More trials, better data, faster access

Opportunities to innovate in translational research for rare conditions

A policy report

March 2026

LifeArc Translational Centres for Rare Disease Hub

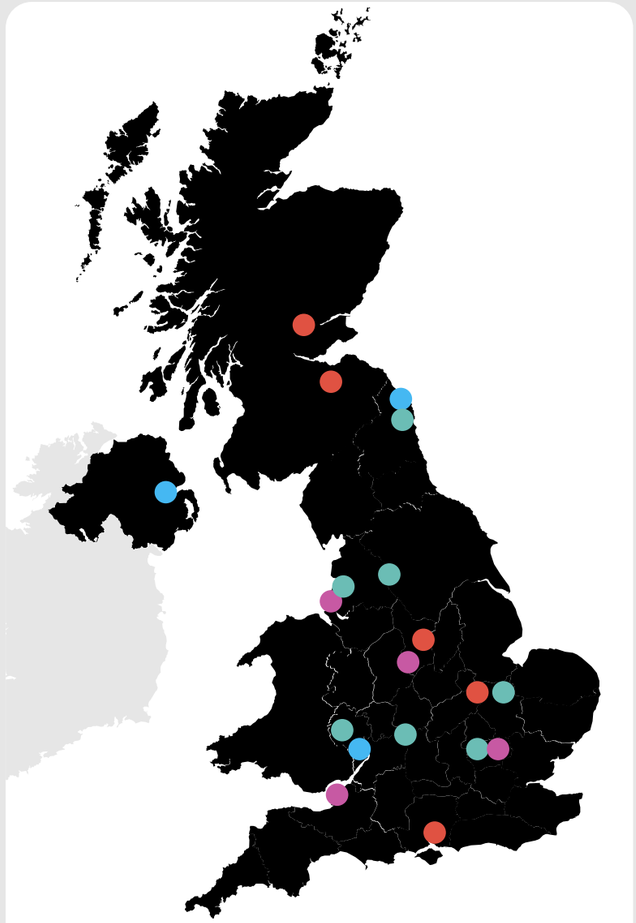
GENETIC ALLIANCE UK

The UK has made strategic investment in rare conditions. In 2024, four LifeArc Translational Centres for Rare Disease were launched. These Centres represent a £40 million investment that is dedicated to translational research for rare conditions over five years.

These centres aim to:

- fast-track new treatments and tests by providing researchers with the right infrastructure, connections, expertise and support
- break down barriers to clinical trials, improving access and efficiency, alongside knowledge-sharing and training, bringing vital expertise to those who need it
- engage with those living with rare conditions and their families to ensure research is aligned with their needs and priorities.

LifeArc has also set up a cross-centre 'Hub' in collaboration with Genetic Alliance UK and Beacon For Rare Diseases. This report outlines three areas that the LifeArc Hub Policy Working Group has identified as opportunities for innovation in translational research for rare conditions. More information on the membership of the Policy Working Group is at the end of this report.



LifeArc Centre
Rare Kidney Diseases
In partnership with Kidney Research UK

LifeArc Centre
Rare Respiratory Diseases

LifeArc Centre
Rare Mitochondrial Diseases

LifeArc Centre
Acceleration of Rare Disease Trials

LifeArc Translational Centres for Rare Disease Hub

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LifeArc supported this work under grant number 10803. The opinions and interpretations presented are those of the authors of this report (Genetic Alliance UK) and members of the Policy Working Group and not LifeArc's. More information is provided at the end of this document.

Foreword

In July 2025, the Accelerating R&D for Rare Disease report outlined that research into rare disease* faces several challenges, including fragmented expertise and limited funding, leading to missed opportunities to translate scientific advances into impact. As a result, the 3.5 million people whose lives are impacted by rare disease in the UK continue to experience diagnostic delays and inequitable access to tests and treatments.

Across the UK there is a wealth of extraordinary scientific potential, deep clinical insight and a highly engaged community. LifeArc is committed to bringing together these strengths, and the LifeArc Translational Centres for Rare Disease were created to accelerate the innovations that people living with rare disease urgently need.

This £40m targeted investment over five years aims to build a connected translational research ecosystem by fostering collaboration between researchers, clinicians and people living with rare disease.

With access to specialised facilities, translational advice, essential skills and research infrastructure, each of the four Centres will become a beacon of translational excellence, where early scientific discoveries can be developed and translated into tests, treatments and – ultimately – cures for this community.

This is a pivotal moment for health policy. We welcome the UK Government's one-year extension of the UK Rare Diseases Framework to the end of 2027 and, particularly, its commitment in the UK's Life Sciences Sector Plan and the NHS 10 Year Health Plan for England to making life science powered by data.

In response, LifeArc launched its first Health Data Strategy in February 2026, which will help to leverage national health data to deliver access to diagnosis, and treatments for people with rare disease. Underpinned by LifeArc's Patient Engagement Strategy, it includes collaborative working with UseMyData, sponsorship of National Patient Data Day, and KidsRare, a first of its kind health data initiative aiming to accelerate diagnosis and new treatments for children living with rare diseases in collaboration with Great Ormond Street Hospital.

The forthcoming UK wide health data research service and Our Future Health, for which LifeArc is a founding charity partner, support these efforts to improve access to secure and interoperable data for rare disease research. In this landscape, the Centres serve as safe 'policy sandboxes' where key priorities can be identified and innovative approaches and solutions deployed, benefitting not only people living with rare disease, but other disease areas beyond.

* In this context, we are using 'rare diseases' to represent both 'rare conditions' and 'rare diseases'.

Focusing on the 'first translational gap' experienced by those working in rare disease translational research, this report highlights three areas of opportunity: new approaches in clinical trial design; the use of AI-enabled approaches to streamline data analysis; and the ability to link different data for more precision in research findings.

These opportunities are within our reach to fast-track transformative treatments and diagnostics to people living with rare disease.

Through coordinated national efforts and continued partnership across the ecosystem, under a renewed UK Rare Diseases Framework, we can ensure that the progress made in research and innovation translates into transformative change for people whose lives are impacted by rare diseases.

LifeArc is committed to helping realise this future.

Dr Alessandra Gaeta,
Head of Rare Disease, LifeArc

Executive summary

LifeArc Translational Centres for Rare Disease Hub

95%

95% of rare conditions do not have an approved treatment, yet access to innovative diagnostics and therapies in the UK remains limited due to a combination of barriers.

3.5 M

To improve health outcomes for the **3.5 million people whose lives are impacted by a rare condition in the UK**, we need an ecosystem that supports innovation.

1st

This report focuses on the **'first translational gap'** that prevents a number of promising UK discoveries from reaching the people who need them most via the NHS.

Emerging UK national policy signals opportunity, but this progress **must account for the unique challenges facing those that work on rare conditions**.

To build on current momentum, we outline three areas of opportunity:

Novel clinical trial designs for smaller populations

More flexibility can help promising treatments reach people with rare conditions faster by making better use of limited numbers.

New types of trial design could also help make clinical trials more ethical and inclusive, particularly where traditional approaches do not work.

AI to address complexity and analytical bottlenecks

AI can help researchers make sense of small and complex datasets to speed up discovery, potentially reducing the cost for rare condition research.

Used responsibly, AI may be used to accelerate research and decision-making, but the patient voice and consent in how data are used must not be overlooked.

Multi-omics and multimodal data

Combining different types of data can help researchers uncover new insights by equipping them with a more complete picture of rare conditions.

Linking data across different boundaries would support more precise and meaningful research and help inform decision-making for rare conditions.

To truly improve outcomes for people living with rare conditions, we need an ecosystem that supports innovation in rare conditions throughout the whole development pathway.

To realise this potential, we need to ensure:

- The reformed UK Clinical Trial Regulations enable flexibility to innovate and launch more trials for new treatments and diagnostics for rare conditions.
- The voice of people living with rare conditions and the sovereignty of UK patient data are protected in the development of NHS commissioned technologies.
- The forthcoming UK health data research service is shaped both by and for rare conditions, and delivers equitable access across the devolved nations.

Now is the time to accelerate UK innovation for rare conditions.

We ask the UK government to:

Renew the UK Rare Diseases Framework to provide the national coordination, accountability and long-term commitment needed to support UK translational research for rare conditions.

A renewed Framework would also help us deliver the ambitions set out in the UK Life Sciences Sector Plan to ensure the UK remains a global leader in innovation.

What challenges must emerging UK policy address for rare conditions?

95%

of rare conditions do not have an approved treatment.

1 in 17

people live with a rare condition.

Access to innovative diagnostics and therapies in the UK remains limited due to a combination of issues. Examples like mitochondrial replacement or gene therapy for Huntington's disease show the huge potential of UK-based innovation. Despite a strong investment in research, a gap exists between innovation and their system-wide adoption.

In 2024, only 56% of new medicines approved in Europe were made available in the UK, and developers are increasingly withdrawing from the UK as a launch market, citing uncertainty in equitable access, valuation and infrastructure across the devolved nations to support innovation.

Rare conditions tend to sit off the policy and funding radar, leading to structural under-recognition. Although rare conditions collectively impact the lives of more than 3.5 million people in the UK, their low prevalence and high variability can limit their visibility, leading to a misunderstood severity and urgency of need. As a result, clinical trials for rare conditions often struggle to secure dedicated investment and compete for resources against more visible, non-rare conditions, like cancer.

The *Rare Disease Research Landscape Review* (2023) confirmed rare conditions are underfunded, accounting for only 7% of funding available via NIHR Programmes and the Medical Research Council (MRC). This limited pot diminishes in the devolved nations, such as Wales, which received only 1.6% of the total funds awarded from 2016-2021.

This can lead to both patients and researchers feeling overlooked and under-resourced to drive progress in rare conditions. The All-Party Parliamentary Group on Genetic, Rare and Undiagnosed Conditions met in July 2025 and February 2026 to hear the access challenges facing the community. Action 25 in the England Rare Diseases Action Plan outlines a programme to review how initiatives like the Early Access to Medicines Scheme, the Innovative Licensing and Access Pathway (ILAP) and Innovative Medicines Fund improve the timeliness of access to new therapies.

These are valuable enablers, and earlier-stage discovery for rare conditions would benefit from equally focused support.

75%

of rare conditions are estimated to start in childhood.

Recent changes to strengthen the broader commercial environment signal a more supportive direction of travel. Changes to reimbursement and financial incentives for new medicines and recent updates to NICE's cost-effectiveness threshold to appraise whether they will be made available on the NHS may improve predictability for some innovators, but their impact on access and adoption for rare conditions is likely to be more limited.

The MHRA's planned reforms to regulatory decision-making for market approval of new therapies and diagnostics, developed with a newly formed Rare Disease Consortium, represents a significant step forward. This includes proposals to develop a new 'third' type of licence for ultra-rare and 'n-of-1' conditions without clinical trials, the potential of which was recently demonstrated in with the stories of Mila's Miracle Foundation and Baby KJ in the US.

1/3

of people wait more than 5 years for a diagnosis.

Emerging UK national policy signals opportunity but must account for the unique challenges facing translational research for rare conditions. The NHS 10-Year Plan for England was a rallying point for health policy. Developed in tandem with the UK Government's Life Sciences Sector plan, both prioritise investment in diagnostics and data.

Likewise, Scotland and Northern Ireland are exploring the potential of leveraging cutting-edge technologies like genomics and AI for impact in the life sciences sector; Wales recently published its Strategic Research Plan for genomics. With the UK's AI Opportunities Plan and launch of a National Commission on the Regulation of AI in Healthcare, each nation is now considering how to set standards for safe access to these technologies via the NHS.

300m

lives are impacted by rare conditions globally.

To truly improve outcomes for people living with rare conditions, we need an ecosystem that supports innovation throughout the whole development pathway. In January, the Medicines and Healthcare products Regulatory Agency (MHRA) consulted the public on how to regulate the use of AI, and outlined the proposed changes to clinical trial regulations in April 2026. These developments are also informing how our international counterparts approach the structural barriers facing innovation for rare conditions.

For example, this includes the EU Biotech Act and joint publication of a set of principles on AI for development of new medicines by the US and EU. While UK-US negotiations on healthcare continue, the UK is also working with Australia, Canada, Singapore and Switzerland to reduce regulatory friction with the MHRA's new role as Chair of the Access Consortium.

Now is the time to accelerate UK innovation in translational research for rare conditions

Without targeted investment, the UK risks slowing progress just as new tools and partnerships could accelerate breakthroughs. The UK Government's £55bn five year commitment to R&D by 2030 signalled strong ambition to 'unlock scientific breakthroughs' across a number of sectors, including health, with a £38bn pot allocated to UK Research and Innovation.

However, recent announcements have left significant uncertainty of how much of this funding may be invested in research in rare conditions via the MRC; a limited pot, that once divided across infrastructure, trials and technology over the funding period, is already limited. As we know rare conditions are historically underfunded; this will continue to be the case if changes are not made.

The £600m investment in the UK's health data research service and plans to introduce a Single Patient Record on the NHS app by 2028, place the UK's life sciences sector on the cusp of a breakthrough for innovation. However, the UK Government's independent Sudlow Review (2024) highlighted that, to be effective, this national infrastructure must bring rare conditions with it.

Given rapid policy change in this space, the Policy Working Group of the LifeArc Translational Centres for Rare Disease Hub was tasked with identifying areas of opportunity to 'get policy right' for translational research into rare conditions.

Identifying opportunities to 'get policy right' for rare conditions

The LifeArc Translational Research Centres for Rare Disease have been exploring opportunities to address the policy challenges presented to research into rare conditions. In July 2025, LifeArc and Genetic Alliance UK published a report titled *'Accelerating R&D for rare disease in the UK: an opportunity to change millions of lives'*. The report made ten recommendations across three themes: diagnosis and data, market access, and support for innovators, including a recommendation to renew the UK Rare Diseases Framework.

Building on this, LifeArc and Genetic Alliance UK convened a policy roundtable to explore how the Translational Centres for Rare Disease could support the UK's progress. This included exploring the Centres' perspectives of where UK policy could make the greatest difference for people living with rare conditions, and what action is needed urgently within the next year.

Analysis of the discussions of ten multi-stakeholder groups drawn from the Centres identified ten themes as key barriers that researchers and people with lived experience have faced or observed across the UK landscape for rare conditions. These themes are summarised in brief below.

While nearly all themes identified in the policy round table are important components that underpin the overarching focus of this report (**innovation**), we expand most on: evidence requirements; equity in access; clinical trials flexibility; data and infrastructure; and patient voice.

Themes raised at the LifeArc Showcase for Rare Disease (November 2025)

Theme	Overview
Regulatory alignment	Misalignment between MHRA approvals and NICE decision-making leads to delays and uncertainty, and we need faster, clearer appraisal routes tailored to rare conditions.
Evidence requirements	Current standards do not serve people living with rare conditions; we need more acceptance of real-world evidence, patient reported outcomes and innovative approaches to clinical trials.
Equity in access	Access to diagnostics and treatments varies significantly across the four nations. Not everyone will be able to access the benefits of innovation due to where they live or their socioeconomic status.
Clinical trials flexibility	More flexible clinical trial designs, including decentralised models, are essential to widen participation. This includes ensuring children are not unjustifiably excluded from participating.
Data and infrastructure	Fragmented data collection significantly limits sharing of data for research and service planning. There is an unmet need for harmonised, interoperable data infrastructure across the UK.
Patient voice	People with lived experience are under-represented in policy, regulatory and commissioning decisions, despite the patient voice being a critical component for designing meaningful pathways.
Workforce capacity	Shortages in clinical specialists and 'research-ready' staff limit access to trials. As we expand access to diagnostics and treatments, the current workforce will be unable meet the demand expected.
Equity within rare	While policy tends to prioritise genetic and treatable conditions, it can leave other groups underserved. A more holistic definition of rare conditions is seen as necessary to address this.
Financial incentives	Existing mechanisms for pricing and reimbursement do not align with the reality of rare conditions. We need new incentives and risk-sharing models to ensure the UK remains attractive to investors.
International alignment	We can learn from how other countries approach these challenges in their regulatory frameworks. If we do not align, we may overlook an opportunity to strengthen the UK's global competitiveness.

To build on current momentum, this report outlines three areas where the UK can act now. The Policy Working Group of the LifeArc Translational Centres for Rare Disease Hub has identified three areas of opportunity that are urgent to explore how emerging technologies can address the unique challenges of rare conditions: novel trial designs, AI, and the role of technologies that involve linking different types of data for analysis, such as multi-omics and multimodal integration.

1. **Novel clinical trial designs for smaller populations**
2. **AI-driven data to address complexity and analytical bottlenecks**
3. **Multi-omics and multimodal integration to enhance precision**

This report focuses on opportunities for the 'first translational gap' that exists in the early stages of developing new therapies and diagnostics for rare conditions. A number of reforms are underway to address the 'second translational gap'. However, some of these developments are still emerging, as referenced at the end of each section for context.

The LifeArc Translational Centres for Rare Disease can serve as 'policy sandboxes' to accelerate innovation for rare conditions and beyond. In this context, the Translational Centres could pilot potential solutions for rare conditions across discovery, preclinical and early stage trials within the critical pathway before wider rollout across the UK. As challenges faced in translational research for rare conditions are also increasingly reflected in clinical settings for more common or complex conditions, findings from the Centres and work with NHS partners may also help uncover new approaches to bridge some of these translational gaps seen in research into other conditions.

The critical path within UK health research

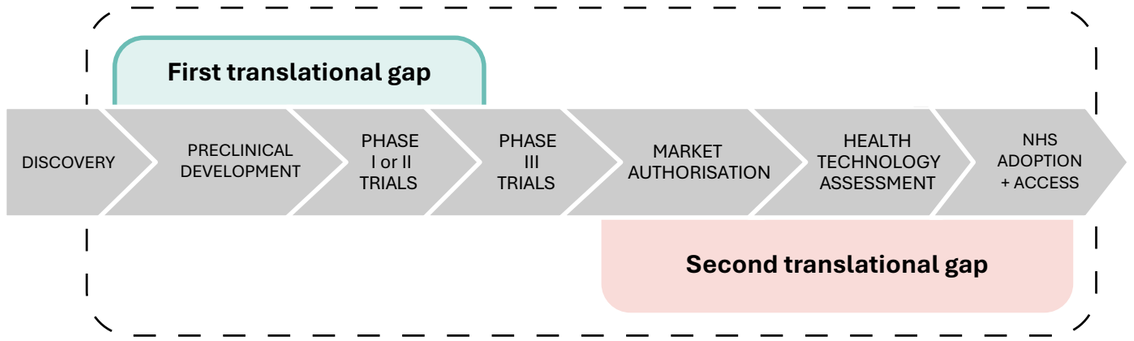


Figure simplified and redrawn from the Cooksey review into UK health research funding (2006).

1 Novel clinical trial designs for smaller populations

Many promising therapies for rare conditions never reach patients because few people are eligible and supported to join studies. Of this group, many are often excluded due to current regulations, such as children, and this is an equity issue. Additionally, traditional trial protocols, which move stepwise from preclinical research to Phase I (safety), Phase II (efficacy and dose-finding) and Phase III (large confirmatory studies), cannot change in response to early findings and so may be too ambitious for ultra-rare conditions. A more pragmatic approach to trial design could deliver safe and effective treatments for rare conditions faster.

Early experimental studies can reveal crucial information before larger trials begin, helping researchers decide quickly which therapies to progress. Introducing Phase 0 and microdosing studies allows people to receive a very small, sub-therapeutic dose to see how the body processes a potential treatment and whether it safely reaches its intended target.

For example, delivering small doses of a potential new therapy directly into the lung, rather than via the blood, can enable researchers to measure its effects locally and confirm whether even tiny doses reach the intended site of action. Applying these methods to rare conditions could help ensure only the most promising therapies move forward into later-stage studies safely.

Novel clinical trial designs can both accelerate early studies and make mid-stage testing more efficient. Master protocols for clinical trials (platform, basket and umbrella designs) may allow multiple therapies or patient groups to be tested simultaneously. By using statistical methods to strengthen the analysis, master protocols enable researchers to adjust certain parts of the protocol as data emerge (e.g. dose levels, who is allocated a treatment).

These designs allow researchers more flexibility to adapt early-phase studies as new information becomes available, and potentially end trials sooner once enough evidence is gathered. Where only a handful of people in the UK may be eligible to participate, this approach ensures smaller datasets yield meaningful insights to identify new therapies faster and potentially at lower cost.

Master protocols offer more ethical and inclusive options where the traditional requirement to randomise who receives a treatment is not feasible. Where many small, separate trials may compete to recruit a limited number of people, master protocols enable people with conditions with very limited treatment options to access multiple potential new therapies.

Examples of master protocol designs for clinical trials

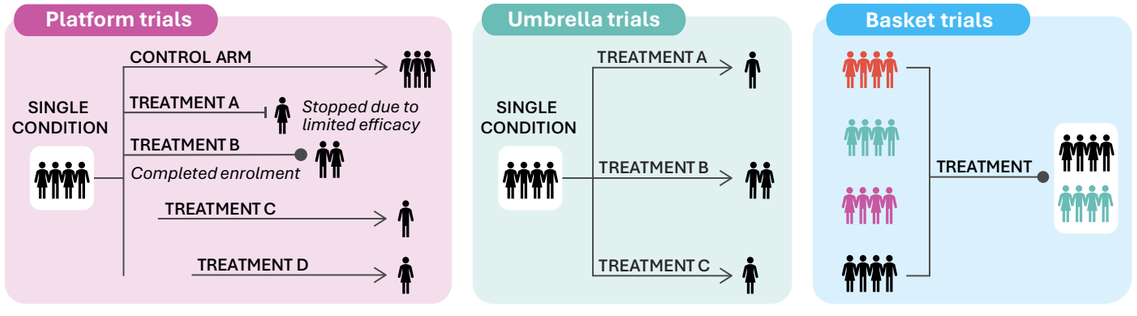
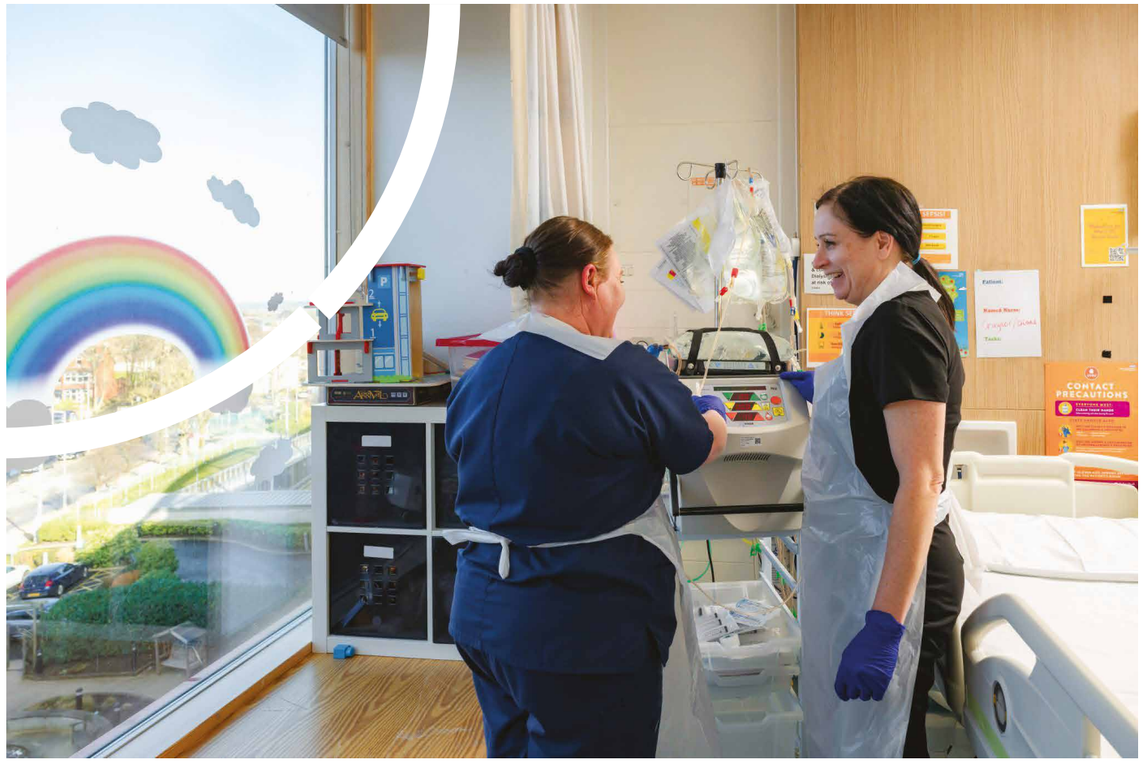


Figure redrawn with permission from the Global Coalition of Adaptive Research.



Platform and umbrella trials also often used a shared control group, while basket trials are designed for different contexts where a single control group is not suitable. This helps generate evidence for regulators without denying anyone access to a potentially transformative treatment.

With clearer standards and joined-up processes, these designs could become the UK best practice for early-stage research into rare conditions. Although current rules already permit Phase 0 studies, there is uncertainty about how best to adopt them, especially for small populations. Researchers also need clearer guidance on acceptable evidence standards, such as when natural history data of a rare condition can be used to replace traditional control arms.

The launch of the MHRA's 14-day notification scheme in 2023 set out to fast-track approval for 'low-risk' clinical trials, enabling a trial for haemophilia A to begin weeks earlier than expected. However, pathways for their approval remain complex, and a number of review processes, including ethical approval, are not yet equipped to support flexible trial designs. The LifeArc Translational Centre for Acceleration of Rare Disease Trials is preparing to pilot designs that are both scientifically robust and operationally feasible in a clinical research setting (e.g. the NHS).

More flexibility in trial designs may also address inequities in trials for more common or complex conditions. For example, many people with a rare condition cannot take part in standard clinical trials (e.g. for cancer or cardiovascular disease), even if their underlying condition is common. Because of the complexity of their rare condition, it means they are not part of a large enough cohort, and together, this is a significant group of people that are excluded from UK health research.

In recognition of this potential, the LifeArc-Kidney Research UK Centre for Rare Kidney Conditions is exploring how to make trial recruitment for people with rare kidney conditions more equitable.

The next step is to build confidence across the system to ensure the anticipated reforms truly enable innovation for rare conditions. The forthcoming reform of the UK Clinical Trials Regulations is a welcome move towards a more proportionate and transparent system, but rare conditions will require tailored guidance. The MHRA recently announced a 'package' of changes related to how clinical trials will be assessed, including which data can be used 'within the limitations of the current regulatory framework'. Due to take effect from April 2026, the role of these changes in accelerating rare condition research remains uncertain.

Novel trial designs work best when paired with more flexible approaches to data analysis, creating space for tools such as AI to identify meaningful signals that traditional methods may miss, as explored further in the next section.

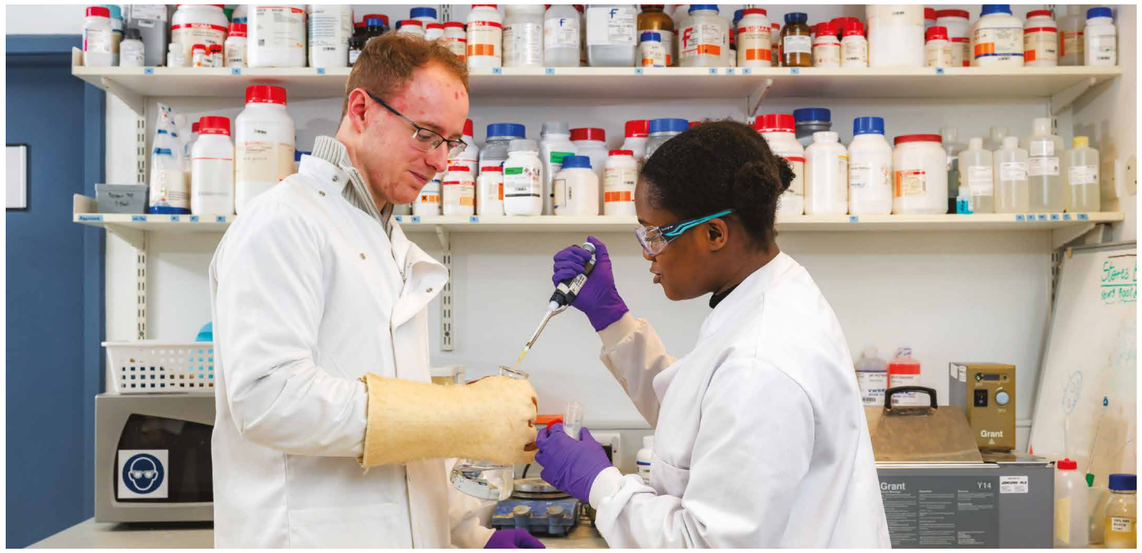
Second translational gap

Several later-stage initiatives are beginning to address the growing recognition that conventional models do not always fit rare conditions.

The MHRA Rare Disease Consortium is developing a framework to outline how therapies that are tailored to an individual may be accessed under a new type of 'investigational' license, drawing on learning from how the US FDA approaches this with its 'plausible mechanism pathway'.

In parallel, the UK's Rare Therapies Launchpad aims to deliver a targeted pilot of an end-to-end pathway for personalised medicines in children. Together, these initiatives signal a shift towards more flexible evidence requirements in regulatory pathways.

While an initiative to support the MHRA and NICE align on timelines and a second consultation on the NHS Commercial Framework for New Medicines instil more optimism, greater predictability across will also be essential to sustain investor confidence in UK innovation for rare conditions.



2 AI-driven data to address complexity and analytical bottlenecks

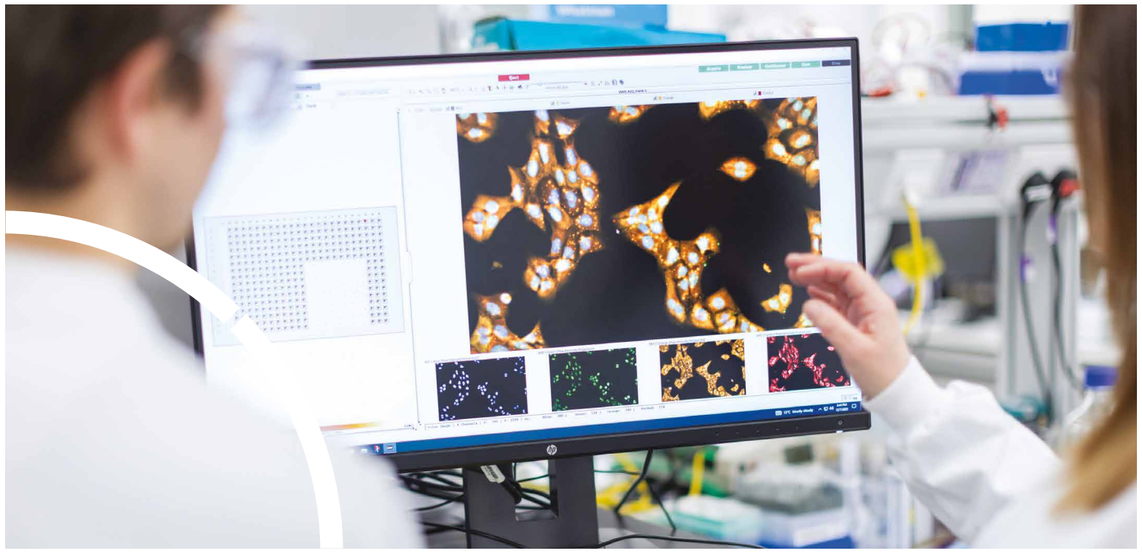
The UK's focus on AI and its rapid adoption via the NHS offers enormous potential to speed up innovation for rare conditions and address 'the diagnostic odyssey'. However, to support researchers to uncover new diagnostic tools and treatments for people living with rare conditions, AI must be underpinned by high quality data. Many rare conditions lack detailed data or consistency in how they are stored, making it difficult to identify eligible participants or measure how treatments respond over time. Researchers spend years piecing together small datasets that are too limited for traditional methods of analysis, meaning potentially life-changing insights can remain hidden in unconnected records or go unrecognised altogether.

Modelling that uses AI may be used to uncover new findings from limited and complex data available for rare conditions. AI may be used to identify patterns that conventional methods may miss or struggle to interpret. This could be used to help streamline the discovery and development of new medicines, help predict side effects or more quickly identify people living with a rare condition.

AI-driven analysis could also help discover existing therapies available on the NHS that may be repurposed to treat a rare condition. Some examples of progress are outlined in the table on the next page.

AI is expected to reduce the time and cost needed to move from discovery to early human studies for very small populations. Where withholding access to a potential therapy is ethically unacceptable, particularly for life-limiting rare conditions, single-arm trials that are supported by natural history or registry data may provide credible comparisons. Synthetic patient data (or 'digital twins') may offer all people enrolled in a trial the opportunity to receive early access to new therapies, without the need for a control group.

The use of AI could also potentially enable more clinical trials for rare conditions to take place. For example, across multiple disease areas, AI-driven recruitment strategies for clinical trials are estimated to improve enrolment by 65%, accelerate timelines by 30-50% and reduce costs by 40%.



Many common conditions already benefit from the use of AI tools, but a number of barriers mean they remain under-utilised for rare conditions. Partnerships between tech giants and publicly-funded researchers via UKRI's £210m Hartree Centre signposts enthusiasm that AI could be the 'silver bullet' needed. However, fragmented access to data and knowing how AI can be embedded between the NHS, patient organisations and academic centres, is holding up progress.

There are also concerns about equitable access to the computing power required and resources needed to upskill and support the workforce to use AI tools. For example, research proposals to pilot AI to analyse electronic health records have stalled due to unresolved questions around data governance and secondary uses of NHS data.

Despite these barriers, AI is already supporting researchers to unlock opportunities to drive innovation for rare conditions for a number of tasks across the discovery pipeline.

AI broadly describes the use of computer systems to perform cognitive tasks

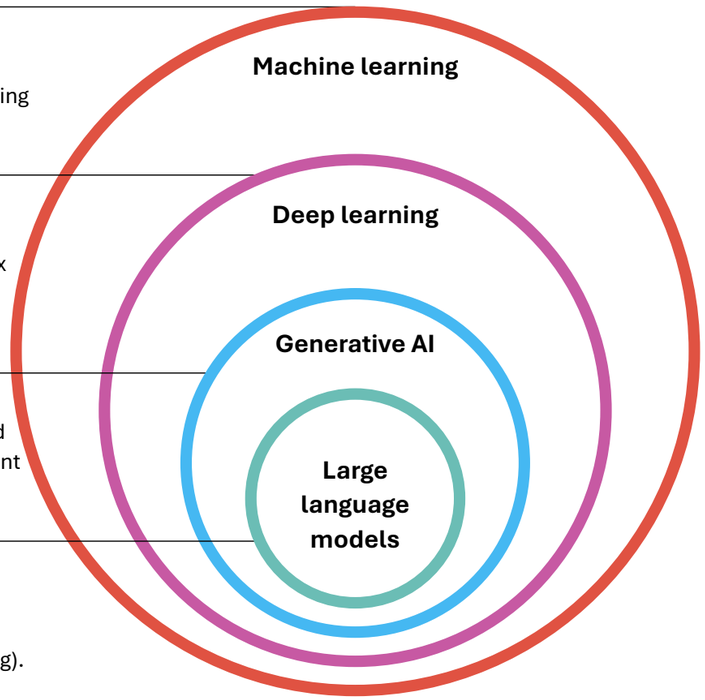
There are a number of overlapping subsets of AI that can support clinical decision-making:

Machine learning
Uses algorithms that learn from data to find patterns and make predictions(e.g. discovering new biomarkers, estimating risk).

Deep learning
Draws on layers of 'neural networks' to recognise patterns in larger or more complex datasets (e.g. detecting subtle changes in genetic orimaging data).

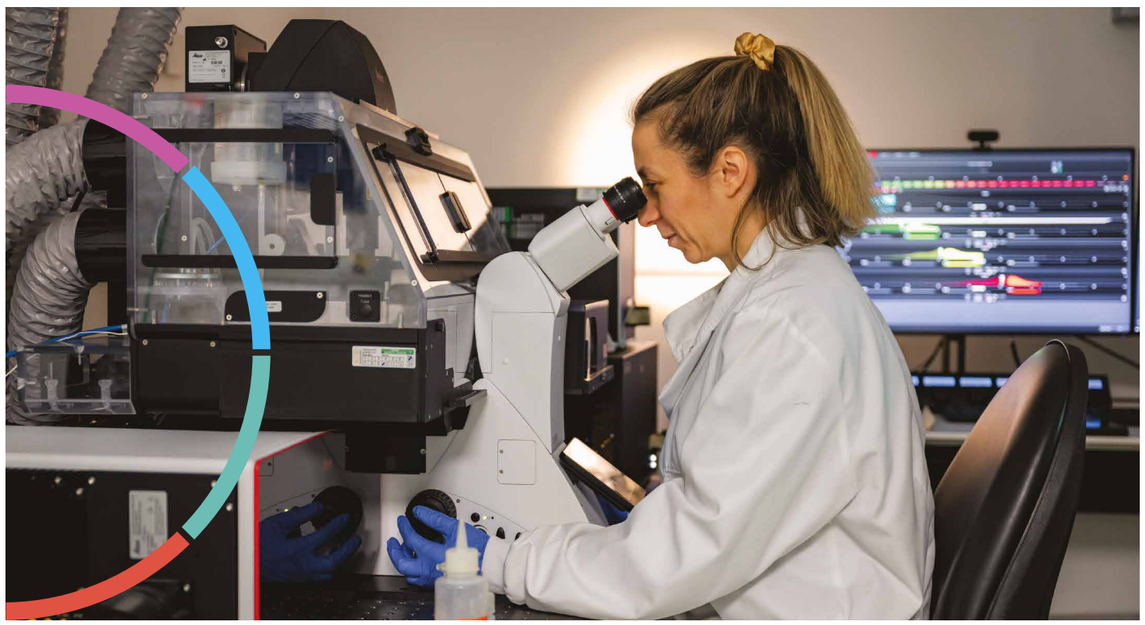
Generative AI
Applies models to produce new or expanded versions of existing data (e.g. synthetic patient records to simulate different scenarios).

Large language models
Processes natural language to generate natural, human-like text (e.g. summarising clinical notes to speed up evidence gathering).



How AI could support innovation in early-stage research for rare conditions

Discovery	Machine learning can interrogate thousands of compounds to prioritise those most likely to work on a particular pathway, making the search for licensed medicines or diagnostics that could be repurposed for rare conditions more efficient. Screening libraries for compounds that restore protein function could speed up repurposing of existing medicines for rare conditions, or generate new ones. For example, a new treatment for the rare respiratory condition idiopathic pulmonary fibrosis was hailed as the 'first drug' where both the target and compound were developed using generative AI.
Pre-clinical studies	Deep learning can be applied to model data gathered from cell lines or other 'wet lab' tools to predict how a potential therapy might behave in humans (in silico testing) and indicate safety and dose requirements early before scaling up. For example, 'kidney-on-chip' systems are being trialled to model kidney injury in Alport syndrome, with AI increasingly being used to analyse the complex data they generate. The US FDA announced it will use this approach to phase out the need for animal testing and reduce the cost of new therapies for rare conditions.
Phase I or II trials	Wearable tech could monitor how an individual respond to a treatment in real-time by producing 'digital biomarkers' that are analysed by AI to help adapt the study protocol. Machine learning could screen people who may be eligible to participate in a trial, while large language models (LLMs) may support researchers to onboard them or draft trial documentation. These tools may also enable more people to participate by removing barriers like the need to frequently travel to trial centres (decentralised trials). For example, the NHS recently launched the world's first remote clinical trial for motor neuron disease.



As AI is increasingly embedded into research workflows and clinical practice, clear standards are needed on consent, ownership and stewardship of trained models. AI is most powerful when used to identify patterns to uncover insights from limited, complex datasets, rather than to replace missing evidence. The rarity and clinical variability of some rare conditions also means that gaps in data used to train models may lead to potential bias in findings.

This means that some applications, such as systems built using generative AI to help automate tasks and scientific reasoning to make decisions (agentic AI) or the use of synthetic patient data, remain areas of active research and debate. Their use will require careful validation to foster more confidence that they may be able to offer meaningful decision-making support. Transparent governance will be needed over how these outputs handle long term patient consent and data, as well as how they shape research priorities and resource allocation in rare conditions research.

Patient and public involvement and engagement (PPIE) remains critical before AI can reliably support decision-making for rare conditions. Many already see AI-driven data analysis as an essential partner, not a replacement, for scientific and clinical expertise. However, it is unclear how the role of patient voice and the wealth of rare condition data held in the UK will be protected.

Even where data is understood to be held 'securely', the mechanisms by which models use data for training is not always visible or clearly understood by people without this expertise. Work by the National Commission on AI and MHRA to clarify standards on how to regulate the use of AI to support innovation is welcome, providing the unique challenges facing people living with rare conditions are not overlooked.

Second translational gap

AI is strengthening regulatory and payer evidence and the UK is building the policy scaffolding to accept it.

AI is increasingly being considered by decision-makers and a number of initiatives signal growing readiness to engage with AI-enabled evidence. In 2025, the MHRA launched seven Centres of Excellence for Regulatory Science and Innovation (CERSIs) to support this agenda.

The MHRA's AI Airlock scheme is also entering its second phase, testing seven new candidates to identify challenges with the use of AI as a medical device. Despite growing public awareness of the potential benefits of using AI tools in a clinical setting, such as through NHS pilots of ambient voice technologies, standards to validate and build trust in AI-derived outputs are still evolving. It's therefore unclear how its benefits for rare conditions, such as efforts to reduce the diagnostic odyssey, can quickly but safely be realised in the NHS.

The most impactful use of AI is when we combine different types of data to deliver clinically actionable and personalised findings, a topic that is explored more in the next section.

3 Multi-omics and multimodal integration to enhance precision

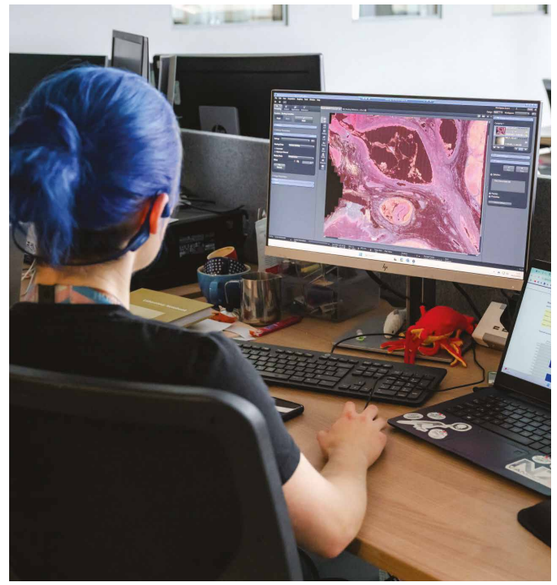
Rare conditions often present differently between individuals, making it difficult to pinpoint causes or predict how a person will respond to treatment. As smaller cohorts of people rely on access to a number of different paediatric and adult care services, progress has been held back by fragmented datasets and the limits of approaches that rely on a single method, such as genomics, alone. The opportunity to link together multiple data and technology streams across research and care pathways could enable earlier diagnosis and more precise therapies.

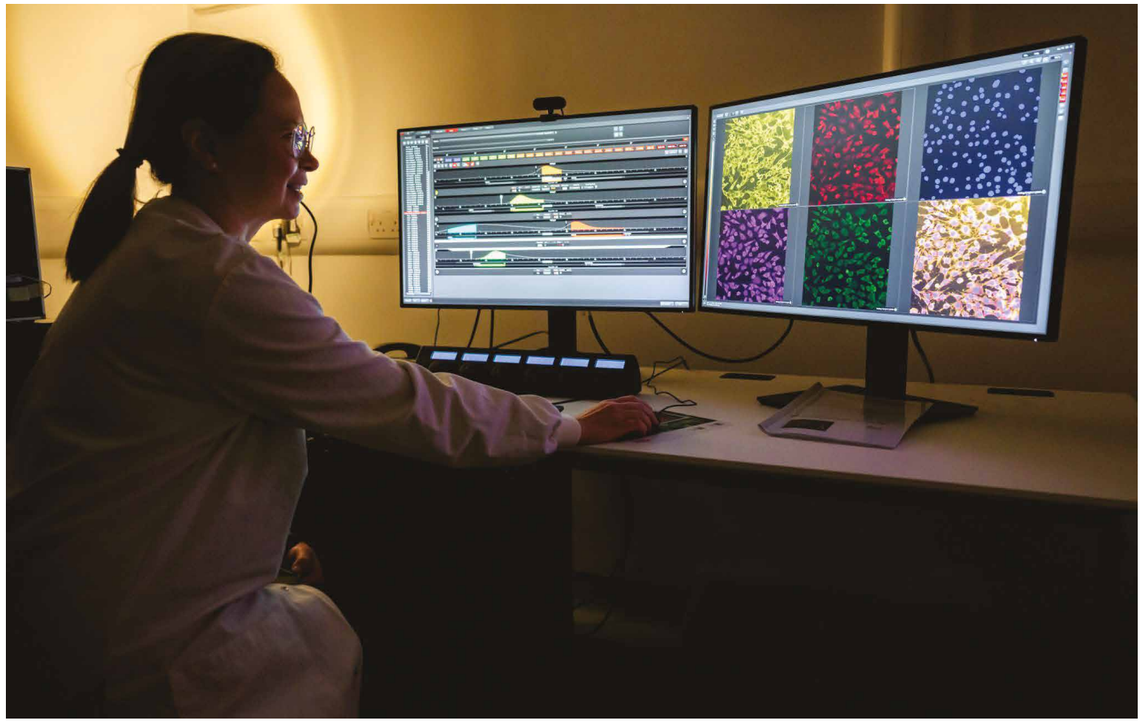
Multi-omics can improve discovery for rare conditions by unveiling signals that genomics alone may miss, helping us uncover new therapies and shorten the time to diagnosis. While genomic testing identifies the underlying DNA changes, it often cannot show how those changes affect overall progression of a condition. Multi-omics describes the combination of different types of molecular data (e.g. genomic, transcriptomic, proteomic) to build a more comprehensive understanding of how new therapies might respond.

For rare conditions where there is more uncertainty, combining genomic testing with other 'omics' is also helping people facing the 'diagnostic odyssey' obtain answers where standard existing tests cannot. For example, studies for mitochondrial diseases have shown this can increase the diagnostic rate by 10%. In one case, this approach confirmed a diagnosis for 36% of people living with a mitochondrial disease whose genetic tests were inconclusive. Using proteomics and metabolomics together has also helped identify early biomarkers of kidney injury to help speed up the time to intervention.

Multimodal data integration can also help us build a more comprehensive understanding to enhance the precision of findings that are clinically meaningful. Extending the principle of multi-omics, linking other types of data that are collected from people living with rare conditions in other healthcare settings would allow researchers to build a more complete picture. There are already strong examples of how linking molecular, digital imaging and structured or unstructured clinical data together for AI-driven analysis can help identify early signs of a condition.

For example, a model trained on over 17,000 facial images identified more than 200 genetic syndromes with 91% accuracy, while combining CT scans, chest X-rays and structured clinical notes has demonstrated over 90% diagnostic accuracy for rare respiratory conditions. AI-driven analysis is also being investigated to help researchers track how kidney cysts grow to better understand how these changes link to underlying genetic or biochemical signals. Using AI to supplement the analysis of clinical trial data with real-world evidence could also help discover existing therapies available on the NHS that may be repurposed to treat a rare condition.





Despite this potential, several barriers still slow clinical use and wider adoption of multi-omics and multimodal tools for rare conditions. Their success depends on more flexibility to incorporate new sources of data in clinical trials as the understanding of a condition evolves. For example, a number of UK patient organisations capture long-term, clinically rich data that can help us interpret complexity for small and diverse populations, such as patient reported outcome measures (PROMs). Building these data into the analysis could help researchers define more useful endpoints for clinical trials that are meaningful to people living with rare conditions.

There is also an abundance of data collected outside the NHS that may offer further insights. The NHS Observatory on Race & Health Observatory, the Genomics in Scotland strategy (2023) and progress report on Northern Ireland's Rare Disease Action Plan (2025) indicate that disparities persist. However, achieving equitable representation in population datasets is significantly challenging. This is amplified for rare conditions, where approaches taken to collecting data on common conditions do not necessarily translate effectively to rare.

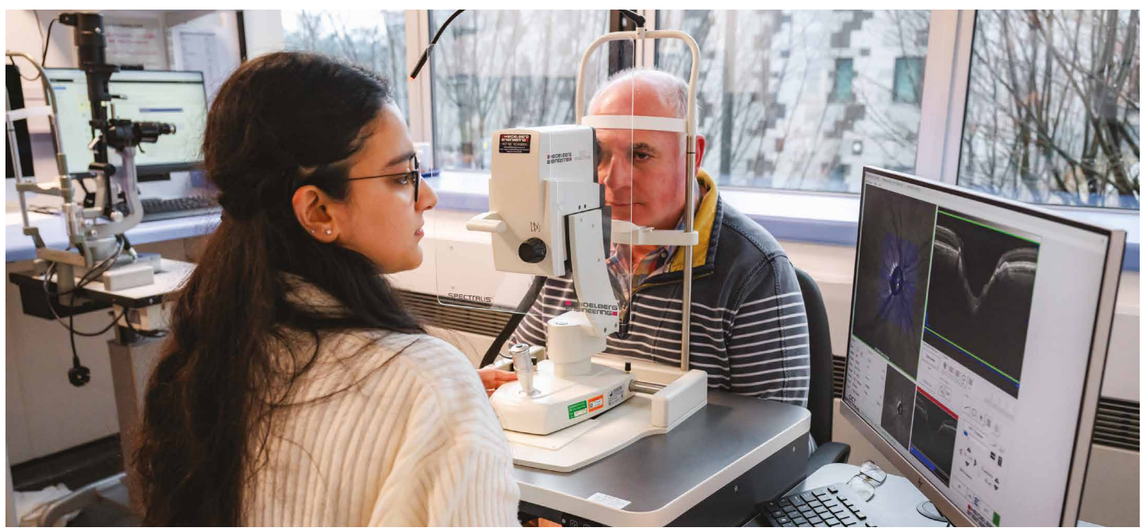
To accelerate innovation in rare condition research, the way in which we collect and share data across different boundaries must be informed and shaped by rare conditions. The opportunities offered by a Single NHS Patient Record that is integrated with a Unified Genomic Record and linked to NHS apps could make it easier for individuals with a rare condition to consent how their data is used. This would grant more flexibility in how research studies and clinical trials are run.

However, regulatory and governance pathways need to work together to enable this in practice, especially for rare conditions. Their success also depends on the ability to draw on AI tools that can process larger and more complex datasets to guide early decision-making. Yet a number of stakeholders have raised that not all rare condition research centres are equipped for this, with a lack of sustained funding for the infrastructure, and gaps in digital and analytical skills needed to operationalise and interpret these data.

We must also ensure that every part of the UK is equipped to both contribute to and benefit from this next phase of rare condition research. The UK's health data research service, coupled with progress in other national resources like the landmark population-level studies being delivered by Genomics England and Our Future Health, signal great ambition. The UK BioBank recently announced it will be able to store primary care (general practitioner) data. Each of the devolved nations have also outlined how they plan to expand their digital infrastructure to support translational research.

Whether all these initiatives achieve the aim of opening a 'gateway' to translational research for rare conditions will depend on effective linking of these disparate sources of data from across UK. It also relies on data being interoperable and following standards that are based on the principles of Findability, Accessibility, Interoperability and Reusability (FAIR).

There is a need for continued proactive coordination across the four nations to ensure equitable access to the tools, standards and capabilities required to contribute to a UK-wide health data research service and help realise its potential for rare conditions.



Second translational gap

Decision-makers are also exploring how complex, real-world data could better inform later-stage decision-making for rare conditions.

The NICE Real-World Evidence (RWE) Framework and its work through the NICE HTA Innovation Lab signal growing openness to incorporating PROMs alongside traditional clinical trial evidence. In parallel, the MHRA's guidance on the use of RWE to support regulatory decisions encourages earlier dialogue on how registries and long term follow-up might contribute to evidence packages.

The NHS Rare and Inherited Disease Genomic Network of Excellence is currently exploring how multi-omics and synthetic (*in silico*) data may be used to improve diagnosis for mitochondrial diseases. The MHRA also proposed to make better use of data 'from overseas studies that meet UK standards' and explore how synthetic data and computer simulations can be used in trials to predict how new therapies may behave in humans before trials begin.

Case studies from the LifeArc Translational Centres for Rare Disease

Rare Mitochondrial Diseases

There is no cure for mitochondrial disease (MD) and many people affected do not yet have an NHS diagnosis due to genetic ‘variants of uncertain significance’. Some MDs also present very differently from person to person, making estimating how a new treatment will respond very challenging, which often leads to them being excluded from participating in clinical trials.

The LifeArc Centre for Mitochondrial Diseases is the first national MD treatment platform. Jointly funded with Muscular Dystrophy UK, the Centre is delivered in partnership with the Lily Foundation and the LHON Society.

For example, the Lily Foundation is working with teams in over eight UK sites on the Precision Medicine Diagnostic Study, which is using AI to help diagnose people suspected to have an MD but remain undiagnosed.

Using the latest DNA sequencing techniques and advanced ‘omics’, such as RNA and protein analysis, the study aims to combine clinical data, genetic testing and advanced sequencing to identify MDs faster and more accurately.

mitocamb.medschl.cam.ac.uk/lifearc-centre-for-rare-mitochondrial-diseases

Rare Respiratory Diseases

People living with rare respiratory conditions often face a long diagnostic odyssey as symptoms may be overlooked and require highly specialised tests. Many of these conditions lead to progressive lung damage and most remain incurable.

To address this, the LifeArc Centre for Rare Respiratory Diseases is seeking to link discovery directly to experimental medicine in early clinical trials. Central to this vision is a UK-wide biobank to link biological samples with clinical and imaging data under a shared national protocol.

Aligned with the US FDA’s move to reduce reliance on animal testing, the Centre is exploring microdosing and Phase 0 studies to test the safety and efficacy of potential new therapies before larger trials begin. A key enabler of this is the Healthcare Technology Accelerator Facility in Edinburgh, which recently achieved MHRA accreditation for the manufacture, formulation and release of novel therapies for microdosing.

The Centre is also working with the LifeArc Centre for Acceleration of Rare Disease Trials, to explore ‘rapid iterative trial’ designs that help prioritise the most promising therapies for onward development so that they reach patients as soon as possible.

rarerespiratory.org

Acceleration of Rare Disease Trials

Researchers face major hurdles progressing clinical research for rare conditions, including delays setting up trials due to current infrastructure, and difficulties with recruitment.

The LifeArc Centre for Acceleration of Rare Disease Trials is working with the other LifeArc Centres and groups, such as the NIHR's UK Clinical Research Facility Network and Rare Disease Research UK, to understand how we can help make clinical trials for rare conditions both more efficient and inclusive.

To address inequitable access to clinical trials, the Centre is building a Rare Disease Recruitment Portal to securely leverage existing registry data and real-world NHS data from across England, Scotland, Wales and Northern Ireland to help identify cohorts of people that are 'trial-ready'. As a condition agnostic platform, the Centre also offers a 'one-stop shop' for trial design to support researchers with protocol development, funding applications and trial management.

The Centre is also investigating novel trial designs (e.g. platform and adaptive designs), how collection of patient reported outcome measures (PROMs), natural history data, data analytics and health economics could be leveraged to better support regulators realise the potential of new therapies for rare conditions via the NHS.

rarediseasetrials.org.uk

Rare Kidney Diseases

In partnership with Kidney Research UK

Progress has been slow for people living with rare kidney conditions. Many children and young people remain on dialysis for years, and the absence of a paediatric clinical trials framework means they are often excluded from clinical trials. As they transition to adulthood, this places additional pressure on renal services: more than one in four dialysis patients have a rare kidney condition.

The LifeArc-Kidney Research UK Centre hopes to address this by linking the UK's 13 children's kidney care centres with national research resources, including the kidney tissue biobank (NURTuRE) and the rare kidney disease registry (RaDaR). So far, analysis has identified ~30,000 people across the UK with rare kidney conditions and shown they are 28 times more likely to progress to kidney failure than those with a common kidney condition. This group is more likely to reside in areas of lower socioeconomic status, highlighting the scale of unmet need and the importance of equitable access to research.

Drawing on this infrastructure, the Centre aims to accelerate the translational pathway to clinical trials that are designed with the ambition of cutting rates of childhood kidney failure by up to a third. The use of AI is also being explored to help link and analyse complex data to identify those most likely to benefit from new treatments to design trials that are more efficient and inclusive.

kidneyresearchuk.org/research/lifearc-centre

How can the UK leverage these opportunities to innovate?

Emerging technologies offer enormous potential for rare conditions but need the right environment for their development. The UK's investment in genomics and AI provides a strong base, but without clear governance, sustained funding and access to secure, high-quality linked data, the potential of these technologies to transform research for rare conditions will be only partially realised.

Below are three considerations for how we can position the UK to leverage its potential for innovation and benefit from these technologies for rare conditions. These build on the ten recommendations outlined in the LifeArc and Genetic Alliance UK report Accelerating R&D for rare disease in the UK.

This includes a recommendation that all four nations commit to refreshing the UK Rare Diseases Framework when it expires, and incorporate the ambitions around data, market access and support for innovators set out in the report.

> "LifeArc doesn't want anyone to miss out on innovation because of complexity, cost, or commercial risk. And we firmly believe that we go further, and faster, when we work together."
>
> **Sam Barrell, CEO, LifeArc**

1. **UK Government ensure that rare conditions remain prioritised by developers and commissioners of these new technologies at every step of the pathway**. Many people working in this field are concerned that deploying these technologies without addressing the specific challenges of rare conditions, including areas of existing regulatory ambiguity (e.g. novel endpoints and digital biomarkers), could force teams to continue partnering or moving key activities abroad, undermining the UK's competitiveness in innovation. A renewed Framework would also provide the incentive to ensure that innovation for rare conditions is positioned to contribute to the delivery of the UK's Life Science Sector Plan.

2. **Representation of people living with rare conditions in the development and deployment of these new technologies in the UK is not overlooked.** We need strong governance for the deployment of AI so that it is trusted to be an accelerant, not a substitute, for clinical judgement. Clear communication of the benefits and limitations of AI is also essential to maintain confidence as adoption accelerates. These technologies must also protect patient data and not undermine the ability to withdraw consent, with PPIE viewed as essential for innovation. A renewed Framework would empower people with lived experience and ensure consistent standards for transparency, accountability and engagement are applied in practice.

3. **The UK's health data research service is shaped by and for rare conditions to drive equitable access to new technologies and trials across the devolved nations**. Implementation of new AI tools in the NHS has already been shown to be more complex than initially thought; these challenges will be amplified for rare conditions. We need an end-to-end system that is equipped for sharing compatible data from rare condition-specific registries. A renewed Framework would help harmonise their roll out across to ensure findings can flow seamlessly into trials and then into the NHS across the UK.

In support of the *Accelerating R&D for rare disease in the UK* report's tenth recommendation:

Renewing the UK Rare Diseases Framework would provide the national coordination, accountability and long-term commitment needed to support translational research for rare conditions.

A renewed Framework will also help us deliver the ambitions set out in the Life Sciences Sector Plan to ensure the UK remains a global leader in innovation.

Further reading

- LifeArc and Genetic Alliance UK. 2025. Accelerating R&D for rare disease in the UK: An opportunity to change millions of lives. lifearc.org/rd-report
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The LifeArc Translational Centres are also engaged in broader initiatives to strengthen the UK rare conditions research ecosystem, including workstreams led by Rare Disease Research UK, a platform funded by the MRC and NIHR (2023–2028).

By contributing actively to these, the LifeArc Translational Centres Rare Disease Hub is ensuring a comprehensive and system-wide approach to tackling unmet need across the research ecosystem.

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LifeArc is a not-for-profit medical research organisation with one clear purpose – transforming the lives of people living with rare diseases and drug-resistant infections. We aim to deliver this by conducting and funding pioneering research, and working with partners to accelerate the translation of scientific breakthroughs into new tests and treatments. Our vision is a world where people living with rare diseases and drug-resistant infections can access effective, life-changing treatments faster.

Charity registration number:
England and Wales (1015243)
and Scotland (SC037861)
Company number: 2698321
lifearc.org

Genetic Alliance UK is an alliance of over 220 organisations, charities and support groups working together to improve the lives of everyone in the UK living with genetic, rare and undiagnosed conditions. Our members are at the centre of everything we do. We actively support progress in research and engage with decision makers and the public about the challenges faced by our community.

Charity registration numbers: England and Wales (1114195) and Scotland (SC039299)
Company number: 05772999
geneticalliance.org.uk

Beacon for Rare Diseases is a UK-based charity that is building a united rare disease community with patient groups at its heart. Beacon's events and training give patient groups the opportunity to connect and collaborate with others across the rare disease space.

Charity registration number: 1149646
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rarebeacon.org

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