nuances of the way the regulations will be interpreted. I think it is due to report fairly soon. One of the important things is whether genetic data are put in a category of being extra-specially sensitive. We would hope that they were not.

Vicky Ford: That is really worth reporting, because the UK will probably play a leading role in implementing that part of it.

Chair: Thank you, Vicky. Most impressive.

Q152 **Neil O'Brien:** Ms Murphy, do you have any concerns about the future of the UK Genetic Testing Network and its being replaced by a body within NHS England?

Fiona Murphy: I am not concerned about its being part of NHS England at all. We have been party to discussions, as have Wales and Northern Ireland, on the future of UKGTN. It has been a fantastic organisation and has helped with a lot of the appraisal of evidence and new tests. I think we all recognise that with new technologies and platforms there needs to be a different way of deciding on testing strategies. Sian mentioned the test directory that will be coming out from NHS England. We may not have exactly the same test directory, but we will use the basic clinical and technical information behind it. My understanding is that some of the functions of UKGTN—we have been using their audit function and their

benchmarking—will continue and will be part of the consultation on where UKGTN goes in future.

Q153 **Neil O'Brien:** Listening to some of the earlier conversation, it seems that Scotland has only relatively recently started sending sequences to the 100,000 Genomes Project, which will stop sequencing next year. Is there an argument for better co-ordination between NHS England and the rest of the devolved Administrations? Are you happy overall about the way that relationship works, or could it be more tightly gelled together?

Fiona Murphy: It is important that the whole of the UK works together. As I said at the beginning, we have a slightly different starting point, so we recognise the need for NHS England to reorganise its laboratories. We do not feel we need to do that; we did it a good number of years ago. We are not all in the same position, but it is important that we all learn together and share the expertise that we have, and that Wales has as well. One of the concerns that we and colleagues from Wales have submitted is that just now we have a lot of cross-flow—cross-border work—on samples. We send to NHS England labs and Wales, and equally they send to us, and we need to work out how that is configured in future. I do not see any short-term change, but potentially in the long term, as the balance of the test directory changes, that might change. I am very pleased that NHS England has recognised the need to discuss that as four nations.

Q154 **Neil O'Brien:** My last question is the flip side of that. Are there any aspects of the Scottish experience from which you think NHS England could usefully learn?

Fiona Murphy: The consortium model we have had in Scotland has shown dividends. When you look at benchmarking reports from the UKGTN in the past, we tended to have a higher testing rate, and less variation between different parts of Scotland. Some of that is what NHS England is now adopting to try to concentrate some of the laboratory specialties and reduce variation.

I mentioned that we have some leading lights in genetic research. That joint working between academics and clinicians has worked terribly well in Scotland. We have learned from their bioinformatics resources in particular and applied that directly to clinical labs. That joint work with academia is very beneficial.

Chair: Thank you all very much indeed. It has been a fascinating session, and we appreciate your time.

Examination of witnesses

Witnesses: Lord O'Shaughnessy, Dame Sally Davies and Professor Chinnery.

Q155 **Chair:** Welcome to all of you. Thank you very much for your time in coming to give evidence to us.

Professor Davies, in your report you speak of a "genomic dream." How central is whole genome sequencing to that vision? The 100,000 Genomes Project was all about whole genome sequencing. Do you expect the NHS genomic medicine service to lead to more or less whole genome sequencing following the end of the project?

Dame Sally Davies: Thank you very much, Chair. Let me explain my interest. As chief medical officer for England, I get to write an annual report, and this year's, published on 4 July, was called "Generation Genome." I chose genomics because I have a passion for it, which goes right back to why I went to medical school, and the clinical practice and research that I did. I tried to clone genes. I was extraordinarily bad at it, but I tried and learned a lot.

Chair: It has not held you back.

Dame Sally Davies: Now is the time when it is real, and we need to move it forward. We established the 100,000 whole genome project in summer 2013, having had it announced in December 2012 by Prime Minister Cameron. At that time, we were all really interested in where it would take us. We know the genome is extraordinarily long; we know that only about 2% is coding for proteins and the rest is not. When I was brought up, I was always told, "It's junk, it's junk," yet, because it was protected through evolution and across species, it is clear that it has roles. Professor Chinnery, as an expert from Cambridge University, will be able to speak to this far better than me, but it has roles in controlling whether genes are on or off, how strongly they work and how things are spliced. From one bit of coding gene, you can make different proteins and things. Clearly, it is important, but as we started the project we did not know how important it would be.

It has become clear that whole genomes are extraordinarily important. At the beginning, a lot of people in the NHS said they wanted to do just point mutations, arrays where you collect lots of point mutations or coding exomes. We said, "No. This is a novel project about translation of the service of the NHS and research combined, and we are going to do whole genomes." We now know that, even if you want the exome, you are much better getting it from a whole genome, because it picks up inversions and quite complicated things and gives you a better-quality exome.

Meanwhile, we now know—Professor Chinnery can speak to the data much better than me—that we are upping our diagnostic rate for people with rare diseases. With infectious diseases such as TB where all patients in England get a whole genome of the TB, we are picking up the MDRs—the multi-drug resistants—and they are getting treatment much earlier because of genomic diagnosis of the whole genome.

In cancer, where at the beginning a lot of people pooh-poohed this, it has become clear that there are mutations and alterations in the non-coding part that absolutely control the type of cancer and argue for different

treatments. Whole genomes are already beginning to prove their value, and it is this project, worldwide, that is proving that.

Q156 **Chair:** Dr Burton, from whom we heard, was concerned about the lack of an overall evaluation of the 100,000 Genomes Project, so that we learn constantly from it, and learn about cost-effectiveness and so on. Does that concern you? Do you share that view?

Dame Sally Davies: No. She is clearly not close enough to the project. Professor Chinnery can answer this better, but once you find a mutation, you have to evaluate whether it is truly the cause of the disease. Professor Chinnery can talk to how experts do that. That is one form of evaluation. The next form of evaluation is cost-effectiveness. In my report, we have a chapter on cost-effectiveness. It is something we will have to do as we go forward, and it is in its infancy, but that very chapter shows it is on our minds, how we are looking at it and what we are doing. Then there is evaluation of the process of rolling out whole genomes, and the data we collect through Genomics England on turn-arounds, speeds and everything like that give us a very good process evaluation. It is difficult to explain everything to people who are not part of the system and not excited by it.

Professor Chinnery: Before I moved to Cambridge, I was in Newcastle and ran one of the pilot sites for the 100,000 Genomes Project. We learned an enormous amount from that pilot project about how we might, at scale across the country, deliver this kind of genomic programme.

Q157 **Chair:** What period was that?

Professor Chinnery: That was in late 2012 and for about two years thereafter. That set the scene. Of course, it was evaluated, and the processes put in place for the main programme a couple of years ago were based on our evaluation of the pilot project.

I have a couple of other comments. In the end, sequencing the whole genome provides a definitive, comprehensive answer to the question: what is the genetic make-up of that individual or that cancer? You cannot get that with any form of targeted analysis. The other point is that for technical reasons the quality of the data is infinitely better than the other technologies that preceded it, so it boils down to an issue of deliverability and cost.

Q158 **Chair:** Are you confident that enough evidence has been gathered from the project to start replacing existing diagnostics with whole genome sequencing?

Professor Chinnery: The evidence is extremely strong. There have been a number of independent scientific publications, partly from the UK, such as a study of rare inherited eye diseases led from Moorfields Eye Hospital, but also studies from the big North American groups, that demonstrate that the diagnostic yield from whole genome sequencing is superior to anything else that preceded it.

Another important point is that the pilot project and the subsequent main programme have in themselves driven down the cost of sequencing, from several thousands of pounds, which is what it currently costs in the US, to less than £1,000 per genome, so the project has made it more affordable.

Dame Sally Davies: One of the pilot projects was on people who bleed because of coagulation factor abnormalities or abnormalities of tiny blood cells called platelets, or who get blood clots easily. It sequenced 3,000, and in one in two patients came to a conclusive diagnosis. That never happened before. I speak as a haematologist. It picked up 20 new genes.

What matters is not just giving patients the diagnosis; some of the genes that have been found are associated with fibrosis of bone marrow, so you get an anaemia that becomes malignant, or it goes straight into leukaemia at some point. The ones with those mutations are now being followed very carefully, and some of them are having bone marrow transplants early to protect them. We are changing the pattern of disease by the work that is already happening.

Q159 **Chair:** The project accepts patients from across a variety of cancers. Would you expect most cancer patients in the future to receive whole genome sequencing, once genomics becomes part of routine in NHS care? Is that your expectation?

Professor Chinnery: It will be a while before that situation arises.

Q160 **Chair:** What is the rough timescale?

Professor Chinnery: Five to 10 years. We are learning about the potential relevance of whole genome sequencing in the context of common cancers. In the context of rare cancers, it is much clearer that the whole genome sequence will have a more immediate impact. There are examples, one of which you heard, where whole genome sequencing is identifying genetic abnormalities that steer the precise treatment patients get. We know from clinical studies, such as in chronic myeloid leukaemia, that this influences the overall outcome for patients.

Q161 **Chair:** Professor Davies, at the time of your report, you were reported as talking about a five-year period for mainstreaming this into NHS care, but there have also been reports that NHS England has said it will be operational from next year and mainstreamed the year after. What is your view about a realistic timescale?

Dame Sally Davies: The plan of NHS England is to be commended, with a service procurement in quarter three to four this year, and they are progressing that, and operational in quarter two next year and mainstreaming in quarter two 2019. But it is not just how they change the laboratories; it is how we take clinicians with us. That is what will take the time.

Q162 **Chair:** And train them, presumably.

Dame Sally Davies: That is what I mean. They need some training. Let me say one other thing before I come back to training.

I am very clear that it is time we moved in this area, and, I would argue, for most pathology, away from lots of little labs—a cottage industry that has served us well in the past—to factories where you get higher quality, faster throughput and turn-round and cheaper prices. That is a very painful thing for the NHS, but if we can move to two or three factories for the country, it will become much easier. There will be big savings and we can use them to spread the service and make it more equitable.

NHS England is working on training. We need a directory of tests so that people can say, "With this disease, or constellation of findings, I need this test," and request it. I used to look through a microscope and see what was called a Howell-Jolly body in a red cell. I would say, "Ha. This patient hasn't got a spleen. Was it taken out on purpose post accident or for some other reason, or is it one of the diseases that gives you no spleen?" I would write on the form going back, "This patient hasn't got a spleen. Look for the following. Here is the next set of tests you could consider. Give me a ring if you need help." They did not need much training. It is about training, but it is also about culture; they need to want to do this. It is about putting patients at the centre.

Q163 **Chair:** Minister, thank you for your patience. There have been calls for a clearer molecular diagnostic commissioning framework at national scale. Is the NHS planning to move towards that, and, if so, when will it be in place?

Lord O'Shaughnessy: Thank you, Chair, for inviting me to speak on this subject. You have heard from Professor Davies and Professor Chinnery about the need to move beyond that cottage industry and have a national framework. Everything is gearing up for that in two ways: first, with the national genomics testing laboratories that are out for procurement, and, secondly, with the test directory and the common framework.

What has been convincing to Government—obviously we are reliant on the evidence of the experts—is the ability to substitute a range of tests for whole genome sequencing, which, as has been explained, can be much more productive effectively, particularly as the cost per unit of doing the tests has come down. The intention is to move from the project, which was always time-limited, and turn it into a sustainable ongoing service within the NHS, building on the three pillars of rare diseases, cancer and public health. It is fair to say that there will be some transition, because a new infrastructure needs to be built up.

Q164 **Chair:** What is the timescale?

Lord O'Shaughnessy: The timescale is as described.

Q165 **Chair:** But for national commissioning in particular.

Lord O'Shaughnessy: The operational framework will be fully in place from 2019 onwards, so that is the point at which these kinds of tests will be offered for rare diseases and rare cancers, building up over time to offer it to more and more patients.

Q166 **Chair:** Is it some time in 2019? Do we have a target date?

Lord O'Shaughnessy: Quarter two 2019.

Q167 **Chair:** Thank you. When will the national genomics board that Sally recommended be set up, and which Minister will be in charge of it?

Lord O'Shaughnessy: I will be chairing it.

Chair: Excellent.

Lord O'Shaughnessy: It has been decided in time for discussing it today, as is often the case with these things.

Q168 **Chair:** Was it last night?

Lord O'Shaughnessy: Possibly. There is a serious point. The intention of the genomics board is to oversee the transition into what has been an extraordinary world-leading project that has established the UK at the forefront of the field. Obviously, it was time-limited and was to some extent a niche product. What we intend to do now is mainstream it, and that brings all sorts of considerations, such as data security; throughput of enough testing to make sure that we continue to get a better price for more sequencing when it happens; and putting the laboratory programme in place. The board will oversee that. It is not a separate institution.

Q169 **Chair:** When will it be established?

Lord O'Shaughnessy: We are establishing it now. We do not have a date for the first meeting.

Q170 **Chair:** Who will be on it?

Lord O'Shaughnessy: An important point is that we are not having to set up a new institution or bureaucracy. Effectively, it is a programme board, so it will comprise all the relevant public sector bodies, as well as patient representatives, clinical representatives and potentially industry representatives.

Q171 **Chair:** Do you imagine that it will meet at the beginning of the new year?

Lord O'Shaughnessy: Yes, and it will meet on a quarterly basis, with a work programme supported by a secretariat, making sure that we move smoothly towards the new position where it is a day-to-day part of NHS activity from 2019 onwards.

Q172 **Vicky Ford:** On the comment you made about taking it from a cottage industry and mainstreaming it, could you confirm that it is a highly innovative, world-leading cottage industry?

Lord O'Shaughnessy: I should point out that that is Sally's language rather than mine.

Dame Sally Davies: I did say earlier in this session, and I say in my report, that it has served us well; it has been excellent, but we are moving beyond simple genetic tests to something where you need factories. If you do not run the machines 24 hours a day, you are wasting money.

Professor Chinnery: It is important to cast our mind back to five years ago. I was working in Newcastle trying to make diagnoses in rare diseases. When I went to Europe and met my colleagues, it was embarrassing. We were behind; we were not up to date in taking on board the new scientific advances at the pace of the rest of Europe. Now we are ahead of them.

Vicky Ford: Thank you.

Chair: Are you happy, Vicky?

Vicky Ford: That's much more positive.

Q173 **Graham Stringer:** On the point about moving from a cottage industry to factories, is this a decision and project that is being implemented, or is it a glint in your eye at the moment? Is it a project or a good idea?

Dame Sally Davies: It is halfway there. It is not where I would take it, but it is getting there. I think we need two or three. Who am I to say? I am only the CMO. NHS England is going for seven or eight genomic hubs.

Q174 **Graham Stringer:** It is going for smaller factories.

Dame Sally Davies: They will be smaller factories, in the first round.

Lord O'Shaughnessy: The point is that they are part of a national infrastructure adhering to common standards and underpinned by a national strategy, so that is the move.

Q175 **Chair:** You think there should be fewer of them and on a larger scale.

Dame Sally Davies: Yes; it is only a question of scale.

Q176 **Graham Stringer:** That is interesting. The genomic medicine service is due to be launched in less than 12 months. Are the workforce trained and ready?

Dame Sally Davies: The workforce will never be trained and ready to do it themselves, in the sense of understanding all the genes. In my report, I made a big issue about how people need to understand that, if they want the best and latest diagnosis, their genome needs to go into a research-based database. If it does not, it will rely on their clinician, first, being able to read the genome and, secondly, knowing what that means; and, thirdly, being up to date with the literature. Even the best cancer geneticists are usually focused on one particular type of cancer rather

than all of them. For the best service to patients, we need their data to be in a research database so that researchers scan it and say, "We've seen one of those before. That's new, and this is probably what it means," so they get the best answers in the world. That is what Genomics England is doing.

Q177 **Graham Stringer:** I am just trying to absorb that. I am not sure I completely understand it. Does that mean you believe that the assessment should be done centrally and not within the different specialisms of medicine?

Dame Sally Davies: It goes with having a factory and doing a good turn-round. We have set up the world's first semi-automated calling pipeline so that things we know are genetic abnormalities spew out of it, and they say, "We've found that." For the next five years, maybe 10, we will be finding new constellations and changes and trying to understand those, and the patients need researchers to interpret them, because everyday clinicians will not be up to scratch.

Q178 **Graham Stringer:** What assessment of NHS skill levels are you undertaking at the present time? What proportion of NHS staff will need to receive genomic training?

Lord O'Shaughnessy: There is a genomics education programme that runs until next year, and from that point onwards Health Education England is running, effectively, a genomics masters course. I think it is about 1,000 modules per year. If you think about that scaling up over time, you are hitting quite a lot of clinicians. Obviously, that is the point at which they understand the role genomics can play in their clinical role. It is not a research role; it is not the diagnostic bit Sally was talking about.

Q179 **Graham Stringer:** Is the funding of the follow-up genomics education programme comparable? It was £20 million, wasn't it?

Lord O'Shaughnessy: It was £20 million for the start-up funding, over four years, and the HEE programme is about £1 million a year, so it is less, but obviously there was a huge amount of up-front training required to get from the position Professor Chinnery was describing.

Dame Sally Davies: And there is pump priming. A lot of coursework and modules are available online, and that needed to be paid for up front.

Q180 **Graham Stringer:** We have received evidence that multidisciplinary teams are working voluntarily on interpreting genomic results, essentially running on good will. From what you said previously, I am not sure whether those multidisciplinary teams of clinicians are the way forward or whether it is going to be the specialist researchers. I am not sure whether my question is redundant in the light of your previous answers, or whether I really understand what you have been saying.

Dame Sally Davies: I can speak only to blood disorders because I know more about them. Professor Chinnery could probably speak to something else.

Q181 **Graham Stringer:** Perhaps you could explain the future structures rather than me struggling through the questions and understanding your answers.

Dame Sally Davies: We will produce a result on which the researchers will have a view and, if it is a standard result, some advice on what it probably means; and, if it is not a standard one, what it could mean. In the blood area—the bleeding ones I was talking about, a pilot of 3,000—a multidisciplinary team meets. It has both national and international members. The researchers, the bioinformaticians, the clinicians and ideally the clinician of the patient discuss it together. The clinician can contribute information about the individual patient, but they also learn what other clinicians who are more expert in genomics say, and the bioinformaticians play into that. The clinical team has clearly moved beyond just the immediate care team to include researchers, bioinformaticians and everyone who contributes to the MDT. I gather they got through 60 patients in a day a couple of weeks ago.

Professor Chinnery: I think this may hinge on the word "voluntary," which implies it is part of the voluntary sector and hobbyism.

Graham Stringer: That was not what I meant.

Professor Chinnery: I am sure it was not, but it is important to clarify that these are all professionals, either in universities or in the NHS who are committed to establishing a way of working. Perhaps what the previous evidence was trying to explain is that that way of working has not been fully worked out yet, but is evolving rapidly, and is not fully embedded in what we would call the job plans of the individuals concerned, but I think that is just round the corner.

Q182 **Chair:** When do we get genomics embedded in basic specialty training across the piece? The understanding I had from the previous evidence is that it is just not happening yet.

Professor Chinnery: I cannot speak for all specialties; I can speak for neurology and some of the physician specialties. The answer is that it is creeping in.

Q183 **Chair:** Is that enough?

Professor Chinnery: It is important to make the point that it is not starting from zero. I was doing my specialty training in the mid-1990s and we learned about genetics using the technology at the time. This is an evolution. I accept that the evolution is moving at a faster pace, but, from my personal experience in neurology and some of the physician specialties, I believe it is moving at an adequate pace. I do not think the

challenge is training the next generation, who understand the language of genomics and have grown up with it; the challenge actually is—

Q184 **Chair:** The continuing professional development.

Professor Chinnery: We have a workforce in place.

Q185 **Chair:** Do you think sufficient attention is being given to that at the moment?

Professor Chinnery: The awareness is much greater than it was a few years ago.

Q186 **Chair:** Awareness is one thing, but does it need to go beyond that?

Professor Chinnery: It could go beyond that; it could go into the revalidation requirement that you are competent in genomic medicine.

Q187 **Chair:** Do you think it should, given the profound potential impact of this?

Professor Chinnery: It probably should; people need to be aware of it.

Q188 **Darren Jones:** I seem to have a hobby horse around digital infrastructure, so I am going to ask more questions on that now that we have the opportunity to do so. In a previous hearing, Professor Sue Hill, chief scientific officer for NHS England, gave evidence on the budget requirements to get all the kit to work for the system to be fully rolled out. She has written to the Committee. I want to go through the paragraph and see if I can break it down because, with the greatest respect to Professor Hill and civil servants, it is a bit civil-servicey. She writes: "Within the planned commissioned NHS Genomic Laboratory Hub network," which is what the Minister's board will deal with.

Dame Sally Davies: It is to keep an eye on them.

Lord O'Shaughnessy: Exactly.

Darren Jones: She continues: "provision has been made for key informatics and data posts to be established to enable the interfaces within the nationally provided solution to be established within the Hubs,", which means how you communicate between those seven factories. Is that right? Is that what she means by "within the hubs"?

Dame Sally Davies: I think it means—because I know what we are trying to do—collecting, sucking out of the NHS, the clinical data, because there are all those different clinical systems within a hub, inside a hub.

Q189 **Darren Jones:** What is a hub?

Dame Sally Davies: A hub is basically a centre of excellence that is usually a teaching hospital housing some laboratory services of the more simple kind that are not forwarded on to a factory, and has real clinical genetics and expert genomics clinical staff. It reaches out to a network, asking, through it, for advice and samples to be processed.

Q190 **Darren Jones:** She goes on: "and within all requesting organisations".

Dame Sally Davies: That is the network as well as the hub.

Q191 **Darren Jones:** The network means GPs and hospitals.

Dame Sally Davies: More generally, it means hospitals.

Q192 **Darren Jones:** The document goes on: "and for the ongoing data capture work." Does that mean storage?

Dame Sally Davies: No; it means sucking it out of the system.

Lord O'Shaughnessy: It is the provision of patient data. It could be from the genome once it has been sequenced or it could be from the health records; they can combine the two.

Q193 **Darren Jones:** I may not be clearer about it, but the discussion is positive. She goes on to say: "The costs of this will be locally determined." What does "locally determined" mean?

Dame Sally Davies: How much each hospital is prepared to pay, but we are looking at whether we need a national system, which I think we do, to interface with the myriad clinical systems, including laboratories, suck out the data, allow the hubs and their networks to request tests, ship the data alongside the sample to Genomics England, or other relevant places, and then send back the results.

Q194 **Chair:** Is that what we are going to have, or is it an issue under discussion?

Dame Sally Davies: We are doing a spec for just that.

Q195 **Darren Jones:** Do you agree, Minister?

Lord O'Shaughnessy: Yes. I am not going to pretend to be the technical expert on this. At the moment, we have in Genomics England a project that has been sequencing whole genomes at a rate unseen in the world. We are all concerned to turn that into real benefit for NHS patients. The question, therefore, is: what is the underlying infrastructure? It differs from place to place, which is what is meant by locally determined funding. In some areas, that will be well put together and in other areas it will not be, which reflects the fact that different places are starting from different things and we have not been doing this systematically across the NHS. At the moment, we are looking at what is the right system for pulling everything together—as you pointed out, I will be overseeing that process through the board—and, therefore, what is the capital investment required to make that happen.

It should be pointed out, and it is implicit in that paragraph, that there is a huge amount of infrastructure already existent through Genomics England. One is what they called bioinformatics—data and the way it is shared and brought together across different datasets—which is fantastic and we can build on it. There is a lot of existing backbone. There is no

need to create an entirely new IT or digital infrastructure that underpins something.

Q196 **Darren Jones:** You think the existing backbone is fit for purpose.

Lord O'Shaughnessy: The view of experts is that it is a good starting point.

Q197 **Darren Jones:** When your board reviews what the evidence calls "the digital maturity of the bidding entities," will you be able to share that with this Committee so that we can see what it looks like across the country?

Lord O'Shaughnessy: To clarify, the board is an oversight body; we are not doing the procurement. The procurements will be done by NHS England or whatever is the procuring body. We are trying to make sure that, for example, there is consistency across the country in the kind of service that is available and that it is being delivered on time, but the actual procurements would be done by the relevant services.

Q198 **Darren Jones:** The decision on sharing that will be NHS England's, not the board's.

Lord O'Shaughnessy: Or whoever is doing the procurement.

Dame Sally Davies: With NHS Digital, and with Genomics England as the science adviser.

Lord O'Shaughnessy: We do not procure. We are not procuring, as a Department.

Q199 **Darren Jones:** When that assessment is done, we will know, will we not, what the extra costs are to get it right?

Lord O'Shaughnessy: Yes.

Q200 **Darren Jones:** It has been suggested that it is between £6 million and £9 million above the current £250 million allocated in the 2015 Budget. Was there anything in the 2017 Budget that gave some extra money to this?

Lord O'Shaughnessy: Not specifically in the Budget. Hopefully, what you saw in the industrial strategy yesterday were plans for growing our genomics capacity. John Bell, in his paper on life sciences and industrial strategy, talked about building on our genomic leadership and sequencing many more genomes within Genomics England. There is much more impetus and investment going into this as a whole. The £6 million to £9 million depends on what is put in place. Clearly, we are all committed to making this happen, so we will fund it from one route or another. Whether it is Paperless 2020 or whatever programme, we will make sure that funding is in place to put it in.

Q201 **Darren Jones:** On the previous point, were you saying that there is new money under the industrial strategy that could help fund the infrastructure costs?

Lord O'Shaughnessy: There is a proposal to fund, I think, another 50,000 genomes on top of the 100,000.

Dame Sally Davies: I think the Government are going to respond to Sir John on Monday.

Lord O'Shaughnessy: Yes. There is a proposal to do that in John's report.

Q202 **Darren Jones:** Maybe we will wait for Monday to see what comes of that. On a broader point, in the Wachter review it was suggested that NHS digitisation targets should be pushed back to about 2023. Do you agree with that, or do you think we can get there before that?

Lord O'Shaughnessy: As you know, the Secretary of State is a great believer in the transformative power of technology and is very committed to it; indeed, he made even more commitments at Expo this year on things like electronic patient records, the ability to state preferences for your care and so on. We are very much pushing ahead with what we call PHC—Personalised Health and Care 2020—which is a range of programmes, many of which come out of the Wachter review. We are absolutely pushing ahead with that.

Q203 **Darren Jones:** To give a constituency example, the North Bristol Trust, in my constituency, has a hospital with a genome lab. If they needed extra money for infrastructure, would they bid directly into the existing health service budget, or would they be able to bid somewhere else for that funding?

Lord O'Shaughnessy: I do not know the specifics, so it would not be right for me to say. Obviously, what has been put in place is a national infrastructure for genomics testing, so they will have a role to play, potentially, within that, but I do not know the specifics.

Q204 **Darren Jones:** My last question is on cybersecurity. In our briefings, I was conscious that in 2014-15 a large percentage of the breaches reported to the Information Commissioner related to health data, so clearly that is something citizens will be concerned about. We heard about the hacking incident—I can't remember the name.

Lord O'Shaughnessy: WannaCry.

Q205 **Darren Jones:** That's the one. Thank you. One of the issues was that a lot of NHS systems were not being updated because of lack of investment locally in trusts. We have talked about the digital maturity of different trusts, and different trusts bidding for different amounts of funding. Do you think there is a risk similar to that, which means that you will not have a uniform approach to cybersecurity standards?

Lord O'Shaughnessy: There are three things. First, we have had the Caldicott and CQC reviews on data security. The Government have accepted all those recommendations—the 10 security standards. Those have now been rolled out throughout the entirety of the NHS.

Secondly, in terms of cybersecurity, the problem with WannaCry was outdated systems, particularly Windows XP, and unsupported systems. We have put in place a programme to support those systems. But if you look at Genomics England, which is the host for a lot of this, its data standards are of the highest. I could run down its ISOs, the placing of it in the UK cloud, its information governance and all the rest of it. It has very robust standards just on storage.

Equally, it has very robust standards on access. It is not the case that data are shipped out of it at different places. Researchers or others wanting to use the data on an anonymised or pseudonymised basis have to come in through a virtual airlock, as it were. They can look at data but they have to leave them behind. The idea is that it is a reference library, not a lending library, which George Freeman talked about before. The standards around Genomics England are very high. Of course, there will always be attacks. As we all know, we are under cyber-attack all the time, so it is about putting standards in place. Genomics England has very high standards in place.

Q206 **Darren Jones:** My next question is a very technical one, so feel free to write back. I am conscious that DCMS is, I think, looking now at the designation under the network and information security directive—the EU cybersecurity directive. Do you know whether the genomics database is going to be under that regulation in terms of reporting data breaches?

Lord O'Shaughnessy: I do not know. I will have to write to you on that.

Q207 **Stephen Metcalfe:** I want to talk a little about public awareness or understanding. Genomic medicine requires the gathering, analysis and sharing of huge amounts of data, but when we tried to do that previously with care.data, for whatever reason it did not go according to plan, and we ended up pulling back from that. What have we learned from the experiences with care.data, and what are we doing to inform the public and get them to buy into the benefits that come from genomic medicine?

Lord O'Shaughnessy: The shadow of that experience hangs over this, but in a way that is not unhealthy. As you said yourself, if you go to the root of why previous attempts have not succeeded, it is on two levels: one is about standards of security, and the other is about involvement of patients. We are in a much better place in terms of standards of security, and will continue to be so as we roll out the data standards. They are inspected by the CQC under its well-led framework; it will be doing unannounced inspections of trusts that it considers might be vulnerable. The whole security environment is much better.

We have a much deeper understanding of the need to communicate to patients, particularly those who have not experienced the benefits of datasharing. Those who have tend to be zealously in favour of it; those who have not—probably still the majority when it goes beyond their direct care—still need to be convinced, and convinced through a conversation, to understand that, if at the end there is anything that

worries them, they have the power to opt out, which was not the case three or four years ago.

Dame Sally Davies: Genomics England has set up the database extraordinarily carefully to protect patients, but it is a research-based database to give patients the best answers and responses. Therefore, there is individual patient consent. For genomics, we go for consent. That has built on Genomics England running a year-long public engagement programme. It is built on my own efforts at public engagement in this area and it is looking to widen the public dialogue even further, so there is quite a lot of work on that.

Professor Chinnery: The acid test boils down to whether or not individuals give their consent to be part of the existing programme. I think it was extremely astute to begin in the sphere of rare diseases. The challenge with these diseases is that they are rare, and patients and families want to find other individuals with exactly the same condition. They understand that is the key to understanding the cause and treatment of their condition, so they absolutely grasp the idea that sharing data is key for them, and for the wider populace to benefit. In my personal experience, in consenting not far short of 500 people for this programme, I came across three where there was sufficient suspicion for them not to want to go ahead with the programme. There is an enormous appetite from this group in society to take advantage of the opportunity of sharing their data.

Q208 **Stephen Metcalfe:** But at the moment it is a specialist one-to-one discussion, isn't it?

Professor Chinnery: It is.

Q209 **Stephen Metcalfe:** As this becomes rolled out on a national basis, somewhere between quarter two 2018 and fully by 2019, is there not a need to get much wider public understanding, so that there is not a body of thought with residual in-built suspicion about it? How do we do that?

Dame Sally Davies: There is a consultation, and it will help. There are videos. There is a new group set up by NHS England with Genomics England input about patient consent to try to mainstream it. That is why I talk about the social contract. If I may put it this way, I think you, here, have a big role in raising awareness and understanding, and helping the pull from patients. People were totally surprised when I said it is not in a patient's interests not to agree to put their data into the research database because they will get an out-of-date result, if one at all. That sort of concept is very difficult for a lot of people, but we have had a lot of support from patient charities and from many people. It is going to be a long haul.

Lord O'Shaughnessy: A huge amount of work is going on within that sector—the medical research charities; Wellcome Trust and others—to test people's worries and concerns, and how to meet them and reassure

them. Two things come out of that. First, the foundation stone of this stuff is that when you share your data it is secure. We cannot build the positive argument until we have demonstrated that security. The second is the point about consent to being engaged in the whole genome sequencing project, which is positive consent, or giving people the ability to opt out of their data being shared for purposes beyond their direct care.

Q210 **Stephen Metcalfe:** Will that consent framework be in place by October 2018?

Lord O'Shaughnessy: Yes, it will.

Q211 **Stephen Metcalfe:** Data is a buzzword around this place at the moment. We have the EU general data protection regulations coming forward. What impact will they have on this area, and does the Data Protection Bill have an impact as well?

Lord O'Shaughnessy: The Data Protection Bill gives effect to the GDPR, as it is known, in the UK. The UK has had a very important role in making the case for the right kind of framework that provides reassurance and consent more generally, in terms of use of data and patient consent in health, while making sure that there are opportunities to share data, particularly for research purposes. The DP Bill is effectively the vehicle for putting that in place.

Q212 **Stephen Metcalfe:** It does not have any additional restrictions on processing data.

Lord O'Shaughnessy: It introduces some restrictions, but it provides consistency across sectors, so you will not have something different in health compared with telephone usage, or whatever. From that point of view, consistency across the economy, if you like, is important. I know Sally has concerns about whether GDPR can account for the way in which genomic information can be used.

Dame Sally Davies: We are trying to make sure that, as we put it into Britain, it allows us to do what patients need. We think it will, but we are keeping a very close watch on it.

Q213 **Stephen Metcalfe:** My final question relates to the NHS constitution, which I believe Sally suggested needs to be changed. What changes would you make, and, therefore, Minister, are you considering making those changes?

Dame Sally Davies: That's a bit mean.

Stephen Metcalfe: Thank you.

Dame Sally Davies: The NHS constitution is a social contract. I have argued that for genomics we need to rethink our social contract. The elements of it are that, if I take a consent from someone at the moment and say, "I want to do the following," it is limited by our knowledge at the

moment, yet—I bet Professor Chinnery has some good examples—five years later science will have moved on, and in the interests of that patient and a group of patients, we want to manipulate, use, link and look at the data differently. Ten years on, there will be a very different landscape of science and data and what we want to do in the patient's and the community's interests.

I think we need to recognise that social contract, stop saying everything is black and white, and try to refind the original NHS set-up that had research as part of it, and people's altruism—solidarity might be a better word—that as individuals they get a benefit, but it will benefit their community and society. It is not that the NHS constitution is bad or wrong. It says, "You have the right to request that your confidential information is not used beyond your own care and treatment," of course, but that does not look at the research and future research aspects. It is not something where a Minister can say, "Change it." It needs public debate and discussion.

Q214 **Chair:** You need to go out and make the case for it, presumably.

Dame Sally Davies: Yes.

Lord O'Shaughnessy: If you think about the traditional model, if the data were shared, beyond use for direct care, for research purposes, it would go into a database and researchers would use it. They would go off into the world, perhaps partnering with a private company, investors or whoever, and create a medicine. Then it comes all the way round, and, if you were still alive—you might not be—you would use it as a consumer. The point is that genomics, in effect, breaks down the barrier between research and direct care, because your data can go into research, produce results that mean they know some treatment will work and some will not, and then flow straight back to you without having to go all the way round. That changes what we mean by direct care, because research becomes an integrated part of direct care.

The constitution says "not used beyond your own care and treatment." At this point, I do not think we need to change the constitution, but we need to explain to people the nature of the way medicine is going and that that is breaking down. Therefore, sharing your data for research purposes has a direct impact on you and your care, which is something different.

Q215 **Chair:** You do not anticipate that the constitution needs to be reviewed.

Lord O'Shaughnessy: I think it needs to be interpreted very carefully, and explained as such.

Q216 **Chair:** Do you agree with that, Sally?

Dame Sally Davies: That is one way of doing it, as long as we end up at the right place. There are always different ways. I made the case—Professor Chinnery and the Minister have made it—that the clinical team is no longer the doctor and nurse in front of you; it is the

bioinformaticians. We loosely use—I am sorry to say this—"sharing data," but it is a legitimate use in the interests of advancing knowledge that should benefit patients. We did focus groups and we discovered that, if you talk to the public about sharing data, they see a box of sweets on the table and everyone can dip in. That is not what it is about. We have a very secure system; it is about legitimate use in the interests of discovery and impacting patients.

Professor Chinnery: I can give a very nice example of a recently described genetic condition. Through whole genome sequencing, a rare condition called dystonia was diagnosed in a group of patients who were said to have cerebral palsy. In the past, those patients would have got the diagnosis and been sent off to the periphery and forgotten about. However, by whole genome sequencing, it was possible to identify that specific group, and they are benefiting from existing treatment in the NHS, deep brain stimulation, which is having transformational effects on the disability. The bottom line is that our definition of diagnosis is changing and, unless we have real-time consent, those individuals will not benefit from the advances.

Q217 **Vicky Ford:** I absolutely get your plea to us to help explain the benefits, and I would love to do a follow-up session on the way that could happen, especially if we had some data on people's concerns about data—for example, the Minister's answer about the problem of cybersecurity being solved and making people confident about that.

Lord O'Shaughnessy: I would not make the claim that it has been solved.

Q218 **Vicky Ford:** I have two questions that come up when you talk to individuals about their data concerns. The first is about insurance and the second is about the NHS making money out of it. On insurance, do you expect the concordat and moratorium to be extended? Will it be amended, and why did the review not take place?

Dame Sally Davies: The review was delayed because I was looking at it as part of my annual report. It has now gone back to a joint discussion with the Association of British Insurers. My view, having looked at it and taken soundings around the place, is that because we have the NHS, which is quite different from any other country, I support the flexible non-statutory regulatory structure and the moratorium. I think we should keep the long-standing agreement, but we need some inflation-proofing on the amounts and we should continue with regular reviews.

Q219 **Vicky Ford:** What about more types of predictive tests? I understand that at the moment it is only for Huntington's that a predictive test is done.

Dame Sally Davies: I am not aware that they have asked for other predictive tests, but I would have to check.

Q220 **Chair:** Can you come back to us on that?

Dame Sally Davies: We can come back on that.

Q221 **Vicky Ford:** My next question is a techie one about whether the moratorium will also ban insurers from using secondary findings of whole genome sequencing as part of routine NHS care. If you find something you were not intending to, will that come into it?

Dame Sally Davies: At the moment it does, and I expect it will continue to do so, but we have a very careful process. As people consent, they say whether they would want certain things fed back. Most of it is not fed back, only to the ones who want it.

Vicky Ford: The industrial strategy talks about the importance of genomics feeding into the entire UK industry. How will the NHS make its data available to industry, and, given that the Discovery Forum is not charging for data access and the Department of Health has said it will not sell data, how do we make sure that the NHS benefits from the commercial value of the data?

Lord O'Shaughnessy: To be absolutely clear, the data are not sold or shipped out. That is the fundamental principle. The point is that storing the data has a running cost. The intention is that researchers will pay for access to be able to use the data in their research and then take their findings, but not the data, out of Genomics England.

Q222 **Vicky Ford:** This is the reference library, not lending library point.

Lord O'Shaughnessy: Precisely. You bring your algorithm and apply it to the dataset. You then take your results out, but leave everything else behind. Clearly, there is a cost in operating that process and we would look to recoup it.

Q223 **Vicky Ford:** That will enable the NHS to cover its running costs without giving away the data.

Lord O'Shaughnessy: It will make a contribution, because clearly research is not the sole purpose of having the dataset; it is part of it.

Q224 **Vicky Ford:** Are there any other comments on that?

Dame Sally Davies: We have partnerships with industry, and it is on those understandings. While they are very excited about it, they will need some hand-holding, not about security because that is covered, but about what to do with the data and how to use it. We believe they will find new targets for treatments; we will find drugs that can be repurposed, and clearly they have to pay for that access. We also hope there will be a growth of small industries around annotation and different ways of helping patients. We are looking to try to generate income. That will then keep us ahead in the genomics race in this world and benefit patients as a result.

Q225 **Chair:** Is it just about recovering costs, or is it about securing commercial value for the NHS for the benefit of all its patients?

Dame Sally Davies: Clearly, we would like to do both. We need to start by covering the costs. If we can get the commercial value, remembering the restrictions to protect patients, we must, and that money can be used to keep us and our NHS ahead in the genome revolution.

Lord O'Shaughnessy: I agree with that. It is important to say that any income generated flows back into the NHS. Initially, we are talking about cost recovery for the researchers using it. In the wider world, we see some interesting partnerships emerging in spin-outs from university teaching hospitals and the private sector, with hospitals involved in the development of products, their trial and testing, having equity in vehicles and the potential to generate income. That is a very welcome approach, because we need all the different bits of the puzzle—the NHS as purchaser, the public sector as funder of basic science, investors scaling up businesses, the academic world and so on—working together to generate what will be increasingly personalised medicines, which are difficult. They will have smaller and smaller target groups, and that is not something any one bit of that can do alone.

Q226 **Vicky Ford:** To turn it on its head, we have often heard the life sciences community say that we invent drugs in this country and then the NHS does not buy them. Will this turn it around and mean that, because the NHS is part of the whole research offering the data, our patients should be able to get access first?

Lord O'Shaughnessy: It is part of a change in approach that I absolutely want to see, with the NHS seen as, and wanting to be seen as, more a partner of the life sciences industry, rather than being solely the purchaser of drugs, treatments, therapies or whatever it is.

Professor Chinnery: It is not all about new drugs; it is about using existing drugs better, and it is also about avoiding the toxic effects of the drugs already in the NHS. Patients will benefit directly from both of those immediately.

Vicky Ford: Fabulous.

Q227 **Chair:** Identifying when an existing drug is appropriate for a particular patient.

Professor Chinnery: Yes. Often, our basis for drug use is a large randomised control trial. Within that, we know the structure of the data and the patients. Genomics provides a tool to identify which sub-groups benefit, which do not and which may be harmed. That allows us to use existing therapies more effectively. That is personalised medicine.

Q228 **Darren Jones:** On pricing, it would be great to see how you structure the pricing when you get to that point. I would like you to be quite bold on that. For example, globally you may have profit-making commercial enterprises having access to what Dame Sally says is a unique feature—our national health service and the data pools we can create. I am hoping it will not be just a one-time access fee, and you might be able to look at

revenue sharing or licensing.

Dame Sally Davies: Genomics England leads on this. It has a commercial director who comes from the private sector. The Department of Health is the sole shareholder and I sit on the board. We review this regularly and try to help nurse it on to do exactly what you are saying.

Darren Jones: Excellent.

Q229 **Chair:** Minister, how are the Government addressing the ethical issues associated with genome editing following the abolition of the Human Genetics Commission in 2012?

Lord O'Shaughnessy: We have a number of bodies outside Government, for example the Nuffield Council on Bioethics, and we have the Human Fertilisation and Embryology Authority to provide that kind of advice. There is no shortage of good quality advice on ethics.

Q230 **Chair:** Do you think the existing framework is adequate for these purposes?

Lord O'Shaughnessy: I believe it is. I have not seen evidence to suggest that it is not. We are seeing, particularly through gene editing, some fast and very exciting progress in the ability to treat horrible diseases. At the moment, I do not think that is throwing up ethical issues that we cannot cope with. Of course, it may change over time.

Q231 **Chair:** Sally, are you happy that the ethical issues are properly covered?

Dame Sally Davies: We are talking about two things. One is somatic cells and gene editing, and we welcome that. It is at its beginning and it will happen. The other is about changing the embryo. Our legal framework would prohibit that. While others are beginning to discuss it, at this time the Government have no plans to review the 14-day rule.

Q232 **Chair:** That was the question I was going to ask. You say the Government have no plan. Are you satisfied with that? Do you think that is the right position? There is slight hesitation.

Dame Sally Davies: No. I think it is the right decision because, unfortunately, the Act covers a lot of other things. You cannot consider this in isolation; you would have to open up the whole Act, and that might lead to results I would not like to see, and we are not ready to do that. I think there is an ethical debate that will take another five to 10 years, but there are risks in opening that Act, because it is not about mitochondria and gene editing; it is about a lot of women's health.

Q233 **Chair:** In the overall scheme of things it is right to have this at this stage.

Dame Sally Davies: Yes.

Q234 **Chair:** Professor Chinnery, is that your view?

Professor Chinnery: Yes, I agree. Our thinking about gene editing is essentially about technological changes. I do not think it fundamentally alters the kinds of applications people have been using with less directive and efficacious approaches in the past. I do not think there has yet been a paradigm shift from the ethical perspective.

Chair: Thank you very much indeed. We appreciate your time in giving evidence.