What if biosensors could help treat rare diseases?

Most rare diseases are incurable. Research into new diagnostics and therapies is hampered by the low number of patients, limited amount of data, lack of multi-centre coordination and low profitability. Biosensors are a technology that, driven by continuous advances in artificial intelligence, can help disease detection, lower the cost of novel therapies, replace placebo groups in clinical trials and foster patient-centred, personalised (e)-medicine. Governance of biosensor technology involves targeted action addressing various EU laws and policies.

Up to 36 million people in the EU live with a rare condition, namely one that is defined by the European Medicines Agency as affecting fewer than 5 people in 10 000. Of these diseases, 80 % are genetic and chronic. Most appear in early childhood and lead to debilitating and degenerative conditions that diminish the patient's quality of life. Many of them still have no cure. Examples include:

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- **cystic fibrosis** – a genetic disorder affecting the lungs and often associated with secondary bacterial infections;
- **sickle-cell disease** – a genetic blood disorder that leads to cardiovascular deficiencies;
- **amyotrophic lateral sclerosis** – a progressive neurodegenerative disease that affects the muscles.

More than 90 % of rare diseases lack sufficient diagnosis and treatment tools. Treatment is limited by the high cost of research and development (R&D) and low success rate, creating market failures referred to as 'unmet medical needs'. This is particularly problematic for rare diseases owing to their low prevalence and the lack of statistically significant clinical trials. A second common challenge is the limited sharing of research data, namely between industry and academia. This reality is driven by patents and other intellectual property (IP) protections, siloed research organised around single disorders, and limited coordination between research networks.

There is therefore a need for improved research, diagnosis and therapeutic developments. One way of tackling this issue is economic, revising the public incentives awarded to the pharmaceutical industry for R&D in the area of orphan medicinal products. This is one of the goals under assessment in the European Parliament with regard to the Commission's proposals for revised pharmaceutical legislation.

A second approach is technological, by harnessing ongoing developments in artificial intelligence (AI) to find novel treatment approaches. Biosensors are an often overlooked tool that can facilitate early detection and treatment, while keeping costs down. They are medical devices that detect biological parameters, such as the presence of an ongoing infection, altered phenotypic levels, genetic mutations and pharmacological drug effects. These devices can be used as point-of-care equipment, as wearables (e.g. smart watches, smartphones, eyeglasses, patches, smart textiles) or even as ingestibles and implantables. They can be applied to various medical fields, from genetics and genomics, to neurology, oncology, immunology, cardiology and metabology. Examples of biosensor use for rare disease detection and treatment include:

- a neural network-based tool that can detect patterns in facial morphology to assist in diagnosis;
- nanoparticle therapies to treat chronic bacterial infections associated with cystic fibrosis;
- 'human-on-a-chip' (HoaC) and 'organ-on-a-chip' models, to study disease states in a cost-effective and patient-specific way;
- smartwatch monitors that can evaluate drug effect in patients with sickle-cell anaemia;
- ultra-sensitive biosensors that can detect cancer in a blood test;
- enzymatic and electrochemical sensors that can help diagnose and monitor phenylketonuria disease;
- graphene biosensors that detect DNA and RNA;
- a remote wound monitoring device.

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Potential impact and development

Biosensors can be used for disease **diagnosis**, significantly reducing diagnosis times from the average of 4 to 5 years. They can also contribute to disease **treatment**, through monitoring of disease progression, prognosis and response to drug treatment. When applied to rare diseases, biosensors can unravel breakthrough advances in two fields: clinical trials and personalised medicine.

Clinical trial designs for rare diseases face limitations caused by the small number of study groups, requiring novel approaches to assess and monitor the safety and efficacy of the proposed interventions. Biosensors permit continuous data collection and analysis (e.g. heartrate or insulin levels), which can help define clinical endpoints and patient-reported outcomes. Biosensors help study the efficacy and safety of new drugs and approaches, namely gene editing and RNA therapies. In addition, they can enable a placebo group to be replaced with modelling based on real-world data, providing more robust statistical analysis.

Coupled with continuous advancements in AI, namely the internet of medical things (IoMT), biosensors have become a type of **personalised medicine**, whereby wearables can be used as smart medical devices to monitor vital parameters, ensuring high precision, continuity and comfort. They can send real-world data to be monitored and evaluated remotely by a general practitioner (**telemedicine**), allowing for better care that considers the patient's environment and needs, for better decision-making. Data collection can then be funnelled towards basic and translational research, which is essential for R&D in the area of novel therapies for rare diseases. The application of biosensors also entails technical, financial, legal and ethical issues, however, that need to be considered when managing large volumes of data (e.g. General Data Protection Regulation).

Anticipatory policy-making

Advancements in AI have made large amounts of data available, data that can foster health research, drive innovative treatments and improve evidence-based care. Biosensors fall within the scope of the Medical Devices Regulation, but are also affected by several other pieces of EU legislation.

A key issue for the coming years pertains to data collection and coordination for R&D in the area of novel diagnostics and treatments. The EU has 24 **European reference networks** (ERNs) to strengthen coordination in R&D. The **European Platform on Rare Disease Registration**, meanwhile, seeks to reduce the fragmentation of patients' data contained in hundreds of registries across Europe. Orphanet is an EU-funded consortium of 40 countries within Europe and the wider world. The upcoming **European health data space** legislative proposal aims to promote the use of big data on rare diseases, by assisting Member States in pooling resources, increasing cooperation between national health systems and enabling the secure use of health data for clinical, healthcare planning and patient care.

Further progress could be made in open science and data-sharing, a point left untouched in the Commission proposals to revise EU pharmaceuticals legislation. A 2021 STOA study proposed policy options to achieve this goal, namely through the creation of an EU body for R&D, with public ownership of IP rights.

Another challenge will be to ensure that access to patient care, treatment and therapies is made equitable and affordable across Member States and different socioeconomic groups, and that strong ethical standards are upheld, including for data privacy and security. The **AI act** aims to protect health data from potential misuse and unlawful access.

A fourth aspect pertains to R&D. The EU has financed over 440 research projects in rare diseases, for instance the Horizon Europe call on how to tackle rare diseases. Yet EU health research, including on rare diseases, still suffers from fragmentation, and requires better coordination. Another recent STOA study set out policy options here, which also included the creation of an EU body for health R&D coordination.

Biosensor governance is also impacted by the proposal for a 'SoHO' regulation, regarding the treatment of samples of blood, tissues and cells, and the Cross-border Healthcare Directive.