**Centre for Personalised Medicine podcast**

**Season 3 Episode 5**

***Health economics***

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(Our podcast logo features a section of the artwork [‘A Lifetime of Measures’ by Aneesa, aged 12, from Oxford High School](https://cpm.ox.ac.uk/centre-for-personalised-medicine-art-competition-2022-23/), the stunning winning entry to our 2022-23 Youth Art Competition).

**SPEAKERS**

Rachel Horton, Sally Sansom, Padraig Dixon, Sarah Wordsworth, James Buchanan

**Rachel Horton**

Hi, I'm Rachel Horton, I’m a Junior Research Fellow at the Centre for Personalised Medicine, or CPM. In this series of the CPM podcast, we're looking at the themes we've identified in our new strategy.

Today's topic that we'll be talking about is health economics. This fits under our sustainability theme as it involves thinking about the economic sustainability of healthcare decisions. Joining me to discuss it, I've got Sally Sansom from the CPM team.

**Sally Sansom**

Hi, I'm Sally Sansom. I'm a Junior Research Fellow at the Centre for Personalised Medicine, and I'm a doctoral researcher within the Health Economics Research Centre at Oxford, exploring the health economics of genome sequencing for rare disease diagnosis.

**Rachel Horton**

And we're also delighted to be joined by…

**Padraig Dixon**

Hi. I'm Padraig Dixon. I'm a senior researcher in health economics in the Nuffield Department of Primary Care Health Sciences at Oxford. I'm also Research Director and Associate Director for Health Economics in the Central and South Genomic Medicine Service Alliance, and I'm a member of the steering group of the Centre for Personalised Medicine at Oxford.

**Sarah Wordsworth**

Hi, Rachel. I'm Sarah Wordsworth. I'm a professor of health economics at the Health Economics Research Centre at University of Oxford, which is based in the Nuffield Department of Population Health. And I'm also on the steering group for the CPM.

**James Buchanan**

Hi, Rachel. I'm James Buchanan, I'm a senior lecturer in health economics at Queen Mary University of London. At Queen Mary, I lead and work on the health economic aspects of precision, diagnosis and treatment and translational research across the Barts Biomedical Research Centre.

**Rachel Horton**

Thanks so much for joining us today. To start as a quite basic question, coming from someone who doesn't know very much about health economics. What is health economics and what does the work of a health economist involve?

**Padraig Dixon**

So I would probably start from the view that it's a field of study that uses the tools and principles from economics, and most of those tools are directed to understanding how healthcare resources are allocated and used, and how they could be used in different ways to achieve different outcomes, so that might be in relation to efficiency, effectiveness. We also think about a lot about the word value, which we might talk about later. And there's also issues around incentives and behaviour in the healthcare system, and that's not even touching on other issues like healthcare financing or access to care, or the impact of public policies on health outcomes.

**Sarah Wordsworth**

And as you said, ultimately we're looking at trying to help decision makers with difficult decisions about how to allocate scarce healthcare resources and which patients would most benefit from different healthcare interventions, whether that be diagnostics, treatments, or other forms of healthcare.

**Rachel Horton**

And just in terms of sort of where health economics and the evidence that is generated by the work of health economists, how does it fit in the kind of broader health system context?

**Padraig Dixon**

Well, I think if you think about, say, the NHS in England, there's a lot of strategic planning supported and done by health economists in the Department of Health and Social Care. So obviously, a really central role in places like NICE- the National Institute for Health and Care Excellence. So something health economists might be doing there is reviewing industry submissions that include economic analysis, economic models for, say, a drug or some type of intervention. They would be doing their own modelling. They'd be critiquing submissions that may come from industry, and they support the appraisal committees at NICE where they're interpreting the results and helping adjudicate on some of the ambiguities.

And NICE guidance is mandatory for drugs and treatments that go through the technology appraisal program. So that means NHS providers have to fund recommended interventions, and that depends really centrally and critically on health economics, and health economic evidence that's come through that process. So in that respect, it's very, very influential in determining certain types of interventions that are made or not made available to clinicians and to patients in the NHS.

**James Buchanan**

And NICE are obviously the body that deal with that in England and in Wales. But NICE are not unique. There are plenty of other NICEs around the world as well. What NICE do is sometimes called health technology assessment. And there are health technology assessment agencies in many countries around the world now, and not just high income countries, but also in some low and middle income countries.

**Sarah Wordsworth**

But also, to add, there's a lot of health economics analyses undertaken outside HTA processes- many health economists don't work with NICE at all, and they do lots of work alongside clinical trials. So the NICE-type work is probably quite a small proportion of the overall activities that are undertaken by a lot of health economists.

Not all countries have equivalent processes to NICE, and the US is one example where they don't have a health technology assessment process that's similar to NICE, but yet, there's still a lot of health economists working in the US who do really important work in evaluating new tests and technologies, particularly in the area of personalised medicine.

**Rachel Horton**

In terms of how you'd sort of approach a question from a health economics perspective, there must be so many factors to consider. And I'd imagine you could go kind of quite wide in terms of thinking, how does this affect the person? How does it affect their sort of, their ability to work, or their family, or, you know, people who might need to care for them? Was it… I’m just thinking of some random factors, but like, how wide do you go in a health economics assessment when you're thinking about funding an intervention, or whether it's helpful?

**James Buchanan**

I mean, if we start with NICE, and then we can maybe think beyond NICE, but NICE have quite a narrow focus. NICE’s focus is primarily on the health side of things. So the health outcomes associated with interventions. Normally, these are the health outcomes that accrue to the patient or the person who's affected. In some instances, they think a little bit more broadly about health outcomes in their family, but generally speaking, it sort of stops at health outcomes with NICE, but that's not to say that you can't and we do go broader than that at times.

**Sarah Wordsworth**

Examples would be in the areas of severe dementia, where there are many informal caregivers providing support to family members and friends, and much of that care falls outside the healthcare system. So in that case, you would want to capture the, you know, the time off work and other activities in an economic valuation. But it could be other interventions where it wouldn't be as important to go quite as broad. It depends on the evaluation you're looking at in question.

**Padraig Dixon**

I think when you move away from a patient-centred, health-focused type process for economic evaluation, you introduce a lot of wide, wider issues, some of which are quite ethically complex?

So countries like Germany and the Netherlands do take into account some of the factors that James and Sarah were talking about in terms of productivity. One rationale for doing that is, if you look at how healthcare is distributed over the life course, being born is a little bit expensive because babies are very greedy. Then it tends to be very flat over the school years and working age. And then when people get to retirement, age 60,70, costs become very, very high, a lot of which are driven by care at the end of life. But of course, you don't know that *ex ante*.

And one reason for maybe taking into account the productivity benefits or otherwise of particular drugs is that you're helping people who are economically active to be even more productive, and then to pay taxes or to pay insurance premiums that support everyone else. The other side of that equation is, if you are privileging people who work or have particularly well-paid jobs, and you want those people to be working and paying taxes, then, as a consequence, you're necessarily placing less emphasis on people who maybe can't work or won't work, or have particular health conditions that stop them from contributing.

The NHS tends not to do that, but maybe we'll touch on it later with some of the new interventions, where they are possibly curative and life changing, and some of the biggest impacts will be helping people work. But once you start moving away from a patient-centred, health-focused perspective in economic evaluation, you have to account for these wider issues.

And just as a final point in that if we are thinking about caring responsibilities, we also have to account for the fact that some people don't have any caring networks. So if we are accounting for the impact on, say, a spouse caring for their partner with dementia, we have to make sure we're not hurting the interests of people who don't have spouses, or don't have families, or who don't have, say, children bearing the consequences of a particular health condition. NICE and the NHS England perspective, I think is relatively simple compared to many approaches to economic evaluation, although it's inherently complex in itself.

**Sarah Wordsworth**

So at that point, we should probably mention what economic evaluation is. So it's a technique used often by health economists and other types of economists where you effectively look at two or more different interventions and look at their costs and effect. So it could be two different drugs for, say, in the area of diabetes, and it could be comparing the cost of both drugs against effectiveness, which could be life years, say, for instance, but it's always a *comparative* analysis, and it's pretty much bread and butter work for many health economists, and you know, have a cost effectiveness cost benefit analysis. These the types of economic evaluation that health economists and other economists work with.

**Rachel Horton**

It's so fascinating to think about all the factors that could be brought in, but the sort of ethical and, I guess as well, kind of practical, pragmatic challenges, kind of governing what you should select from all of that. And I'd imagine as well, there must be some situations where there's kind of considerable uncertainty around the kind of variables you're working with. How do you sort of manage that as health economists?

**James Buchanan**

Okay, so to build on what Sarah said about economic evaluation. So when we do an economic evaluation, we're comparing the cost and the outcomes of two or more interventions, and what we normally end up with is something like a cost per quality adjusted life year gained, or a cost per life year gained- some measure of how efficient an intervention is, but it's not always a single estimate. We can often, and we normally do, put boundaries around that to indicate how confident we are or not that that is how cost effective a particular intervention is.

**Padraig Dixon**

So in principle, all future consequences of an intervention should be accounted for, although, in practice, that's extremely difficult to do pragmatically. So if you save the life of a child from, say, a cancer, a consequence of saving the life of the child is then their risk of ultimately developing Alzheimer's in their 90s one day is now back in the discussion. And of course, we would discount those- place less weight on future health consequences. So that might not be material to the decision, but we, in principle, we do need to take account of that.

In practice, it's really, really difficult to do that, and as James said, perhaps the best we can do is try and be honest about the uncertainty and maybe quantify it as best we can.

**Sarah Wordsworth**

And just to add that uncertainty is something that we're used to working with in health economics. So often it can be uncertainty not just related to the evaluation results and what's happened, it's happened afterwards, but also the data that you're using? So for instance, if it's a new sequencing technology, the cost of the technology can be quite uncertain early on. And what we do routinely within an economic evaluation is do sensitivity analysis where we vary the different costs and effects of the intervention. So basically, looking at elements the evaluation that we're not quite sure about the data, and try and look at different estimates and see how that changes the overall results of the evaluation. So definitely, uncertainty is something that we do think about a lot.

**James Buchanan**

And it's not something that we fear. Just to again, build on what Sarah said, of course, there's uncertainty in the work that we do, and that might mean that there's a risk in implementing a new healthcare intervention, but there's also a risk of *not* acting, so we should always be aware of that as well. There's always a risk, and there's always some uncertainty.

**Rachel Horton**

That's a very interesting example, Padraig, about the child with cancer, who you could treat, and it was just making me think for some interventions, you know who it is who's been helped by it. So I guess I'm thinking about personalised medicine from a *really* personalised perspective, like these, N of one treatments, which might be very expensive, but you know who you've helped, versus something like giving aspirin to 100 people and perhaps that might kind of a different benefit… health economics, is part of it trying to sort of get that sort of, I guess, like emotional layer of knowing who's involved a bit out of the question. And so you can make decisions more in a sort of quantitatively, how many people is this going to benefit/help?

**Padraig Dixon**

Yeah, I think identifiability is really interesting and important word in this context, because often the people who bear the biggest cost of an intervention aren't the individual or their family. It's anonymous people that we can't identify and can't even know, who are bearing the opportunity costs. And taking emotion out is probably one of the key aspects of economic evaluation in the context that we're talking about because… If you think about the GMC duties of a doctor, it talks about the care of *your* patient is *your* first concern. The economic perspective is much more utilitarian. It's much more population level. And I think the big responsibility on health economics is to offer evidence and perspectives that account for people who can't be identified, but who exist and who are getting the boring aspirin, as opposed to, perhaps, you know, the very unfortunate child who may benefit from a very expensive new therapy.

**Sarah Wordsworth**

So, yes, so we do kind of take out the emotional side, but I would say that as health economists, the reason why we're here, as health economists working in academia is that we care about patients. So we're interested, obviously, in the numbers, the analysis and having, you know, looking at it independently, but we do that in a way that we hope is thoughtful, and will help the health service. So that's why we're here, as, you know, academic health economists, not working in the private sector, in the stock exchange, for instance. We really want to make a difference to patients, and also healthy individuals who can benefit from care in the future.

**Sally Sansom**

So I noticed, Padraig, that you mentioned the concept of opportunity costs, and I thought this might be a good point to define that for our listeners. So the opportunity cost is the value of the next best alternative treatment or intervention that we forego, when deciding to pay for or invest in a certain treatment or intervention. And this can be quite challenging to estimate. Maybe we could talk about kind of the methods that we use to do this and some of the uncertainty involved in that as well.

**Padraig Dixon**

One way to think about opportunity costs that I think is quite helpful sometimes is the price of anything, is the amount of life you give up to get it. So if you measure a particular health intervention in a particular individual, and then you compare that to the cost you're paying in terms of other people's health, which might be displaced to secure that benefit in a single person. That's a way of making opportunity costs tangible. In terms of how they're calculated, I think it's about accounting for the next best alternative, as Sally offered in her definition and making sure that the cost on others is at least weighed against the benefit in the particular individuals who are receiving the intervention under discussion.

**Rachel Horton**

That really makes you think actually, because Sally you very kindly helped me with a report I was writing recently, and I think I'd said something like whether it would use money from other areas that then couldn't be used for those other areas. And Sally was like, well, it *will* use money from other areas. And the question is, what's the more valuable use of it?

I guess it brings it back, as you say, Padraig, the duties of a doctor make the care of your patient your first concern, and then kind of almost it feels… uncomfortable to recognise that in using resources in one area, that's a choice that means resources aren't available in another area. And so important to kind of gain evidence such that those decisions are really kind of soundly based.

**Sarah Wordsworth**

I guess the flip side of that, Rachel, is that it's also uncomfortable to be using resources in an inefficient way. So if there's a new intervention that would be much more effective and cost effective and help a large number of people, to *not* try and invest in that new intervention is uncomfortable, but then obviously other people have to be sacrificed, as it were. So it's uncomfortable all round.

**Sally Sansom**

This all is underpinned by the principle of scarcity of resources. So health systems and, you know, many other government budgets are not unlimited, and they operate within a kind of fixed context. And so really, as health economists, we're working to decide, or to inform decisions about how best to use those limited health system funds.

**Rachel Horton**

So if we sort of bring the discussion a bit more towards *personalised* medicine, what are some of the key challenges that health economists face when they're kind of evaluating personalised medicine interventions?

**James Buchanan**

There are plenty- I'll kick off, but I'm sure Padraig and Sarah will have plenty to say on this as well. We can start with to think about outcomes. So we've already mentioned that NICE and health technology assessments more generally, tend to have a reasonably narrow focus on health outcomes, which is important and relevant for many healthcare interventions in precision medicine.

And if we think about genetic tests and genomic tests, health outcomes are possibly only one consequence, and maybe sometimes not a big consequence of having these tests. And there are other outcomes that may also be important that we can call non-health outcomes. Sometimes personal utility is another word that's used for them as well.

So we can think about broader impacts on wellbeing, not just on survival or quality of life, but on things like getting a genetic diagnosis means that you have access to perhaps a clinical trial that you could join. You have information you can use that is helpful to plan your life, can inform reproductive decision making, and so on and so forth. So one of the challenges that we have is that we work in a health technology assessment context that values health outcomes, but a lot of the outcomes that might be important to people when undergoing genetic tests and personalised medicine more generally, may not be health outcomes.

**Sally Sansom**

Yes, I agree with James's comments, and this is quite related to the area that I'm researching in my PhD, where I'm looking at, how should we measure the outcomes of using genome sequencing to seek diagnoses for people with a rare condition. And so related to that, there's a number of frameworks that exist looking at this concept of clinical utility, but also personal utility. And so these concepts encompass changes in health and clinical management of patients that may result from genome sequencing, but then moving more into the personal utility side of things, really considering a much broader range of outcomes, such as informing health habits, informing future planning, such as insurance coverage, other sorts of big life decisions, reproductive decisions, access to social support groups and things like that.

So there's a number of aspects to consider. And I think what really helps to demonstrate this is even once a patient receives a diagnosis of a rare disease, in many cases, there's not an approved treatment that that is available for them to use, but yet, people with rare conditions and their families still really value having this information. So I think there's a really interesting kind of conflict going on there, where in health economics, we tend to look at these very health related outcomes, but, but if people aren't able to access a treatment, or if there's no change in clinical management for them, even after receiving this information, how do we capture those broader aspects of value, and should they be considered in the decisions as to whether and how to make this technology available?

**Rachel Horton**

And I guess as well, I'd imagine you'd need people to measure outcomes in a fairly comparable way for across interventions, to let you compare them?

**James Buchanan**

Again, we can turn to NICE as the exemplar, but there's others that exist. NICE tend to focus, tend to measure outcomes using someone called the EQ5D, the five dimension version of the Euroqual instrument, and that measures impacts on quality of life, then combined with impacts on survival. Mortality. EQ5D is preferred because it's an instrument that you can apply across all healthcare contexts, and *is* applied across all healthcare contexts, and that means that you have comparability in everything that NICE does. Those instruments don't tend to exist in the same way to measure non-health outcomes. And there are many more options, but they're not all applied consistently. You don't have that sort of consistency in decision making, perhaps.

**Padraig Dixon**

James is speaking about the complexity of the outcomes that are relevant in these discussions. Also, the disease phenotypes are very complex, and that makes it challenging to support diagnosis, and therefore that means it's difficult to assess all the economic consequences.

And of course, there are other aspects that aren't necessarily specific to the economic challenges. You know, small patient populations, difficulties of generating high quality evidence, even if there is a potentially viable intervention. And often we simply don't know very much about the long-term outcomes of the condition itself, or possible interventions, all of which contributes, then to the cost of managing the condition, even if there's no treatment. And if the treatment does exist, it's usually very expensive.

**Sarah Wordsworth**

And I guess going back to the original question about challenges, I mean some of these challenges highlighted by James and Padraig are not unique to personalised medicine. I think it's just the *amount* of individual challenges that we face in evaluating this particular area as health economists, there are lots of on the effects side. There are lots on the on the cost side, and it's quite similar to other areas. Think about, for instance, mental health or obesity. They're quite complex areas where some of the same challenges are faced. But it's just they come together at the same time, which can be quite tricky.

**Sally Sansom**

I absolutely agree. And I think one area which is interesting when it comes to genomics and personalised medicine that perhaps *does* make it different to other areas, is the kind of familial nature of genetic information, and what uncovering findings related to that may mean for people other than the kind of the primary patient in question, particularly thinking about, you know, their parents and siblings and other family members who may benefit, or potentially experience harms from perhaps a finding from genetic testing or a similar sort of intervention.

**Rachel Horton**

Recently we had a day at the CPM where we were kind of talking about this idea of newborn genome screening, so sort of screening a lot of a new baby's genetic code to try and forecast like health issues that might affect them in their early years, so that ideally, you could preempt or do something to improve that for them. But the challenges of sort of evaluating that process when so many of these conditions are so rare, they probably won't actually come up in… in the kind of, even very large studies. And James, I remember you talked a bit about the work you were doing around that, would you mind telling us a bit more?

**James Buchanan**

Sure. So there is an evaluation team who have been asked to do a mixed methods piece of research looking at the Generation Study in the UK, which is a study that's sequencing the genomes of 100,000 newborns that's currently underway, and I'm leading on the health economics in that study. We're collecting a bunch of different data points to try to establish whether this is a cost-effective use of limited NHS resources.

So we're collecting information on the health outcomes, obviously, of the newborns, but also on the health outcomes of parents, the non-health outcomes that are occurring to parents and the rest of the families. We're looking at the cost of implementing newborn genome sequencing, out of pocket costs as well, basically, taking a very broad view on what the possible costs and consequences might be of implementing newborn genome sequencing.

This is not straightforward to do, because a typical economic evaluation will look at perhaps one intervention in one condition. The Generation Study, as an example in the UK, is looking at about 500 genes and about 220 different conditions, testing them all simultaneously, and modelling all of that out is incredibly complex.

**Padraig Dixon**

Can I ask James, what will the role of your cost effectiveness evidence be in influencing whether that scheme is rolled out to all newborn babies or stays in a research study?

**James Buchanan**

Sure. So this is a tricky one to answer. We've talked about NICE in England and Wales and how they use health economic evidence. In the context of screening, we should also mention the existence of the National Screening Committee. Now, the National Screening Committee have a remit that, as their name suggests, is to focus on managing and implementing new screening programs in the population. And one of the factors that they consider when making decisions is the health economics and the cost effectiveness of new screening programs.

Newborn genome sequencing is no exception- the NSC have already spent a lot of time evaluating the existing blood spot program and additions to their blood spot program, and we are working quite closely with them to understand what their requirements might be to make decisions on the implementation or not of newborn genome sequencing going forwards. Interestingly, the NSC have a slightly different view on value compared to NICE. NICE, as we mentioned, has quite a narrow view on value. With the NSC, I think there may be a little bit more scope to account for broader impacts within the decision-making process. So that is an interesting dynamic that we will see play out in the coming months and years.

**Padraig Dixon**

So one, one question that sometimes comes up in this space is whether traditional or conventional economic frameworks or perspectives are still relevant for evaluating personalised medicine, and that leads to the question whether we need new frameworks? Sarah and James have spoken on some of the areas where I think some change might be needed, such as how we characterise outcomes.

I think one, one area that's really interesting, that's got less attention, is the possibility of ‘one and done’ therapies in this space. So this might include gene editing therapies. There are a lot of companies looking at one off, say, base editing interventions, which might improve long term treatment adherence as well as clinical outcomes. So you would reduce dose frequency with lower treatment burden, as well as minimising symptom relapse for some of those chronic conditions.

And I think health economists possibly haven't thought enough about the methodological consequences of that, because we said earlier that accounting for all future consequences of an intervention is very, very difficult. In this case, if some of these new interventions are actually curative, then we have much more certainty than we would normally have, that we'd be very confident that, for example, for example, someone receiving Casgevy for beta cell thalassemia and the other indication is for sickle cell disease, they’d have many, many, many fewer, possibly zero, chronic exacerbations that require… chronic, occlusive crises, that require emergency care, that require other expensive treatment. And are we actually accounting for the fact that some of these interventions really might give us lower uncertainty about the future than all the conventional analyses we would do for other types of intervention which would require ongoing treatment burden, continued adherence.

Another aspect of this is for ‘one and done’ therapies is environmental footprint. So in the NHS, about 5% of the carbon footprint is due to patient travel. So if we could reduce patient burden, not having people come in getting treatments or liver tests or whatever, then we'd actually be solving that problem as well.

**Sarah Wordsworth**

And I guess one of the one of the big questions for healthcare funders with gene editing is the high costs of some of the technologies, and that's a big concern from payers perspective. But as Padraig’s pointed out, if these interventions are curative, you know, you could save a lot of costs in the future, so, but what you have is upfront high costs and then uncertain future costs. So there's definitely a lot of interest in health economists to think about these genome- so called ‘genomic therapeutics’.

There's a large study being led by Oxford University, funded by the Medical Research Council, which is going to spend the next 14 years thinking about how we about how we evaluate these new gene editing type technologies, how they can be produced, how they can be invented and produced at scale, and what the health economic consequences are, and whether or not the evaluations go through a NICE-type process. Because NICE has got a really interesting way to evaluate technologies, but some of the ideas on gene editing fall outside what NICE would normally look at. So for instance, the numbers are so small that the evidence is going to be very, very limited the first few years.

**Padraig Dixon**

Presumably something like ASOs- antisense oligonucleotide therapies- would fall into that where it might literally be n of 1, there'll be no RCTs, there'll be single arm, there'll be no evidence. But even so, we might be really quite confident that the therapy is effective and merits consideration, even in the absence of evidence that we would expect for more conventional interventions.

And it might be worth touching on some of the solutions to what Sarah mentions, so extremely high upfront cost, but potentially long term benefits. And that is another way in which perhaps the way economic evaluations are usually conducted might need to change. So one way you could manage that situation, so a very severe, very high upfront cost, is things like a mortgage payment, where you spread things out over time, but you can make the payments contingent on the medicine actually delivering specific clinical outcomes within a defined period. And there are many examples of that internationally.

You could have other sort of instalment, outcome-based hybrid models, and I think they're going to be increasing part of the debate in this space. So if you take something like Casgevy, which is a new drug for beta cell thalassemia and sickle cell disease, the upfront costs are very, very high, but it's potentially curative. If every person who potentially would be eligible for that treatment received it in one year, it would be an absolutely huge proportion of the overall NHS budget, and it's not really feasible to think it could all be delivered at once.

So there are two issues there. One is, how do you spread the payments out? And should you and can you link it to define clinical outcomes? I think that's feasible, but if you're not giving it to everyone up front, on what basis are you prioritising some patients or some types of patients compared to others? And I think there'll be plenty of work in the coming years working out some of the health economic issues in that space.

**Rachel Horton**

I suppose that that frustration of you need more money now to save money in the long term, and how you handle that in…

**Padraig Dixon**

Yeah, and I think that the important thing there is contingency. So the continued mortgage payments would depend on the drug doing what it said it would do. And there are some examples of this already in the NHS through, for example, the Innovative Medicines Fund and the Cancer Drugs Fund, where, in principle, a new therapy that's promising could be made available before all evidence that might be desired otherwise is actually available, but it can be given to a small number of patients. Outcomes would be monitored. And if things are going as expected, it can be rolled out and made more widely available.

So there are models of that, but I think if- you know, hopefully things like the rare disease therapies launch pad will create lots of antisense oligonucleotides for rare conditions. If that really comes on stream and starts making lots of therapies, then we need some thinking about how we actually make them available. And I think these kind of mortgage- contingent payments- models will become much more important in the NHS than they are today.

**Rachel Horton**

That's probably all we've got time for. But thank you so much for joining me for a really fascinating discussion. I've learned so much from it, and it's been really interesting to hear about the role economic considerations play in the development and application of personalised medicine. The CPM is all about exploring personalised medicine from a range of perspectives, and you can find more resources on this topic and many others by visiting our website, cpm.ox.ac.uk. Thank you very much for listening to this episode of the CPM podcast.