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ERC Frontier Research for Artificial Intelligence in Health

From disease prevention to diagnosis and treatment

2026

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Foreword

The uptake of AI in health care offers a growing range of established and promising applications, even as its added value and real-world impact are still unfolding. The promise is ambitious: algorithms that detect disease earlier and more accurately than clinicians, predict individual risks with unprecedented precision, and personalise treatments across the full life cycle of care. Yet the central question remains whether AI can help overcome the structural problems that afflict many health systems—such as incentives that reward billing over patient care, the spread of defensive medicine, and the limited training of many physicians in understanding health statistics. If these problems are not addressed, the full potential of AI cannot be realised.

A classic example illustrates this point: When the RAND Corporation reviewed electronic patient records in 2013, it found—contrary to expectations—that the promised annual savings of $81 billion had not materialised. Instead, costs had increased rather than decreased. Software systems were gamed to inflate medical bills, patients were no better off, and access was still limited rather than universal. Competing software companies had developed incompatible formats to increase brand loyalty, not patient safety.

This report aims to contribute to a more reflective and responsible use of AI in health. It analyses 238 projects funded by the European Research Council up to 2022, representing a total investment of around €450 million. A closer examination reveals the diversity of applications already emerging: machine learning tools to rapidly design antibodies and enzymes; predictive models integrating genetic, clinical and behavioural information; advances in medical imaging, robotics and autonomous surgical assistance; and new computational frameworks supporting personalised medicine.

At the same time, the report addresses key challenges and risks. ERC researchers point to problems of data quality and access, the opacity of black box models, difficulties in clinical validation, regulatory uncertainty, and the need for trust and accountability when AI systems are involved in health decisions. These insights underscore the importance of transparent models, meaningful human oversight, and risk literacy among both developers and users of AI.

In this sense, the report offers more than a snapshot of frontier research. It reminds us that smart technologies require smart people and institutions – and that we must understand carefully where AI works and where it does not. The future of AI in health depends on better algorithms, but also on wiser choices about how they are designed, evaluated, and governed.

Gerd Gigerenzer
Director at the Max Planck Institute for Human Development
and former Member and Vice-President of the ERC Scientific Council (2020-2025)

Executive summary

This report presents an in-depth analysis of ERC projects working on **AI in health research and healthcare, from disease prevention to diagnosis, treatment and disease management**. The projects focus on the development and application of AI-based models, clinical decision-support systems and platforms, including machine learning and deep learning algorithms, for the purposes of enabling early disease detection, and tailoring risk prediction, diagnosis, prognosis, treatment and disease management to individual patients. AI is also paving the way for integrating multi-omics, phenotypic and health data, while also playing a role in supporting the entire lifecycle of medicines, from drug discovery to clinical trials.

This report is a follow-up analysis from two previous feedback-to-policy (F2P) reports by the ERCEA. An overview of 1,048 ERC-funded projects developing, using or studying AI, as well as their relevance for key EU policy domains, was published in 2024. A survey of these projects was the basis for a foresight report on the use of AI by ERC researchers in the scientific process, their perspectives on future developments by 2030, as well as the opportunities, risks, and potential impact of generative AI in science.

Overview of ERC portfolio on AI in health

The portfolio in this analysis comprises **238 ERC-funded projects** under the FP7, Horizon 2020 and Horizon Europe (until ERC 2022 calls), totalling **450 million EUR** in funding (chapter 2).

It has a wide coverage of scientific domains: **91 projects in Life Sciences, 101 projects in Physical Sciences and Engineering and 38 projects in Social Sciences and Humanities** (figures exclude Synergy grants due to their interdisciplinarity). The top 4 ERC scientific panels are prevention, diagnosis and treatment of human diseases (LS7), computer science and informatics (PE6), systems and communication engineering (PE7) and the human mind and its complexity (SH4).

When it comes to disciplines (ERC Mapping Frontier Research/MFR classification), artificial intelligence (34%) and applied computer science (20%) are the most represented, followed by cognitive neuroscience (16%) and neuroscience, including neurology (14%). In terms of the main topics (also according to the MFR classification), machine learning is the most predominant (more than 45%), while in terms of methods, computational modelling and simulations stand out (more than 60%).

Deep dive on AI in health

A **deep dive into 59 ERC projects on AI in health** (chapter 3), carried out with the support of the Horizon Results Booster, provides insights on **projects' results and impact** (details on the Methodology section). Based on desk research, a set of both quantitative and qualitative parameters, ranging from publications, clinical studies, devices and prototypes, and patents, up to broader social, technological, economic or policy impact, were reviewed for this report.

Synergies within this selection of ERC projects were explored in collaboration with **the European Health and Digital Executive Agency (HaDEA)**. The analysis offers an overview on the research and innovation flows between different parts of Horizon Europe starting from this selection of projects, namely between Pillar I - Excellent Science and Pillar II – Global Challenges and European Industrial Competitiveness. It shows that 13 researchers within the subset of 59 ERC projects had/have an active role (as coordinator or beneficiary) in 21 projects in calls implemented by HaDEA in Clusters 1 and 4.

Case studies and insights from ERC researchers

Based on interviews and desk research, the **case studies on 20 ERC grantees** (from the deep dive) offer main research findings, and the nature and extent of impacts, including for instance key publications, methods, prototypes or tools developed, spin-offs, additional funding and relevant links. Projects cover 6 application areas in chapter 4: **disease detection and monitoring; drug discovery; forecast of risk factors and outcomes; imaging; medical robots; and personalised medicine**.

Key challenges for the development and adoption of AI in health were identified by ERC researchers via interviews, along a range of scientific, technological, economic, legal, cultural, social or other dimensions. As examples of the top challenges detailed in chapter 5:

- The need for **interdisciplinary collaboration** between researchers from diverse backgrounds in each phase of the research process, from beginning to end.
- **Quality and availability of biomedical data**, currently fragmented, proprietary and inconsistent across countries, plus unclear standards for application in biomedical research.
- **Accessing and processing sensitive data** about individuals from different countries, and difficulties in integrating different types of data in a way that respects privacy.
- Insufficient rigorous validation studies, transparent decision-making processes and careful integration of **AI systems into clinical workflows**.

Present and future risks were also pinpointed by ERC researchers, based on their experience in the field and again considering the full range of dimensions. As top examples further detailed in chapter 6:

- Uncertainty over final **accountability, responsibility and contestability** when an AI system is involved in the decision-making process in case of errors or harm to patients.
- How to **monitor dynamic, self-learning AI tools** for decision support for clinical use and how to integrate human oversight when required or necessary.
- **Biased results and limits to their generalisation** due to limited or overfitted datasets, at times within a difficult balance between accuracy and fairness.
- **Non-interpretable and complex AI models** that lack transparency and sufficient high-quality data, coupled with their over-use in cases where simpler models could be more appropriate.
- **Lack of AI expertise and skills** that may lead to misinterpretation and over-reliance but also reluctance in using AI models, compromising its clinical use or trust in AI-based approaches.

Several **types of support** to develop their AI-based systems in health or exploit their innovation potential were also highlighted and further detailed in chapter 7. According to ERC researchers, **stable, long-term funding** is needed to support frontier science and give researchers freedom, while also enabling the translation of early-stage innovations into clinical applications. This must be complemented by **secure, high-performance computing and data infrastructures, sustained investment, and expert guidance**. Access to **large, high-quality, longitudinal health datasets**, alongside **European sovereignty over health data and AI**, was also at the top of identified needs.

Ecosystems and partnerships that integrate funding, infrastructure, regulation, and talent development, such as AI-for-science hubs, were highlighted. Other points mentioned were the need for a **shift in research culture** towards stronger links to industry and startup accelerators, and for **institutional, legal, and regulatory support**, including IPR, GDPR, and clinical liability. There were also calls for clearer, simplified European regulatory frameworks and AI-specific regulatory sandboxes.

1. Policy context

Artificial Intelligence (AI) and its applications are a top priority of the EU policy agenda since the launch of the European AI Strategy in 2018. The present report pays special attention to the EU policy context at the intersection of AI with health. Overall, AI-related biomedical science publications have surged in recent years, with over 80,000 studies published worldwide between 2017 and 2021.

One of the major EU policy initiatives at this intersection is the AI Act (which entered into force in August 2024) and the establishment of the European AI Office. The AI Act designates certain types of healthcare AI systems as “high risk” – for instance AI used in medical devices, which are defined under the Medical Device Regulation (MDR (EU) 2017/745), AI systems used by public authorities to evaluate eligibility for healthcare services, and AI systems for emergency patient triage systems. While the AI Act does not apply to AI systems or AI models prior to their being placed on the market or put into service, any research and development activity should be carried out in accordance with recognised ethical and professional standards for scientific research and applicable Union law

Another EU policy initiative concerns the European Health Data Space (EHDS). It aims to improve individuals' access to and control over their personal electronic health data, while also enabling certain data (e.g. electronic health record systems/EHRS) to be reused for public interest, policy support, and scientific research purposes.

Further strengthening previous initiatives, the Commission launched in April 2025 the AI Continent Action Plan, which aims to make Europe a global leader in AI innovation.

The plan includes actions to build large-scale AI data and computing infrastructures, increase access to high-quality data, foster AI adoption in strategic sectors, strengthen AI skills and talent, and facilitate the implementation of the AI Act. Key components include the establishment of AI Factories and Gigafactories, the InvestAI Facility to stimulate private investment, and the launch of the AI Skills Academy.

As part of the plan, the Apply AI Strategy adopted in October 2025 serves as a blueprint for the full adoption of AI in EU strategic sectors, including pharmaceutical and biotechnology (relevant for the present report).

Serving as the EU’s overarching AI Strategy, the Apply AI Strategy establishes links to the European Strategy for AI in Science, also adopted in October 2025. These two strategies point to the creation of a Resource for AI Science in Europe (RAISE), a virtual institute pooling national and European resources to support fundamental science in and with AI. This policy initiative was previously informed by the Opinion of the Group of Chief Scientific Advisors (GCSA) on Successful and timely uptake of AI in science in the EU, and supported by a science for policy JRC report on the topic.

The Commission has outlined policy ideas to leverage the power of AI to enhance research, accelerate scientific breakthroughs, and boost innovation. The CORDIS Results Pack on AI in Life Sciences, in which 4 ERC projects are featured, further showcases how AI techniques are helping researchers to make valuable new discoveries across disciplines such as biology, neuroscience and biotechnology.

The ambition to support a use of AI in science that is open, human-centric and rooted in scientific excellence inspired specific actions in the European Strategy for AI in Science mentioned above. Central to these efforts are the Living Guidelines on the Responsible use of Generative AI in Research, which provide the research community with principles supporting a transparent, robust and human-centred adoption of AI systems. These guidelines are supported by actions promoting the EU vision for responsible AI through policy dialogues and science diplomacy. These initiatives build on earlier work carried out by the EU to define an ethical framework for AI, notably the Trustworthy AI framework. This set of ethical requirements is part of the legislative and ethics framework applicable to all research funded under the Horizon Europe framework programme.

2. ERC frontier research on AI in health

2.1. At a glance

The European Research Council (ERC), established by the European Union (EU) in 2007, is the premier European funding organisation for excellent frontier research. By giving researchers the freedom to pursue ambitious ideas without predetermined priorities, the ERC enables groundbreaking research with impact beyond science. This research provides knowledge and innovation that can inform and shape EU policies, from design to implementation.

The ERC published in 2024 an overview of 1,048 ERC-funded projects developing, using or studying AI, as well as their relevance for key EU policy domains, including health, environmental sustainability and the green transition, democracy, justice, employment and education. Based on a survey of these projects, an ERC foresight report focused on the current use of AI by ERC researchers in the scientific process, their perspectives on future developments by 2030, as well as the opportunities, risks, and impact of generative AI in science. Both previous ERC reports were prepared in support to this GCSA Opinion, in collaboration with the European Commission DG R&I.E.4 - AI in Science & Critical Technologies and DG R&I.02 - Science Policy, Advice and Ethics / Scientific Advice Mechanism (SAM).

One of the most prominent policy areas identified in the ERC AI portfolio was health, with a total of 238 projects under the FP7, Horizon 2020 and Horizon Europe (until 2022) research and innovation framework programmes.

238 projects

EUR 450 million Budget

20 Countries

91 projects Life Sciences

101 projects Physical Sciences and Engineering

38 projects Social Sciences and Humanities

StG — Starting Grants **94 projects**

CoG — Consolidator Grants **56 projects**

AdG — Advanced Grants **45 projects**

PoC — Proof of Concept Grants **35 projects**

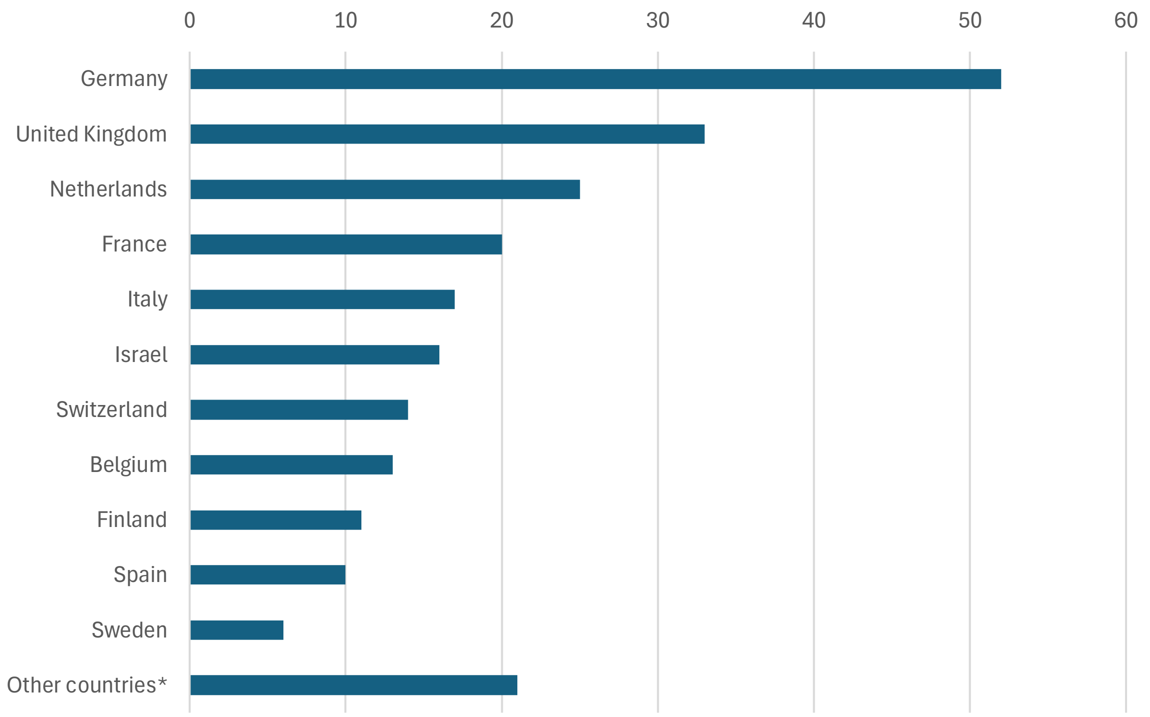
SyG — Synergy Grants **8 projects**

They cover a wide range of research and applications within for instance:

- clinical practice, including automation of image analysis, diagnostic processes, risk prediction, and therapeutic support or decision making, together with applications in surgery, mental health, and cancer research.
- biomedical research, ranging from drug discovery, omics data processing, and personalised medicine.
- assistive technology and robotics, including healthcare monitoring and self-management, medical and surgery technologies.
- public health, such as digital epidemiological monitoring, disease prevalence, and environmental and occupational health.

In terms of geographical distribution, projects in this portfolio are hosted in 20 countries across EU Member States and associated countries (Figure 1). The top 5 countries hosting the highest number of grants are Germany, the United Kingdom, the Netherlands, France and Italy, which host 62% of the projects in this portfolio. Six other countries – Israel, Switzerland, Belgium, Finland, Spain, and Sweden – account for 29% of the projects.

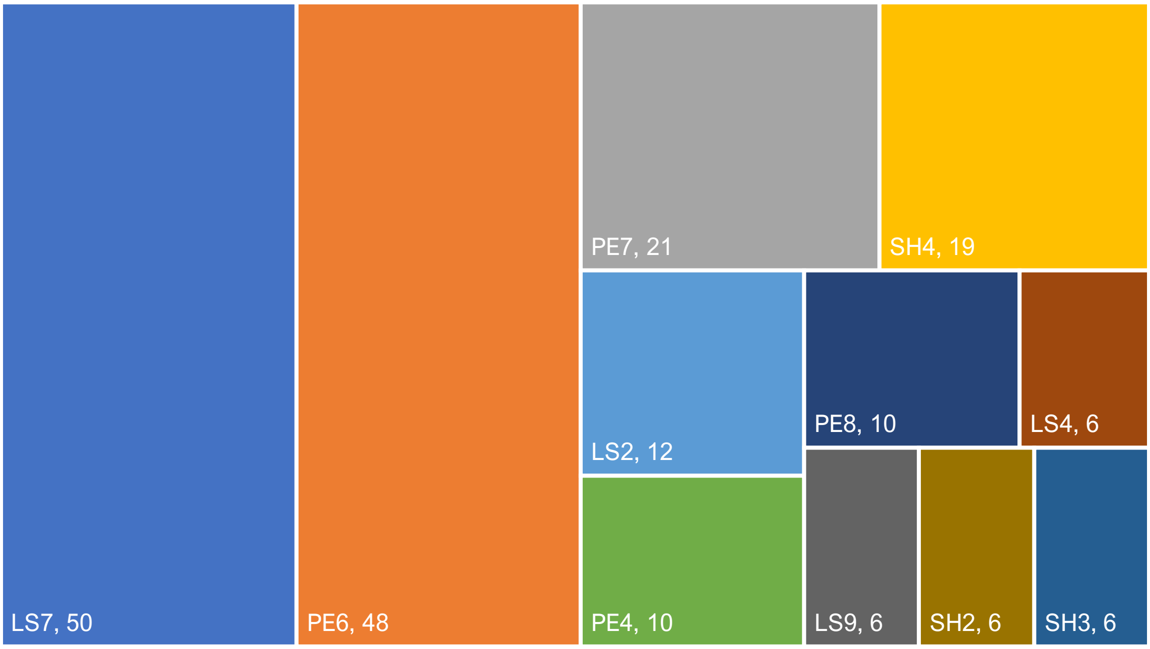
Figure 1: Number of ERC projects on AI in health by country (Host Institution)



*Countries hosting 5 ERC grants or fewer

Regarding the scientific domains visible in Figure 2 (cf ERC Work Programme 2026, pp. 58-60), most projects focus on the prevention, diagnosis and treatment of human diseases (ERC panel LS7), computer science and informatics (PE6), systems and communication engineering (PE7) and human mind and its complexity (SH4). A smaller number of projects address integrative biology (LS2), products and processes engineering (PE8) and physical and analytical chemical sciences (PE4). An equivalent number of projects focus on physiology in health, disease and ageing (LS4), biotechnology and biosystems engineering (LS9), institutions, governance and legal systems (SH2) and the social world and its interactions (SH3).

Figure 2: Top panels of ERC projects on AI in health (in number of projects)



2.1. Scientific landscape: disciplines, topics and methods

Mapping Frontier Research (MFR), an internal ERC classification system, provides further insights into the main scientific disciplines, topics and methods of this group of projects (note that PoC grants are not included, a detailed analysis of ERC PoC can be found here). The figures below show the main disciplines and topics addressed by ERC projects in this portfolio.

In terms of disciplines (Figure 3), as expected artificial intelligence (34%) and applied computer science (20%) are the most represented, followed by cognitive neuroscience (16%) and neuroscience (14%). Computational biology, diagnostic tools and methods and biomedical engineering are also well represented.

In terms of the main topics (Figure 4) addressed by the projects, machine learning leads by far (more than 45%). The other topics covered (by at least 10%) include algorithm development, neural bases of cognition, deep learning and systems, and computational neuroscience.

In terms of methods (Figure 5), computational modelling and simulations leads by far (more than 60%), followed by statistical methods, data analysis, experimental methods, neuroimaging, theoretical/mathematical methods, big data analytics, DNA and RNA analysis and omics approaches.

Figure 3: Top 10 disciplines of ERC projects on AI in health (source: Mapping Frontier Research/MFR)

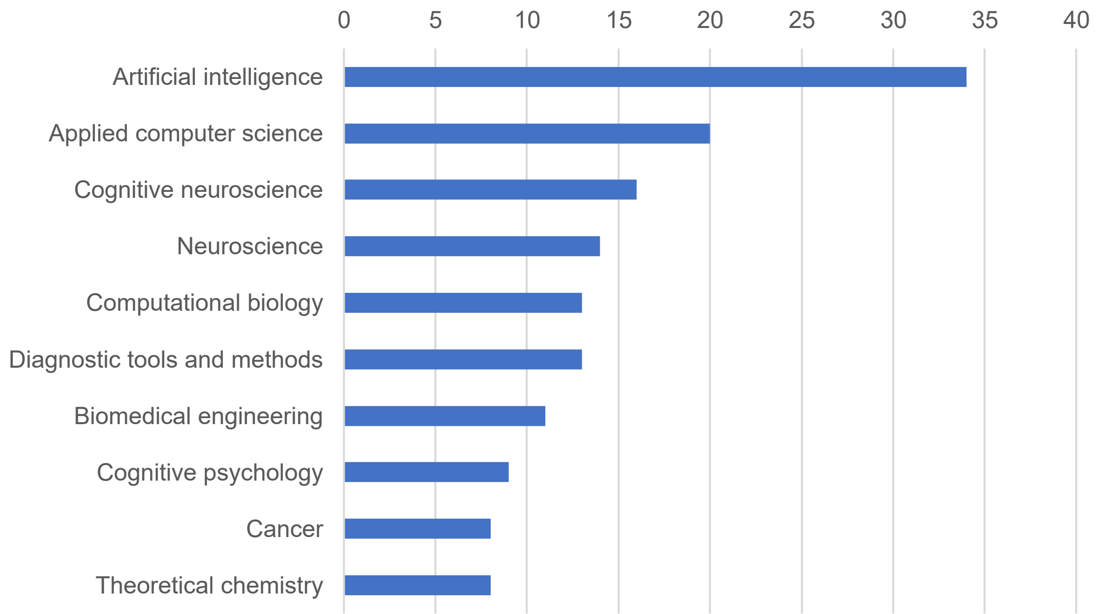


Figure 4: Top 10 topics of ERC projects on AI in health (source: Mapping Frontier Research/MFR)

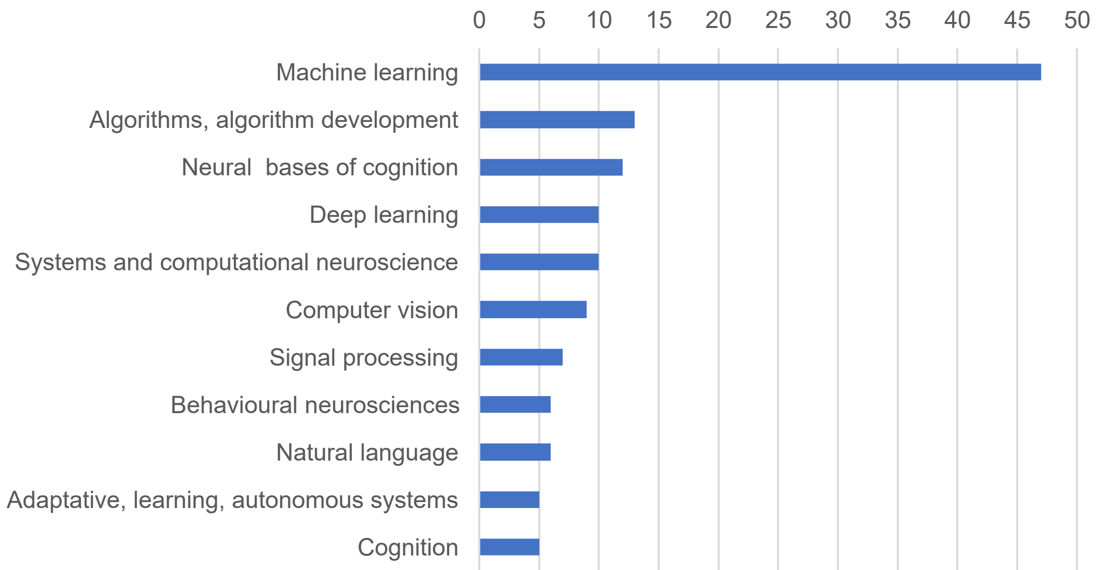
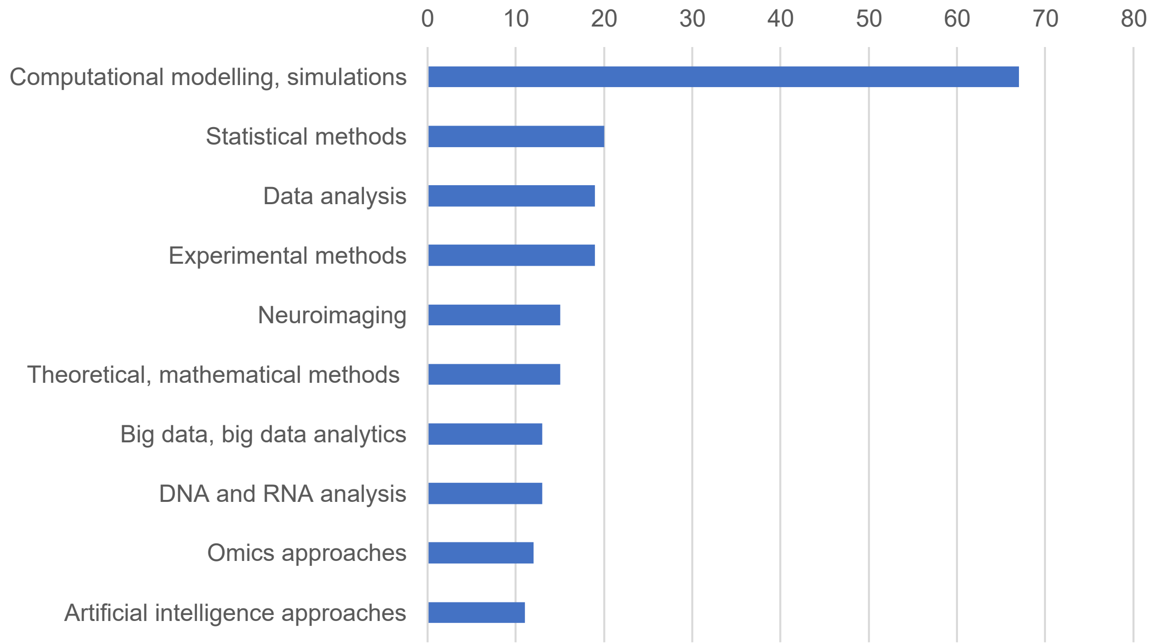


Figure 5: Top 10 methods of ERC projects on AI in health (source: Mapping Frontier Research/MFR)



3. Deep dive on AI in health

3.1 Results from selected ERC projects

A selection of 59 ERC projects on AI in health formed basis for an in-depth analysis with the support of the Horizon Results Booster, on projects' results and impact (for more details, see Methodology section). Drawing on the methodology of the UK Research Excellence Framework (REF), the analysis covered both quantitative and qualitative dimensions, ranging from publications, clinical studies, devices and prototypes, and patents, up to broader social, technological, economic or policy impact.

An overview of the quantitative outputs of the analysed projects, is presented below. The figures refer to the results reported by researchers to the ERC, complemented where necessary with data available from external sources (such as Scopus) and researcher's own websites. Additional results and impact, in some cases extending beyond the end of the project, were also collected through interviews (see Chapter 4 – "Case studies").

Key figures from this selection of ERC projects in AI in health:

- € 83,750,214 in total funding granted
- 908 publications, 27,583 citations, 133 research datasets or databases and 90 toolboxes/models
- 32 clinical trials or studies
- 54 devices and prototypes, including software
- 13 patents (filled or granted) and 8 spin-offs generated from the projects

The figure 6 below provides the number of projects per grant type as well as the funding allocation.

Looking into the last three types of outputs, the highest value of devices and products (including prototypes) was within PoC projects. For spin-offs, PoC projects stand out even more prominently. It is key to keep in mind that the PoCs grants are available as further funding during or after an ERC grant, with the goal to explore its commercial or societal potential. In terms of patents, CoG grants show the highest values followed by PoCs.

Figure 6: Outputs of this subset of ERC projects in AI in health (per grant type)

	Proof of Concept	Starting	Consolidator	Advanced
Number of projects	18	16	14	11
Funding	2,698,413 €	24,171,548 €	27,010,415 €	27,642,915 €
Publications	17	334	225	332
Citations	162	11802	4174	11445
Research data	18	28	25	62
Toolboxes/ models	3	40	20	27
Clinical trials/studies	7	16	6	3
Devices/ products	23	10	10	11
Patents	4	1	7	1
Spin-offs	6	0	1	1

3.2. Synergies with Horizon Europe Pillar II

The deep dive into a selection of 59 ERC projects on AI in health led to a collaboration with the European Health and Digital Executive Agency (HaDEA) from a feedback-to-policy perspective. Together with colleagues from HaDEA.B.2 Digital, the aim was to identify ERC researchers (within this subset of 59 projects) who also conducted research and innovation projects funded via calls implemented by HaDEA under Horizon Europe, EU's current funding programme for research and innovation (2021-2027).

Despite its limited scale and scope, the analysis offers a pilot overview on the research and innovation flows between different parts of Horizon Europe, namely between Pillar I - Excellent Science and Pillar II – Global Challenges and European Industrial Competitiveness.

Within Pillar I, the ERC's mission is to support investigator-driven frontier research across all fields, based on scientific excellence. In the interviews with ERC researchers conducted as part of this report, the freedom to pursue or change research directions as the project evolves, plus the opportunity for researchers at different stages of their career to establish themselves and become experts in their field, were mentioned as unique features of the type of funding provided by the ERC. It was also mentioned that ERC funding can enable researchers to be potentially successful in follow-up or complementary funding due to an excellent track record and profile built during the ERC grant.

The potential to valorise frontier research into diverse directions — including more applied avenues and broad collaborations with other researchers or organisations — aligns closely with the mission of Pillar II. This is particularly relevant for the intersection of AI and health that underpins this report especially through the funding streams of Cluster 1 – Health and Cluster 4 – Digital, Industry and Space. The broad and cross-disciplinary spectrum of AI in health falls under parts of Cluster 1 that aim to improve and protect the health and well-being of citizens by generating new knowledge and developing innovative solutions (including AI) to prevent, diagnose, monitor, treat and cure diseases, and at the same time in Cluster 4, when it comes to shaping competitive and trusted technologies (including AI and robotics, among others) for a European industry with global leadership in key areas.

The analysis undertaken shows that 13 researchers with ERC grants were part of or had/have an active role in 21 projects funded via calls implemented by HaDEA in Clusters 1 and 4 (within this subset of 59 ERC projects). Below the links between the researchers and the projects are outlined, both from ERC funding (in green boxes) and a diverse set of Horizon Europe calls (in purple boxes). For more details on the approach, see Methodology section at the end of the report.

Peter Carmeliet (VIB VZW, Belgium)

ECMETABOLISM (269073), 2011-2016, ERC Advanced Grant
The project pioneered the study of endothelial cell metabolism during vessel sprouting by blocking their metabolic energy supply.

PFKFBLOCK (713758), 2016-2018, ERC Proof of Concept Grant
It developed a novel anti-angiogenic concept and strategy, based on targeting key metabolic pathways in endothelial cells

TECNEC (743074), 2017-2022, ERC Advanced Grant
It built a genome scale computational metabolic model to predict in silico metabolic genes essential for endothelial cell growth.

MystIMEC (101055155), 2023-2028, ERC Advanced Grant
It is developing an AI-based tool that can be made generic to discover any type of function for mystery genes in any cell type.

CRUCIAL (848109), 2020-2024

The project identified the role of microvascular rarefaction in cognitive impairment and heart failure by developing innovative imaging instruments, plus non-contrast and AI methods.

H2020-EU.3.1.1. - Understanding health, wellbeing and disease

Topic: SC1-BHC-01-2019 - Understanding causative mechanisms in co- and multimorbidities combining mental and non-mental disorders

ORGANTRANS (874586), 2020-2023

It aimed to replace liver transplantation for end-stage liver failure patients through liver regenerative medicine. It combined advanced know-how in cell biology, biomaterials, bioengineering, automation, standardisation and clinical translation.

H2020-EU.3.1.3. - Treating and managing disease

Topic: SC1-BHC-07-2019 - Regenerative medicine: from new insights to new applications

Andrea Ganna (University of Helsinki, Finland)

AI-PREVENT (945733), 2021-2026, ERC Starting Grant

It is developing AI approaches to model health trajectories based on nationwide registry data on medications, diagnoses, familial risk and socio-demographic information to obtain accurate risk estimates for cardiometabolic disease.

INTERVENE (101016775), 2021-2025

The project is using AI on a vast and diverse US-European pool of genomic and health data to calculate genetic risk scores that predict an individual's susceptibility to a particular disease.

H2020-EU.3.1.5. - Methods and data

Topic: DT-TDS-04-2020 - AI for Genomics and Personalised Medicine

NEUROCOV (101057775), 2022-2027

The project aims to investigate neurological and neuropsychological complications due to COVID-19. These include a compromised sense of smell and taste, impaired ability to concentrate, memory problems, stroke, and significant brain scan alterations among COVID-19 patients across all ages and independent of COVID-19 severity.

HORIZON.2.1.4 - Infectious Diseases, including poverty-related and neglected diseases

Topic: HORIZON-HLTH-2021-DISEASE-04-07 - Personalised medicine and infectious diseases: understanding the individual host response to viruses (e.g. SARS-CoV-2)

Fosca Giannotti (Scuola Normale Superiore, Italy)

XAI (834756), 2019-2025, ERC Advanced Grant

The project focuses on how to design transparency in machine learning models, to produce controlled black-box explanations, and to reveal used data and algorithms, unfairness and causal relationships in processes.

ProCAncer-I (952159), 2020-2025

The project proposes to develop advanced AI models to address unmet clinical needs, including diagnosis, metastases detection and prediction of response to treatment.

H2020-EU.3.1.5. - Methods and data

Topic: DT-TDS-05-2020 - AI for Health Imaging

TANGO (101120763), 2023-2027

The project aims to create hybrid decision support systems that harmonise human and machine values and objectives, fortifying Europe's prominence in human-centric AI.

HORIZON.2.4.5 - Artificial Intelligence and Robotics

Topic: HORIZON-CL4-2022-HUMAN-02-01 - AI for human empowerment (AI, Data and Robotics Partnership) (RIA)

Philippe Lambin (Maastricht University, Netherlands)

HYPOXIMMUNO (694812), 2016-2023, ERC Advanced Grant

The project provided (pre)clinical proof of concept of highly innovative CT-based radiomics and PET-hypoxia imaging patient stratification tools.

CL-IO (813200), 2018-2020, ERC Proof of Concept Grant

The project addressed the challenges of delivering immunotherapeutics to tumours by incorporating genetically modified Clostridium bacteria as an effective delivery system.

AUTO.DISTINCT (957565), 2020-2022, ERC Proof of Concept Grant

The project developed a fully automated software for fast, accurate, and reproducible detection and volumetric segmentation of lung tumours and metastases on CT images.

ReverseTheAdvantage (101082238), 2022-2024, ERC Proof of Concept Grant

The project developed a model that can identify tumours that exhibit both hypoxia and defects in DNA damage repair to predict the efficacy of anti-cancer drugs.

icovid (101016131), 2020-2023

The project focused on developing, validating and deploying icolung, a CE-marked AI-based medical device software, to support the diagnosis and prognosis of patients suspected of COVID-19 by making use of lung Computed Tomography (CT) scans together with clinical information,

H2020-EU.3.1. - SOCIETAL CHALLENGES - Health, demographic change and well-being

Topic: SC1-PHE-CORONAVIRUS-2020-2B - Medical technologies, Digital tools and Artificial Intelligence (AI) analytics to improve surveillance and care at high Technology Readiness Levels (TRL)

CHAIMELEON (952172), 2020-2025

The project set up a cancer imaging repository facilitating access to large, high-quality sets of anonymised data as a single-access point resource for the community of AI developers.

H2020-EU.3.1.5. - Methods and data

Topic: DT-TDS-05-2020 - AI for Health Imaging

EuCanImage (952103), 2020-2025

The project built a General Data Protection Regulation (GDPR)-compliant and scalable AI platform for leveraging large-scale, high-quality and interoperable cancer imaging datasets linked to biological and health oncology data.

H2020-EU.3.1.5. - Methods and data

Topic: DT-TDS-05-2020 - AI for Health Imaging

RadioVal (101057699), 2022-2026

The project is exploring the potential of radiomics to predict response to neoadjuvant chemotherapy in breast cancer patients, using AI for more tailored treatment decisions and reduction of both over- and under-treatment.

HORIZON.2.1.5 - Tools, Technologies and Digital Solutions for Health and Care, including personalised medicine

Topic: HORIZON-HLTH-2021-DISEASE-04-04 - Clinical validation of artificial intelligence (AI) solutions for treatment and care

GLIOMATCH (101136670), 2024-2028

The project aims to improve clinical outcomes of cancer patients (with adult and paediatric malignant gliomas) by developing an immunology-based approach for personalised immunotherapy.

HORIZON.2.1 – Health

Topic: HORIZON-MISS-2023-CANCER-01-01 - Addressing poorly understood tumour-host interactions to enhance immune system-centred treatment and care interventions in childhood, adolescent, adult and elderly cancer patients

Ben Glocker (Imperial College of Science, Technology and Medicine, UK)

MIRA (757173), 2018-2024, ERC Starting Grant

The project developed new machine learning strategies for more robust and reliable image analysis with the goal of improving disease detection models.

AI-POD (101080302), 2023-2027

The project aims to develop trustworthy AI tools to support clinical decision-making for cardiovascular diseases (CDVs). These tools will offer actionable diagnostic insights and treatment recommendations, aiding patients with CVD and their doctors in managing their health.

HORIZON.2.1.1 - Health throughout the Life Course

Topic: HORIZON-HLTH-2022-STAYHLTH-01-04-two-stage - Trustworthy artificial intelligence (AI) tools to predict the risk of chronic non-communicable diseases and/or their progression

Andre Marquand (Radboud University, Netherlands)

MENTALPRECISION (101001118), 2021-2026, ERC Consolidator Grant

The project aims to stratify mental disorders on the basis of biological markers derived from brain imaging data from tens of thousands of people and quantitative measures of behaviour from smartphone monitoring through statistical and deep learning methods.

environMENTAL (101057429), 2022-2027

The project is investigating how climate change, urbanisation and psychosocial stress caused by the COVID-19-pandemic affect mental health. Using omics analyses and virtual brain simulations, it is developing risk biomarkers, interventions, and evidence-based strategies for environmentally related mental illnesses.

HORIZON.2.1.1 - Health throughout the Life Course

HORIZON-HLTH-2021-STAYHLTH-01-02 - Towards a molecular and neurobiological understanding of mental health and mental illness for the benefit of citizens and patients.

Daniel Rueckert (Radboud University, Netherlands)

Deep4MI (884622), 2021-2026, ERC Advanced Grant

Using machine and deep learning techniques, the project aims to improve image acquisition, reconstruction and analysis and provide higher diagnostic and prognostic accuracy for clinical decision-making.

COMFORT (101079894), 2023-2027

The project aims to develop advanced AI models that can analyse multiple types of medical data simultaneously, including medical imaging and clinical notes, to assist doctors in detecting and diagnosing prostate and kidney cancers.

HORIZON.2.1.5 - Tools, Technologies and Digital Solutions for Health and Care, including personalised medicine

Topic: HORIZON-HLTH-2022-TOOL-12-01-two-stage - Computational models for new patient stratification strategies

Simo Saarakkala (University of Oulu, Finland)

3D-OA-HISTO (336267), 2014-2019, ERC Starting Grant

The project developed novel computer algorithms to analyse bone in 3D from micro-CT data sets and automatise 3D histopathological osteoarthritis grading.

MUOTO (875658), 2020-2021, ERC Proof of Concept Grant

It developed novel imaging biomarkers for analysing osteoarthritis progression from CT-imaged tissue samples.

RESTORE (814558), 2019-2022

The project worked on the treatment of knee chondral lesions. Smart nanoenabled 3D matrices was developed by orthopaedic surgeons, tissue engineers, material scientists, cell biologists and businesses.

H2020-EU.2.1.2. - INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies – Nanotechnologies

Topic: NMBP-22-2018 - Osteoarticular tissues regeneration (RIA)

Samuel Sánchez Ordóñez (Institute for Bioengineering of Catalonia, Spain)

LT-NRBS (311529), 2013-2017, ERC Starting Grant

The project designed a multifunctional device for the capturing, growth and sensing of single cell behaviours inside “glass” microtubes.

MICROCLEANERS (713608), 2016-2018, ERC Proof of Concept Grant

The project demonstrated active micromotors can clean efficiently different types of contaminants such as pharmaceuticals, heavy metals and bacteria.

LABPATCH (790163), 2018-2020, ERC Proof of Concept Grant

The project developed two biosensors to help medical professionals better detect phenylalanine levels – a leading indicator of phenylketonuria disease.

i-NANOSWARMS (866348), 2020-2026, ERC Consolidator Grant

The project has developed nanobot swarms capable to self-propel using biocompatible fuels with key biomedical, enhanced drug delivery and medical imaging applications.

MucOncoBots (101138723), 2023-2025, ERC Proof of Concept Grant

The project developed an innovative therapeutic approach using self-propelled nanoparticles, capable of breaking down the mucus barrier while delivering anti-cancer drugs directly to the tumor site.

ORTHOBOTS (101189423), 2024-2026, ERC Proof of Concept Grant

The project is building enzyme-powered nanoparticles, or nanobots, designed to actively transport growth factors within the joints of osteoarthritis patients.

BioMeld (101070328), 2022-2026

The project is developing a self-monitoring and self-controlling manufacturing pipeline of biohybrid machines. It is using the BHM catheter as a medical device to arrive into hard-to-reach regions of the human body and release drugs there.

HORIZON.2.4.3 - Emerging enabling technologies

Topic: HORIZON-CL4-2021-DIGITAL-EMERGING-01-27 - Development of technologies/devices for bio-intelligent manufacturing (RIA)

Nicola Segata (University of Trento, Italy)

MetaPG (716575), 2017-2022, ERC Starting Grant

The project developed computational publicly available tools that can be applied to characterise the genetic structure of thousands of strains in different populations across the globe.

PB3P (957533), 2020-2022, ERC Proof of Concept Grant

The project developed the first version of the PreBiomics Test, a quick and easy-to-use tool for preventing, diagnosing, and treating mucositis and peri-implantitis.

microTOUCH (101045015), 2020-2027, ERC Consolidator Grant

The project is developing computational metagenomics tools as open-access resources enabling researchers to profile microbial communities and strains with high accuracy.

IHMCSA (964590), 2021-2024

The project brought together an EU partnership and broad stakeholder group to deliver concrete recommendations of the microbiome field, ranging from strategies to refine the development and implementation of standardised processes securing the production of interoperable databases, up to optimise the applicability of microbiome-based information to better prevent and treat chronic conditions.

H2020-EU.3.1.1. - Understanding health, wellbeing and disease

Topic: SC1-HCO-17-2020 - Coordinating and supporting research on the human microbiome in Europe and beyond

ONCOBIOME (825410), 2019-2025

Through its integrative approach of leveraging multiple cohorts across populations, cancer types and stages, the project has laid the theoretical and practical grounds to identify microbiome signatures related to cancer occurrence, prognosis and response to therapy.

H2020-EU.3.1.2. - Preventing disease

Topic: SC1-BHC-03-2018 - Exploiting research outcomes and application potential of the human microbiome for personalised prediction, prevention and treatment of disease

Andre Sourander (University of Turku, Finland)

DIGIPARENT (101020767), 2021-2027, ERC Advanced Grant

The project is exploring digitally assisted parent training interventions (instead of face-to-face parent training). It also sheds light on the use of artificial technology to produce digital content tailored to the unique needs of each family.

RECONNECTED (101081020), 2023-2027

The project is developing and testing a digital support system to promote resilience and connect vulnerable citizens in socially disadvantaged communities and evaluate whether this results in citizens improved mental health, increased mental health awareness, reduced stigma, and improved social participation, at affordable costs for implementation.

HORIZON.2.1.1 - Health throughout the Life Course

Topic: HORIZON-HLTH-2022-STAYHLTH-01-01-two-stage - Boosting mental health in Europe in times of change

ECRAID-Plan (825715), 2019-2021

The aim of ECRAID was to reduce the impact of infectious diseases on individual and population health by generating rigorous evidence to improve their diagnosis, prevention and treatment, and to respond better to threats.

H2020-EU.3.1.6. - Health care provision and integrated care

Topic: SC1-HCO-08-2018 - Creation of a European wide sustainable clinical research network for infectious diseases

Alina Solomon (University of Eastern Finland, Finland)

Brain Health Toolbox (804371), 2019-2024, ERC Starting Grant

The project focused on connecting dementia risk prediction with multimodal lifestyle interventions for risk reduction. It involved developing risk/disease models and prediction algorithms and testing them in actual prevention trials.

LETHE (101017405), 2021-2025

The project aims to provide a data-driven risk factor prediction model for older individuals at risk of cognitive decline building upon big data analysis of observational and longitudinal intervention datasets from four European clinical centres.

H2020-EU.3.1.4.2. - Individual awareness and empowerment for self-management of health

Topic: SC1-DTH-02-2020 - Personalised early risk prediction, prevention and intervention based on Artificial Intelligence and Big Data technologies

4. Case studies

From the deep dive into selected ERC projects on AI in health described in the previous chapter, further analysis was conducted through interviews with 20 ERC grantees (for more details, see Methodology section). The resulting case studies informed by both interviews and desk research, provide a richer understanding of each project's results and impact. They highlight key scientific findings, publications, methods, prototypes or tools developed, spin-offs, additional funding and relevant links.

The projects span six application areas:

- **Disease detection:** from audio sensors in wearable or mobile systems to monitor someone's health; a motion-tracking system for infants and children with autism spectrum disorders; up to the use of longitudinal proteomics data for early prediction of disease progression.
- **Drug discovery:** from computational and machine learning tools to rapidly design antibodies and enzymes; a "chemical space machine" that combines molecular quantum mechanics and AI; a benchtop device capable of detecting hundreds of molecular targets within minutes; up to the use of deep learning and clinical data to discover drug synergies for various tumour types.
- **Forecast of risk factors and outcomes:** from uncovering links between antibiotic resistance and consumption by using machine learning and econometric methods; integrating health data and genetic information to predict cardiometabolic diseases; up to "brain fingerprinting" of neuropsychiatric conditions to calculate disorder-specific risk estimates.
- **Medical imaging:** from a histology-based atlas of the human brain and machine learning tools that analyse MRI scans; generalisable and trustworthy machine learning methods for more reliable medical image analysis; sensors for magnetic tracking of surgical instruments; up to AI-based technologies that mimic more closely the actions of ultrasound operators.
- **Medical robots:** from autonomous robots assisting in surgical tasks like prostate cancer biopsies or potentially carrying out simple interventions; up to nanobot swarms capable of penetrating human tumours and enhancing drug accumulation in target cells.
- **Personalised medicine**: from integrating advanced computational biology and machine learning methods with molecular approaches to microbiomes; building disease models and prediction tools for Alzheimer's disease; enhancing precision medicine through patient stratification, biomarker discovery, personalised treatments, and drug repurposing; up to a computational framework that integrates genetic, dietary, and microbial data to predict drug response.

4.1. Disease detection and monitoring

EAR: Audio-based Mobile Health Diagnostics

Mobile health uses audio sensors in devices to connect body sounds with early signs of disease. The EAR project aimed to improve disease diagnosis by optimising the use of local devices and reducing reliance on the cloud. The approach helped to address challenges like noise and privacy concerns. Additionally, it incorporates diagnostic uncertainty and considers the patient's context to enhance the accuracy and reliability of health monitoring.

ERC Advanced Grant 2018

Cecilia Mascolo (University of Cambridge, United Kingdom)

The ERC Advanced Grant EAR (2019-2025) aims to understand how sounds from our bodies can be gathered and used to improve the automated (or semi-automated) diagnosis of diseases. It focuses on how sounds can be collected from wearable devices, which people already carry with them or could carry with them every day. Such data is used to train machine learning models that also estimate uncertainty, thus improving the interaction with clinical practice. Data is also kept close to users thus helping to maintain privacy standards.

Their work on audio respiratory signals has led to the creation of the largest crowdsourced dataset of COVID-19 related sounds, including over 30,000 samples of coughs, breathing, and voice collected via smartphones. This dataset has been shared with over 300 institutions and published under controlled access as a NeurIPS dataset (Neural Information Processing Systems conference) and aiding organisations like the UK Health Security Agency in validating their findings. The data has led to well-cited publications, and they have further developed an open respiratory health audio-based foundation model, available as part of NeurIPS24. The data have been released openly.

Mascolo has built on this work with a new study on tracking respiratory infections through smartphone audio over time, aiming to eventually reassure users about their respiratory health. In the related RELOAD project (2023-2025) funded by the UK Engineering and Physical Sciences Research Council (EPSRC), Mascolo is developing a smartphone app to collect speech and breathing sound data. Data is then processed by a machine learning system that not only predicts whether patients with respiratory tract infections are getting better or worse but also rates its own confidence in its prediction.

She also developed AI technology embedded in earbuds that uses in-ear audio to monitor activity, gait, and physiology, namely in the MicroPhysio project (2024-25, Horizon Europe Guarantee scheme). This technology has been showcased in events like the Cambridge Festival and featured on BBC Click. Their work won the best paper award at IEEE Percom 2025 for “RespEar: Earable-Based Robust Respiratory Rate Monitoring”.

Mascolo is further pursuing this line of research through the EPSRC HearFit fellowship (2025-2030). She will further explore the use of earbuds for health and fitness sensing. She aims to develop a type of sensors which can be used to sense activity and health, plus machine learning methods applied to this data which include the ability to run the models on device or explore the trade-offs of local and remote computation.

Visit Cecilia Mascolo’s website, plus a Cordis article for more info.

DynaOmics: From longitudinal proteomics to dynamic individualised diagnostics

DynaOmics developed new innovative methods and tools for the use of longitudinal proteomics data for early prediction of disease progression. It provides new opportunities for individualised treatment decisions and improved biomarker detection.

ERC Starting Grant 2015

Laura Elo (University of Turku, Finland)

Early detection of diseases is crucial for improving patient outcomes. However, it has remained a challenge to identify reliable markers that can indicate diseases at an early stage. The ERC Starting Grant DynaOmics project (2016-2022) developed new AI-based computational methods and tools specifically designed for longitudinal proteomics data to enable early disease prediction.

The biomedical focus was on type 1 diabetes, where early detection of the disease before clinical symptoms is crucial for developing future therapeutic and preventive strategies. The project introduced novel algorithms for dynamic biomarker detection, robust feature selection techniques to enhance prediction accuracy, and computational models for individualised disease prediction. The methods were implemented as open-source software tools to promote their use by the wider community, with 11 packages made available.

The methods have been successfully used, for instance, in the INNODIA global partnership between academic institutes, industry and patients, aiming to prevent and cure type 1 diabetes. Another example is the package ROTS for robust and reliable biomarker discovery from omics data, including proteomics, which has become a state-of-the-art in proteomics data analysis and it has been shown to perform well also in large external benchmark studies. The packages have also been featured in popular blogs, such as the popular News in Proteomics Research blog and the official blog of ThermoFischer Scientific (one of the major manufacturers of mass spectrometry instruments).

The group has obtained further funding by the Research Council of Finland for two follow up studies: *Advancing proteomics through AI and high-performance computing (AI.MS)* and *Pushing the limits of proteomics*.

Several new international collaborations have been launched, involving both academic and industrial partners, as well as major international networks, such as the European Network Linking Informatics and Genomic of Helper T cells in Tissues (ENLIGHT-TEN+), the European Network Linking Immune-Mediated Diseases to Early Exposures for Innovative Solutions (HEDIMED), and the Private-Public Partnerships against Type 1 Diabetes (INNODIA and INNODIA-Harvest). They have enabled further co-development and application of the new research tools, educational opportunities, as well as opportunities for public outreach and involvement of patient organisations.

Visit Laura Elo's website and lab for more info.

Figure 7: Early prediction of individualised disease risks using longitudinal profiling of blood samples (DynaOmics project)

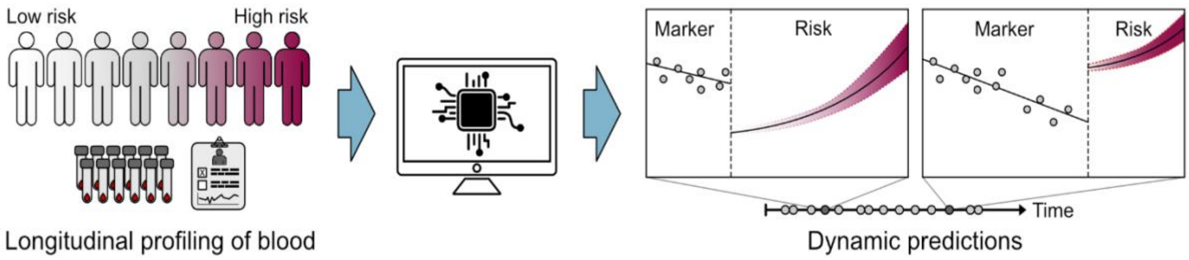
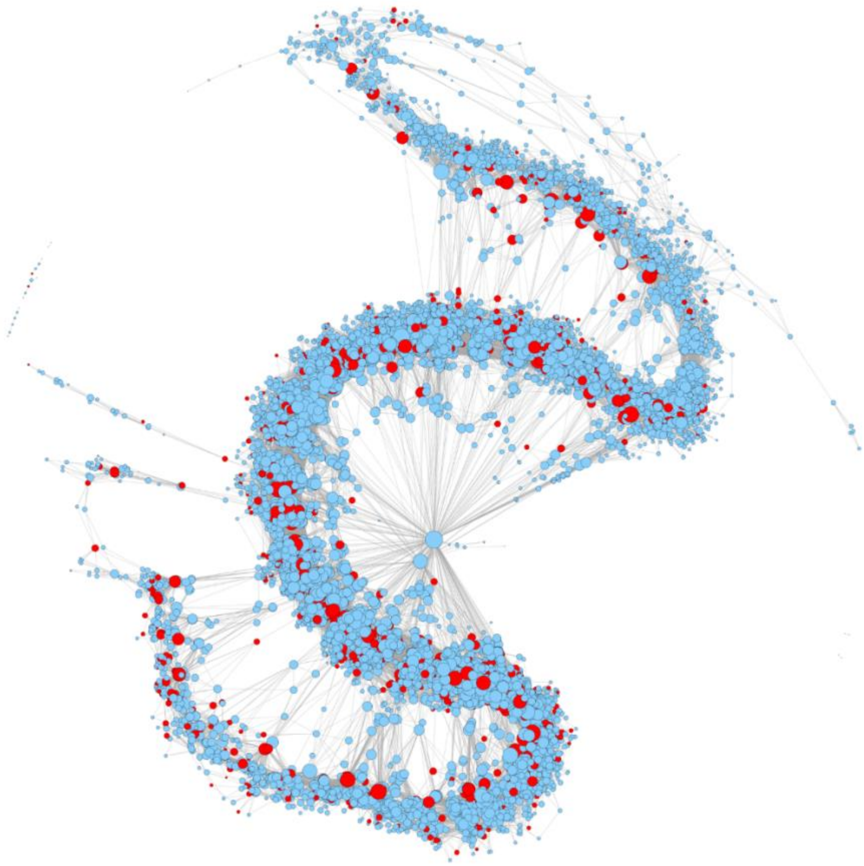


Figure 8: Network of human individuals. Edges of the graph are defined computationally, reflecting the similarity of the individuals. Individuals receiving specific treatment are coloured red (DynaOmics project, original image by Tomi Suomi, University of Turku)



KiD: A low-cost Kinematic Detector to assist early diagnosis and objective profiling of ASD

Motion tracking can provide unique insights into motor, cognitive and social development. A low-cost and wearable system was designed for tracking the movements of enfants and children with autism spectrum disorders (ASDs).

ERC Proof of Concept 2017

Cristina Becchio (Istituto Italiano di Tecnologia, Italy)

Autism spectrum disorders (ASDs) are a heterogeneous set of neurodevelopmental disorders characterised by deficits in social communication and reciprocal interactions, as well as stereotypic behaviours. The ERC Proof of Concept Grant KiD (2018-2019) applied the pioneering approach of the ERC Starting Grant I.MOVE.U (2013-2018) to the study of ASDs. During her ERC Starting Grant, Cristina Becchio and her team made the links between cognitive states (including intentions) and body motions in neurotypical participants and participants with ASDs.

The key novelty of the KiD project was to identify atypical kinematic patterns in children and infants at increased risk for ASDs by using machine learning methods within a co-design human factor engineering. A portable, non-invasive, low-cost device - the Kinematics Detector (KiD) – was developed to track movement kinematics continuously in children with ASDs and development coordination disorders for earlier diagnostic.

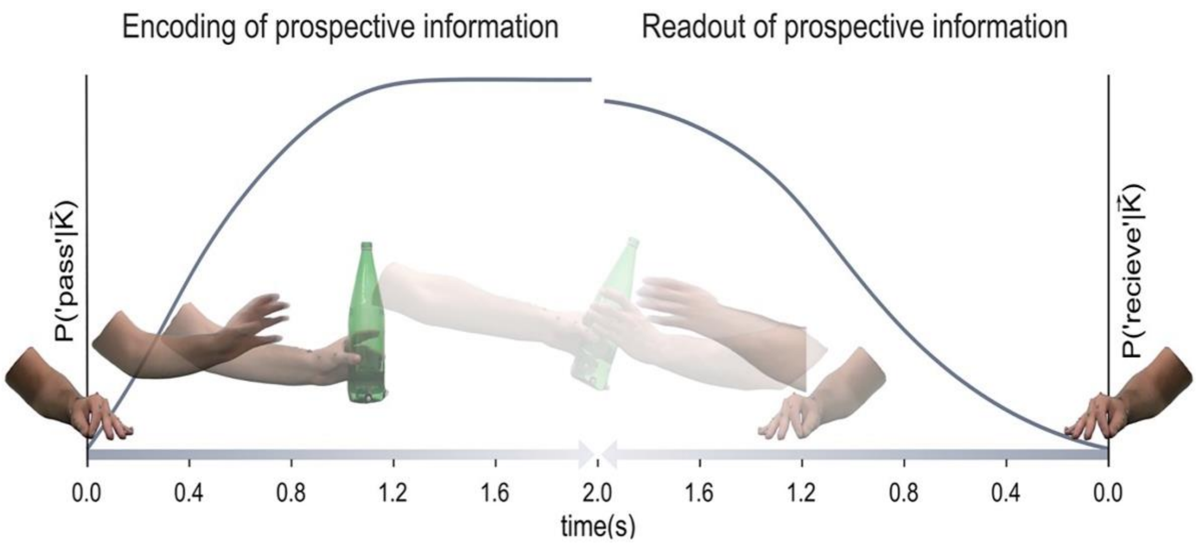
The team used machine learning to understand how abnormalities in cognitive states are encoded in movements and how they may affect social cognition in individuals with ASDs. They also demonstrated reciprocal difficulties in reading intentions from movement patterns in children with autism and typically developing individuals.

The project was able to develop machine learning methods suited to mechanistic research in autism research and generated insights that may ultimately inform clinical practice. Interpretable and transparent machine learning methods are considered crucial by Becchio in her field to understand underlying mechanisms (compared with performance-focused methods pursued by other researchers or research fields).

Both ERC projects led to a broader research programme with potential clinical and translational relevance. Subsequent projects included: the Marie Skłodowska-Curie MINDED project (2018-2024) focusing on a motion-based diagnostic framework for neurodevelopmental disorders; the Horizon Europe ShareSpace project (2023-2025) applying kinematic encoding amplification in VR/AR for neurodivergent users; and the EIC Pathfinder ASTOUND project (2022-2025) dedicated to “conscious” conversational agents (chatbots).

Visit Cristina Becchio’s website for more info.

Figure 9: Kinematic coding enables social transmission of information. Adapted from https://doi.org/10.1016/j.plrev.2024.11.009 (KiD and I.MOVE.U projects)



4.2. Drug discovery

AutoCAb

Automated computational design of site-targeted repertoires of camelid antibodies

Fleishman's research focuses on computational tools for antibody and enzyme design, including advanced machine learning methods. His approach dramatically accelerates the development process of proteins, with key applications for pharmaceutical, chemical, diagnostics and food companies.

ERC Consolidator Grant 2018

Sarel-Jacob Fleishman (Weizmann Institute of Science, Israel)

The ERC Consolidator Grant AutoCAb (2019-2023) developed cutting-edge computational and experimental methods that allow designing, for the first time, millions of antibodies or other functional proteins, and synthesising them accurately and economically for applications in green chemistry, therapeutic antibodies and vaccine immunogens. Selection experiments followed by next-generation sequencing allowed the team to monitor which designs bind their targets and to use advanced machine learning methods to infer rules that would improve the chances of success in the next round of experiments.

The team implemented these methods – including CUMAb, a tool for computational human antibody design - as web servers or in freely available source code to enable other biochemists and protein engineers to customise Fleishman's design protocols for their needs. They also filed for patents on CUMAb, antibodies of therapeutic potential that use CUMAb, and proteins for the cultivated meat industry, gene therapy (for Gaucher disease), and CAR-T therapy.

Recently, Fleishman has shown that deep-learning-based structure prediction algorithms, such as AlphaFold, can be used as reliable starting points for their design algorithms. One-shot protein optimisation distinguishes Fleishman's approach from other strategies relying on cumulative process by enabling generation of as many mutations as needed. One of the first applications was the optimisation of a malaria vaccine candidate, which is now in phase II clinical trials in West Africa.

Methods developed by the AutoCAb project were licensed to two start-up companies, Scala Biodesign and Plantae Biosciences. Scala Biodesign (with Fleishman as Chief Scientist) was established by two former graduate students who were a part of AutoCAb. The start-up develops cutting-edge computational protein design solutions to address complex protein development challenges for top pharmaceutical, chemical, diagnostics and food companies. Scala's one-shot approach dramatically accelerates the development process of proteins into commercial products. For instance, they improved the stability and expressibility of a protein for Boehringer Ingelheim by more than 100 times.

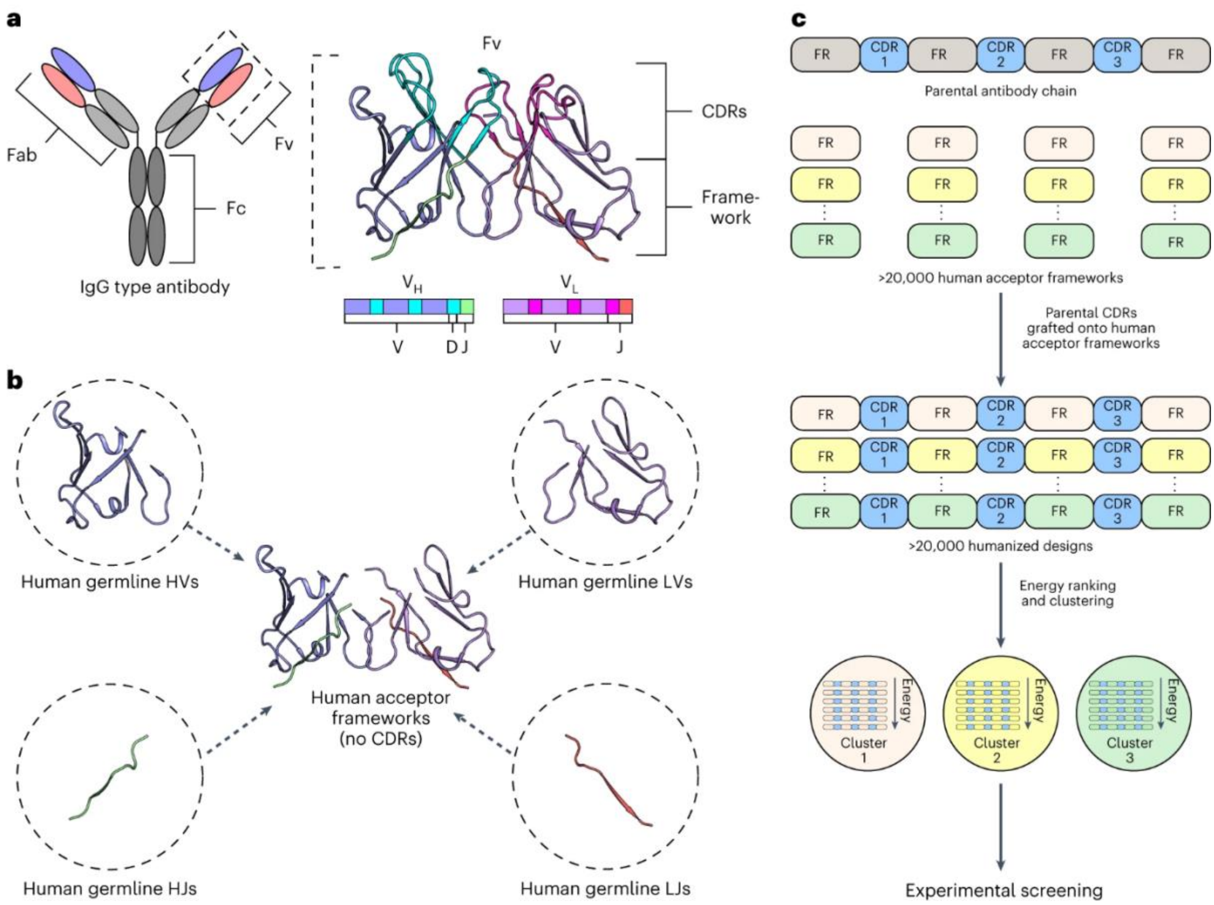
Plantae Biosciences is also using some of the design approaches developed in Fleishman lab in the context of agriculture and health-based products. Plantae, renamed Infinite Acres, has recently been acquired by a major American vertical farming company called 80 Acres Farm, which runs on Infinite Acres technology. Their purpose is to grow high-quality and affordable fresh produce, plus in a more sustainable way by eliminating pesticides and herbicides, dramatically reducing water usage, optimising energy use, and reducing the need for transportation to the bare minimum.

In his new ERC Advanced Grant CADABRE (2024-2029), Fleishman is developing a new computational and experimental strategy to design repertoires comprising billions of human antibodies for phage-display screening. Using new atomistic and AI based methods, the designed repertoires will be "stable by design" and enable accelerated and cheaper development of antibodies into drugs and improved outcomes for patients (with less side effects). One of the outcomes is also to significantly reduce the use of animals in health-related research.

As another follow-up of his ERC-funded research, Fleishman is a participant in the EIC Pathfinder W-BioCat project (2024-2028). The project will introduce a novel enzyme class and develop the processes and technologies required to manufacture this enzyme cost-effectively and in sufficient quantities.

Visit Sarel Fleishman's lab for more outputs.

Figure 10: Key steps in energy-based antibody humanisation using CUMAb. From https://doi.org/10.1038/s41551-023-01079-1 (AutoCAb project)



DISCOVERER: A novel chemical discovery platform enabled by machine learning

A platform for chemical modelling that combines molecular quantum mechanics and artificial intelligence – a “Chemical Space Machine” – was developed for the discovery and design of new drugs, chemicals and materials.

ERC Proof of Concept Grant 2020

Alexandre Tkatchenko (University of Luxembourg, Luxembourg)

Computational discovery and design of new drugs, antivirals, antibiotics, catalysts and battery materials requires the exploration of increasingly growing chemical spaces. Within the ERC Consolidator grant BeStMo (2017-2022), Tkatchenko and his team substantially advanced the ability to model and understand the behaviour of molecules in complex environments.

They successfully developed a set of machine learning and physics-based methods for covalent and non-covalent interactions that now allow an accurate and efficient modelling of molecules of increasing size (from 10 to 1000 atoms). These methods now enable routine calculations of quantum-mechanical properties of molecules throughout chemical compound space. In his previous ERC Starting Grant VDW-CMAT (2011-2016), Tkatchenko developed some of the methods that had an impact for prediction of crystal structures in his subsequent work.

In the ERC Proof of Concept Grant DISCOVERER (2021-2023), Tkatchenko proposed a paradigm shift in chemical discovery by starting with pre-defined parameters from which new chemical entities are designed through machine learning and AI-enabled algorithms. With the goal of translating his research into industrial applications, he integrated these modules into a commercial platform – “Chemical Space Machine” – that can explore compositional and configurational spaces of molecular properties for multiple use-cases in chemical discovery. The PoC project reached a TRL of 4.

A start-up (Quastify GmbH) was launched by colleagues associated with the project, where Tkatchenko acts as Chief Scientist and Co-Founder. Its quantum physics-based AI provides faster, more cost-effective, and higher-performing solutions for discovering chemicals and advanced materials, particularly for pharmaceutical and chemical companies. It offers a significant reduction in the cost of identification of new molecules and in the environmental impact of this process by minimising the amount of wet lab work involved in early molecule discovery. Tkatchenko is launching or is associated with other companies in the US and Luxembourg in his field. He has also engaged in research partnerships with various industrial partners, including Google, Janssen Pharmaceuticals, AstraZeneca, and Boehringer Ingelheim.

Tkatchenko is further continuing his fundamental research through the ERC Advanced Grant FITMOL (2022-2027). It aims to develop and employ a Field-Theory (FIT) approach to describe large (bio)molecules (MOL) within quantum chemistry, towards predictive, efficient, and insightful quantum simulations of large ensembles of molecules.

Concerning his more applied research, Tkatchenko is working on new machine learning algorithms for drug formulation within a new ERC Proof of Concept Grant MACHINE-DRUG (2023-2025). The project aims to develop a novel machine-learning methodology that could accelerate the prediction process for crystal structures by a factor of 100. This methodology can enable researchers and industry to anticipate complications that may emerge over time and use the optimal formulation for each drug.

Tkatchenko is also a partner in the Marie Skłodowska-Curie AIDD project (2021-2025). It works as an Innovative Training Network - European Industrial Doctorate dedicated to preparing a new generation of scientists who have skills in machine learning and innovate drug research.

Visit Alexandre Tkatchenko’s website for more info.

PoreDetect

Bench-top system for detection and analysis of miRNA using solid-state nanopores

The project developed a benchtop device capable of detecting hundreds of molecular targets within tens of minutes, with key applications for personalised medicine and diagnosis, monitoring and treatment of diseases, as well as biological research.

ERC Proof of Concept Grant 2019

Ullrich Keyser (University of Cambridge, United Kingdom)

Building on their innovations in nanopore sensing technology, machine learning and statistics, Keyser and his team within the ERC Proof of Concept Grant PoreDetect (2021-2022) worked to deliver single-molecule detection in an accurate and cost-effective portable device. Fast and reliable detection of single molecules has key applications for personalised medicine and diagnosis, monitoring and treatment of diseases, as well as biological research by offering unprecedented resolution compared with bulk approaches.

Based on work done in his ERC Consolidator Grant DesignerPores (2015-2021), Keyser established novel DNA designs that allow for the identification of short ribonucleic acid (RNA) molecules with length of 20 nucleotides. The strand displacement reactions were used to detect viral RNA as well as synthetic RNA with concentrations in the 100s of pMol range in 10s of minutes. During the project, the production of the prototype for the measurements was re-focused to viral RNA detection; however, as RNA is still the target, the techniques can be used for the original plan of RNA biomarker analysis.

Two patents for detection of long and short RNA strands powered by machine learning techniques were filed through Cambridge Enterprise and were exclusively licensed to a start-up - Cambridge Nucleomics. Launched in 2021, this biotech start-up aims to quantify all short and long RNAs in one simple measurement, with the vision to build an innovative platform technology company for the RNA era of personalised and precision medicine.

With their proprietary nanostructure design technology, Cambridge Nucleomics can customise molecular probes that recognise specific nucleic acid molecules and detect them natively. Their technology allows accurate, fast, high-multiplexed, simple, and direct measurement of the original target molecules without complicated sample processing. The platform technology not only overcomes current pain-points in RNA detection and quantification but is also suitable for the detection of other biomolecules such as DNA.

Key applications include: accurate, fast and direct RNA quantification (native RNA molecules, including short non-coding RNA, e.g. miRNA), drug discovery (quantifying RNA in drug development for all new drug modalities based on nucleotides, such as RNA), and RNA-based diagnostics and prognosis such as cancers (more accurate detection and quantification of RNA).

Cambridge Nucleomics is supported by the Impulse programme at the Maxwell Centre for technology innovators and the Cancer Tech Accelerator by Cancer Research UK and Roche. It has also received grants from Santander Universities in the Accelerate Cambridge programme - the flagship startup accelerator at the Judge Business School, in addition to support from Downing Enterprise.

Visit Ulrick Keyser’s Lab and a Cordis article for more info.

COMBAT-RES: Predicting potent drug combinations by exploiting monotherapy resistance

The project employs deep learning and clinical data to discover drug synergies for various tumour types, including colorectal cancer. The team is tackling cancer drug resistance by using high-throughput screenings and computational methods to identify biomarkers and effective drug combinations.

ERC Starting Grant 2020

Michael P. Menden (Helmholtz Munich, Germany)

One of the key challenges in successfully fighting cancer is overcoming drug resistances. The ERC Starting Grant COMBAT-RES (2021-2025) set out to develop methods that identify drug resistance, detect related biomarkers, and predict drug combinations to overcome monotherapy resistance. For this purpose, Menden and his team are developing advanced biostatistical methods, machine learning and artificial intelligence which are customised to cancer biology.

So far, it has made significant contribution to the development of AI tools for health, focusing on precision oncology and pharmacogenomics. Key scientific achievements include developing AI-driven models for predicting drug resistance and uncovering synergistic drug combinations.

The development of a tool to stratify the patients - the Oncology Biomarker Discovery (OncoBird) framework - is already being applied in clinical trials with promising biomarker findings currently undergoing validation. OncoBird was used in the clinical trial FIRE-3 in colorectal cancer and VARIANZ in HER2-positive gastric cancer, which revealed biomarkers that are now under clinical validation in collaboration with Roche and the Leipzig University Hospital. These findings have the potential to influence treatment strategies and guidelines, demonstrating real-world clinical impact.

Technologically, the project used large language models (LLMs) in clinical trial contexts. It led to a patent on digital twins for patient trajectory simulations while enhancing clinical trial design. The unexpected robustness of LLMs in capturing clinical heterogeneity opened new avenues for AI-based patient modelling. Key software was shared under open science principles, promoting further research and development.

The project's societal impact is enhanced through public outreach, shaping perceptions of AI in medicine, while economically, collaborations with companies like Roche indicate potential commercial opportunities.

Complementary and follow-up funding has been secured from both public and private sources, including Australia's Medical Research Future Fund (MRFF) and the Innovative Health Initiative (IHI) supported UNITE4TB project in Europe. They have also secured partnerships with companies such as Roche, GSK, and AstraZeneca. These collaborations underscore the demand for COMBAT-RES innovations, positioning the project as a keystone for ongoing multidisciplinary research development.

Visit Michael P. Menden's website, and a Cordis article for more info.

4.3. Forecast of risk factors and outcomes

ABRSEIST: Antibiotic Resistance: Socio-Economic Determinants and the Role of Information and Salience in Treatment Choice

Using machine learning and econometric tools, the project identified mechanisms connecting antibiotic resistance and consumption. The goal was to assess feasible and efficient demand-side policy interventions targeted at physicians and patients to battle antibiotic resistance.

ERC Starting Grant 2018

Hannes Ullrich (German Institute for Economic Research/DIW Berlin, Germany)

Resistance to antibiotics is one of the major global threats to human health. Worldwide, every year, 4.95 million deaths are estimated to be associated with antibiotic resistance, and 1.27 million deaths are directly attributable. Antibiotic prescribing has important implications due to increasing antibiotic resistance driven by inefficient antibiotic use. By improving our understanding of prescribing, resistance and antibiotic use, the ERC Starting Grant ABRSEIST (2019-2025) aims to identify and assess feasible and efficient demand-side policy interventions that address physicians and patients. Using machine learning methods, theory-driven structural econometric analysis, and survey-experimental methods, the project has provided rigorous evidence on effective intervention designs.

The project identified first the mechanisms linking antibiotic resistance and consumption by exploiting a unique combination of physician-patient-level antibiotic resistance, treatment, and socio-economic data. The project has showed that antibiotic prescribing largely varies due to differences in physicians' general practice styles. Potential mechanisms leading to such differences include diagnostic information and preferences towards the curbing of antibiotic resistance.

The team further studied the potential complementary role of machine learning methods for decision-making in a typical context of primary health care provision. They used data on bacterial infections and other information encoded in patient-level records from Denmark (microbiological laboratory data linked with administrative data). Using varying data combinations, they evaluated machine learning predictions for diagnosing bacterial urinary tract infections and the outcomes of prescription rules.

The team concluded that decision rules based on machine learning predictions using administrative data may provide a path to improve antibiotic prescribing. Yet, they found that full automation of prescribing fails to improve physician decisions. Instead, it is more effective to aim for complementarity between algorithmic and human decisions. That is, while counterfactual policies based on machine learning predictions alone do not deliver improvements, antibiotic use can be reduced by delegating decisions between physicians and machine learning.

Complementarity arises when physicians possess private or context-specific information that is key for diagnostics but cannot easily be encoded in data and machine learning algorithms. ABRSEIST showed that combining physician and algorithmic decisions can achieve a reduction in inefficient overprescribing of antibiotics by 20.3%. The project also identified potential misalignment of expert decision makers and system designers, which can jeopardise efficiency objectives in public health.

Antibiotics prescription systems should be designed with the inputs from human experts that can improve the overall decision. The project recommends that the value of increasingly rich data combinations and new prediction tools must be quantified by evaluating human decisions they support, which depend on the quality of human experts' risk assessment and their objectives.

Visit the project's website and Hannes Ullrich's website for more info.

AI-PREVENT: A nationwide artificial intelligence risk assessment for primary prevention of cardiometabolic diseases

The team is using AI approaches to integrate nation-wide health data and genetic information with the goal of predicting cardiometabolic diseases. It can bring about a paradigm shift in the way cardiometabolic disease risk is assessed and the identification of high-risk individuals at an early stage.

ERC Starting Grant 2020

Andrea Ganna (University of Helsinki, Finland)

Diabetes, stroke and coronary artery disease (cardiometabolic diseases) are the leading cause of death in Europe. With the ERC Starting Grant AI-PREVENT (2021-2026), Ganna and his team aim to revolutionise the existing approaches to primary prevention by providing AI-based risk assessment of cardiometabolic diseases before someone even steps into the doctor's office for a visit.

As a key achievement, Ganna has set up the Finnish National Health Data Registry (Fin Registry), one of the largest registry-based dataset in the world for developing statistical and machine learning models. It includes over three billion data points containing health and socioeconomic information for all Finnish citizens – their "life stories" or "trajectories" up until 2022 (latest update) - covering public health care visits, health conditions, medications, vaccinations, laboratory responses, demographics, familial relations and socioeconomic variables. It is managed by the Finnish National Institute of Health.

Researchers can use the Fin Registry data to train their machine learning models. Ganna has used it for example in his work in prediction models for one-year mortality and RSV (respiratory syncytial virus) infection in children, or in fairness assessments of AI algorithms, for which linking health and socioeconomic data is key.

Ganna has created and leads the largest international consortium studying the human genetics of COVID-19**.** This initiative aims to generate, share, and analyse data to learn the genetic determinants of COVID-19 susceptibility, severity, and outcomes. Such discoveries could help to identify individuals at unusually high or low risk, generate hypotheses for drug repurposing, and contribute to global knowledge of the biology of SARS-CoV-2 infection and disease.

The establishment of the Fin Registry, supported by the ERC grant, enabled Ganna to access multiple grant sources across diverse research topics. In parallel with his ERC-funded research, Ganna is co-coordinator of H2020 INTERVENE project (2021-2025) and part of Horizon Europe NEUROCOV project (2022-2027).

Other funding sources are the Finnish Research Council, private foundations, and the US National Institutes of Health (NIH). Ganna was awarded in 2022 a prestigious Leena Peltonen Prize for Excellence in Human Genetics by the European Society of Human Genetics.

Visit Andrea Ganna's website and a CORDIS Results Pack article for more info.

CONNECT: Connecting cross-condition patterns of brain connectivity towards a common mechanism of mental conditions and prediction connectomics

The project has built a large MRI database to analyse brain fingerprints across a wide range of neuropsychiatric conditions. It then applies machine learning to understand the similarities and differences between these diseases, while building personal brain roadmaps. Based on whole-brain profiles, the project aims to calculate disorder-specific risk estimate for individuals.

ERC Consolidator Grant 2020

Martijn van den Heuvel (Stichting VU, Netherlands)

Brain disorders are marked by unique features yet share many clinical and genetic associations. The ERC Consolidator Grant CONNECT (2021-2026) aims to map and understand brain mechanisms underlying the overlap and specificities between different neuropsychiatric diseases.

The team has achieved the collection, processing, and analysis of large volumes of MRI datasets: 120 datasets, including over 26,000 controls and 15,000 patients across 20 disorders, in addition to the large-scale UK Biobank comprising 37,000 individuals, encompassing 15,000 patients with neuropsychiatric disorders. The data is used for the identification of brain patterns associated with each of these disorders, bringing 20 different disease brainmaps. The team has developed the software package Connectivity Analysis TOolbox (CATO) for preprocessing large MRI datasets into structural and functional connectomes, which is available under an open-source license.

The project has also built "disease maps", as representations of altered functional connections within the brain associated with various psychiatric and neurological conditions. These maps were computed for each disorder across three modalities: brain morphology, functional connectivity, and structural connectivity.

Another objective was to develop novel machine learning tools, such as the polyconnectomic score (PCS) for network analysis. This metric provides a disorder-specific risk estimate based on comprehensive connectomic profile of an individual. It also correlates brain signatures to clinical and behavioural measurements, which enables a deeper understanding of neurobiological underpinnings within and across various neuropsychiatric conditions with potential clinical applications.

Van den Heuvel has worked with some researchers from the Ebrains initiative, underlining the importance of large-scale data integration efforts in Europe. Originally built by the Human Brain Project, one of the European Future and Emerging Technologies (FET) Flagships, EBrains is now an open research infrastructure that offers an extensive range of brain data sets, a multilevel brain atlas, modelling and simulation tools, access to high-performance computing resources and robotics and neuromorphic platforms to researchers.

Visit Martijn van den Heuvel's website and lab for more info.

4.4. Medical imaging

BUNGEE-TOOLS: Building Next-Generation Computational Tools for High Resolution Neuroimaging Studies

The project developed a unique atlas of the human brain using histology, as well as a set of companion machine learning methods that analyse MRI scans of any resolution and contrast. It can lead to better analysis of clinical MRI scans and increase our understanding of the human brain.

ERC Starting Grant 2015

Juan Eugenio Iglesias (University College London, United Kingdom)

Recent advances in magnetic resonance imaging (MRI) acquisition technology are providing images of the human brain of increasing detail and resolution. However, the ability to analyse these clinical scans has been hampered by the lack of software tools up to the new standards. The ERC Starting Grant BUNGEE-TOOLS (2016-2022) developed a set of next-generation computational tools to enable neuroimaging studies to take full advantage of the increased resolution of modern MRI technology.

One of the key outcomes of the project is the creation of NextBrain, a comprehensive histological atlas of the human brain. This atlas features an unprecedented 10,000 of histological sections, that is, very thin sections of tissue cut from donated brains imaged with a microscope, each with detailed delineations of hundreds of brain structures.

The team also developed innovative techniques for joint image registration and synthesis, which enabled the automated reconstruction of 3D models from the histological sections of five human brain hemisphere. The atlas is publicly shared with a set of companion tools that enable application of the atlas to the automated analysis of human brains with a superior level of detail, compared with previous tools and atlases. This will enable researchers to identify, for example, more subtle signs of healthy ageing or early disease symptoms.

Another major achievement is the development of a deep machine learning method for automated image analysis that can handle brain MRI scans of any resolution and contrast. Traditional AI techniques often struggle with clinical data due to variations in image contrast and resolution found in scans acquired with clinical purposes. To overcome this challenge, the team trained neural networks using synthetic data with random resolution and contrast. This innovative approach transforms clinical brain MRI scans with poor contrast and orientation into research-grade scans to be analysed using existing neuroimaging packages. These AI tools SynthSR and SynthSeg are open-source, free, and easy to use.

Such tools can help analysing clinical brain MRI scans from existing imaging systems in hospitals. The ability to analyse these clinical scans allows for studies to use far more scans than traditional studies, without extra costs since the scans already exist in hospitals worldwide. They also make it possible to study populations and diseases that are often neglected in research studies.

The team also shared large amounts of spatially aligned MRI and histology that researchers can use to build their models, study the relationship between the two modalities, or develop teaching materials.

Iglesias has received further funding from Alzheimer's Research UK (ARUK) and US National Institutes of Health (NIH). He is currently Associate Professor at Martinos Center for Biomedical Imaging at Massachusetts General Hospital, Harvard Medical School and holds an affiliate appointment at MIT.

Visit Juan Eugenio Iglesias and the project's website for more info.

Figure 11: AI tools SynthSR and SynthSeg for quantitative analysis of huge amounts of heterogeneous brain MRI scans acquired with clinical purposes. (From ERC project BUNGEE-TOOLS)

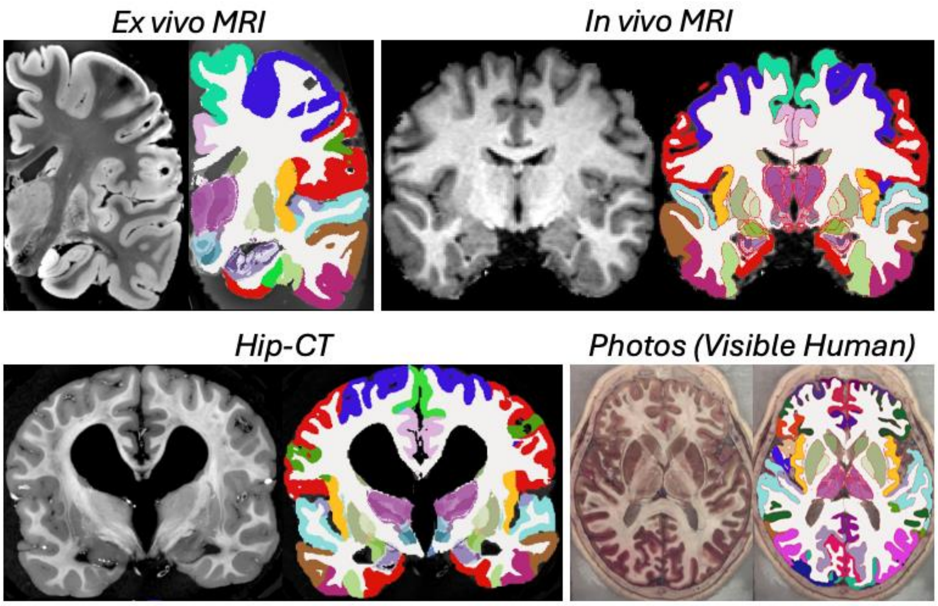
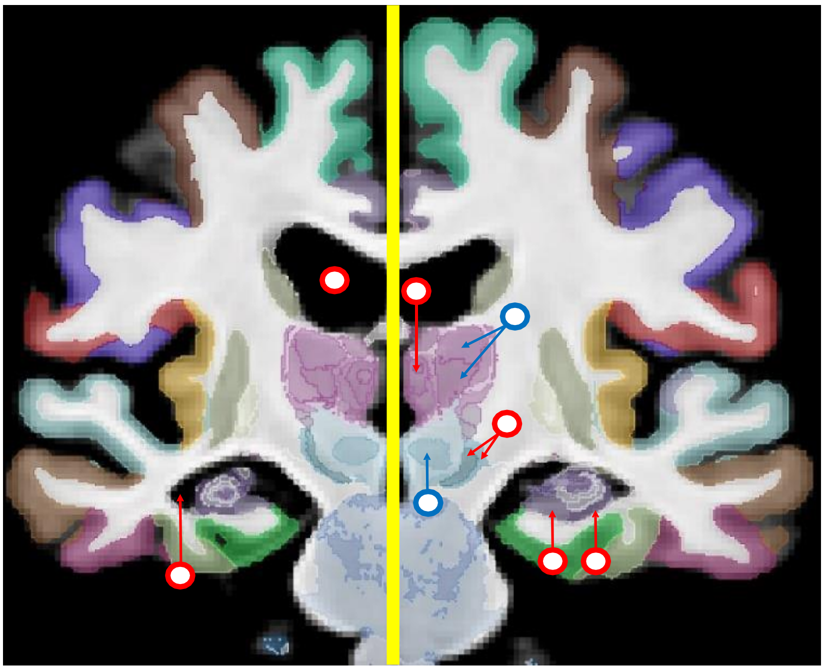


Figure 12: Brain MRIs of 100 subjects with Alzheimer's disease (left) and of 100 aged-matched, healthy, old adults (right). In red regions that atrophy faster than their neighbours in Alzheimer's Disease/ In blue examples of regions that atrophy slower (From ERC project BUNGEE-TOOLS)



MIRA: Next Generation Machine Intelligence for Medical Image Representation and Analysis

Medical imaging is a key technology for clinical decision-making. The project developed new machine learning strategies for more robust and reliable image analysis. New disease detection models were built based on generalisable and trustworthy algorithms.

ERC Starting Grant 2017

Ben Glocker (Imperial College of Science, Technology and Medicine, United Kingdom)

With an increasing complexity and large volume of data, the interpretation of medical images and extraction of clinically useful information require the support from intelligent computational tools. The ERC Starting Grant MIRA (2018-2024) developed algorithms that can learn from each other and exchange information to solve complex image analysis tasks. It leveraged large-scale population data and linking images with non-imaging data such as demographics, lifestyle, genetics and disease to construct powerful statistical models.

A major achievement was the development of a novel approach to causal generative AI. The deep structural causal models developed by Glocker and his team enable, for the first time, high-resolution and plausible counterfactual image generation ("what-if").

The team also built new algorithms for fully automatic, highly accurate image segmentation based on deep learning. Their Brain Lesion Analysis and Segmentation Tool for Computed Tomography (BLAST-CT) uses deep convolutional neural networks to accurately detect, identify and segment different types of bleedings in the brain. The identification of traumatic brain injuries provides key information for deciding on treatment strategies and patient management in the setting of emergency and intensive care.

Glocker further worked on how "black box" machine learning reaches decisions, that is, how it works under different settings and under which conditions it may fail. A methodology for automated quality control and prediction of failure cases that can be used before and after clinical deployment of AI was developed.

With experts from multiple disciplines, including AI regulation and clinical evaluation, bioethics, and computer science, Glocker co-developed a framework for auditing medical AI algorithms. The framework was incorporated in the UK's Medicines and Healthcare products Regulatory Agency (MHRA) official document on 'Software and AI as a Medical Device Change Programme – Roadmap'. Glocker's work is highlighted under 'Best practice AIaMD development and deployment'.

Most recently, Glocker developed a bias detection framework in medical AI algorithms, which revealed important shortcomings of current disease detection models such as subgroup performance disparities across biological sex and race. The study was subject of an independent commentary and news item, both highlighting the potential risks for using foundation models in AI for medical imaging.

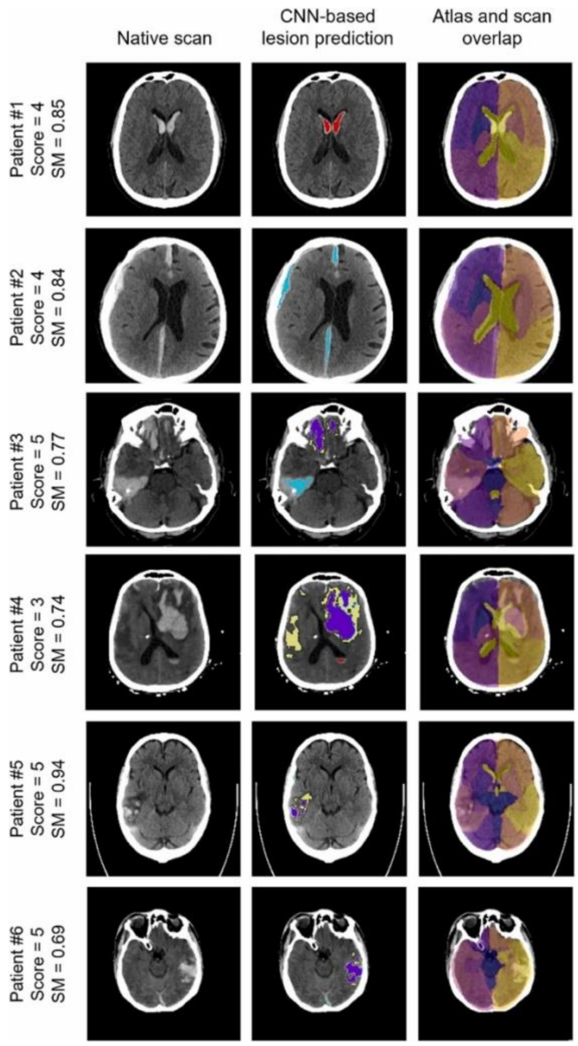
Other initiatives in which Glocker has contributed include: FUTURE-AI an international consensus framework for trustworthy and deployable AI in healthcare; STANDING Together recommendations to encourage transparency regarding limitations of health datasets and proactive evaluation of their effect across population groups; and TRIPOD+AI statement for reporting clinical prediction models that use regression or machine learning methods.

As a follow-up of his ERC-funded research, Glocker is currently the Royal Academy of Engineering Research Chair in Safe Deployment of Medical Imaging AI, supported by Kheiron Medical Technologies, an AI breast cancer diagnostic company.

Glocker leads the HeartFlow-Imperial Research Team as part of a collaborative research agreement between Imperial College London and California-based HeartFlow, a company that offers a non-invasive method to detect and quantify blockages in arteries. Glocker is also the Knowledge Transfer Lead of CHAI – the UK EPSRC Causality in Healthcare AI Hub (£12m funding), dedicated to developing fully explainable causal AI platforms to address healthcare challenges across prevention, diagnosis, and treatment.

Visit Ben Glocker and MIRA project's website for more outputs.

Figure 13: Qualitative atlas mapping results with lesion map prediction from BLAST-CT (From ERC project MIRA, source here)



DEEP FIELD: Seeing the Unseen in Image-guided Surgery

The project is developing innovative sensors for magnetic tracking of surgical instruments. The DEEP FIELD technology aims to change clinical surgery with applications in cardiovascular navigation, endoscopy and robotic surgery, leading to significantly improved patient outcomes.

ERC Consolidator Grant 2020

Padraig Cantillon-Murphy (University College Cork, Ireland)

Image-guided surgery enables surgeons to navigate their instruments with precision and speed. However, it requires the use of harmful X rays or CT. The ERC Consolidator Grant DEEP FIELD (2021-2026) is developing magnetic tracking for surgical instrument navigation, which instead allows for accurate tracking of instruments, tools and cameras inside the patient. It can significantly reduce or eliminate the use of real-time harmful radiation in many procedures, while enabling more accurate surgery and advanced image fusion.

The design and development of the first on-chip sensor for magnetic tracking in surgery is a major achievement of DEEP FIELD. The project has created ground-breaking magnetic field transmitter designs with new magnetic field shaping and distortion rejection techniques to provide faster (2.5X) and more accurate (8X) tracking. The team worked on entirely novel algorithms for surgical instrument tracking using sensor fusion and machine learning approaches to compensate for magnetic field distortion.

Another breakthrough is the development of sensor fusion approaches where combined accelerometer and magnetic sensors are integrated into a single package for catheter tracking. They were prototyped and optimised in collaboration with PixApp, the world's first open-access Photonic Integrated Circuit PIC Assembly and Packaging Pilot line, hosted at Tyndall National Institute.

The technologies developed in DEEP FIELD underwent clinical test planning at Cork University Hospital and the UCC ASSERT Centre, as well as pre-clinical live animal validation in the French Centre for Image-guided Surgery (IHU Strasbourg).

Their first clinical trial is taking place within the context of the ERC Proof of Concept Grant SaorTrack (2024-2026), which involves direct collaboration with a local hospital and clinicians. Cantillon-Murphy and his team will validate a wireless magnetic navigation design for cardiology applications, such as electrophysiology (EP) mapping of the beating heart. This design integrates with existing technology to accurately localise colon abnormalities and enable quicker diagnoses. The project will also demonstrate high-accuracy positional navigation in capsule endoscopy for the first time.

Cantillon-Murphy has co-founded three start-up companies – for instance, Quadrant Scientific, founded in 2018, is now developing customised electromagnetic tracking and navigation technology across multiple clinical segments. Cantillon-Murphy is also co-inventor on 6 patent applications – one of the most recent in 2024 concerns electromagnetic sensing for real-time tracking for surgery (WO/2024/126516).

Visit Padraig Cantillon-Murphy’s website for more info.

Figure 14: On-chip sensor for magnetic navigation (From DEEP FIELD project)

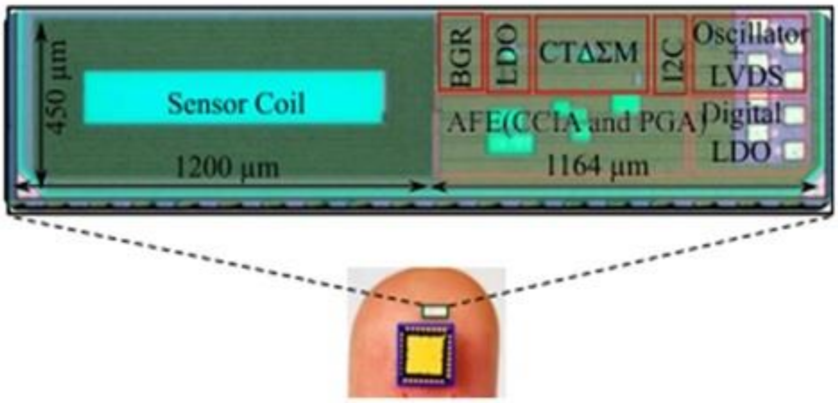


Figure 15: Application of magnetic navigation in bronchoscopy for the diagnosis and treatment of airway diseases like lung cancer (From DEEP FIELD project)

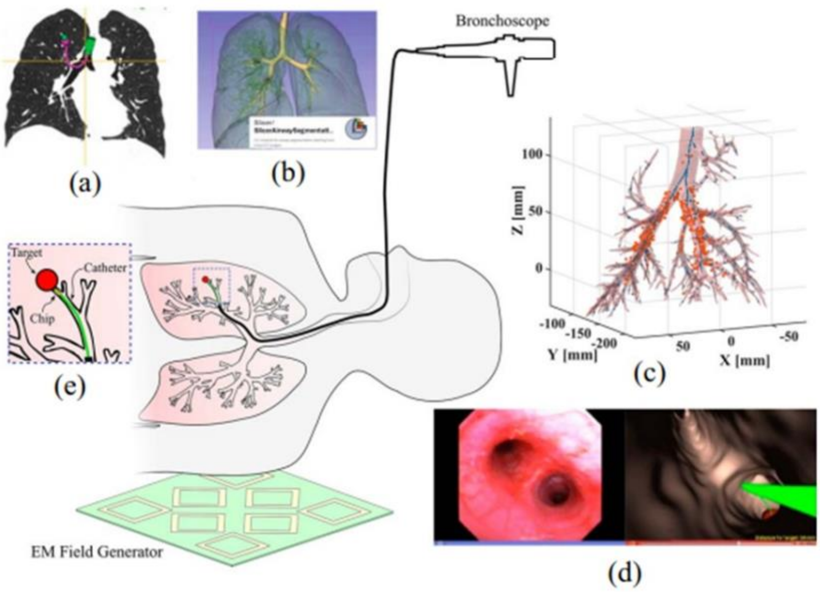
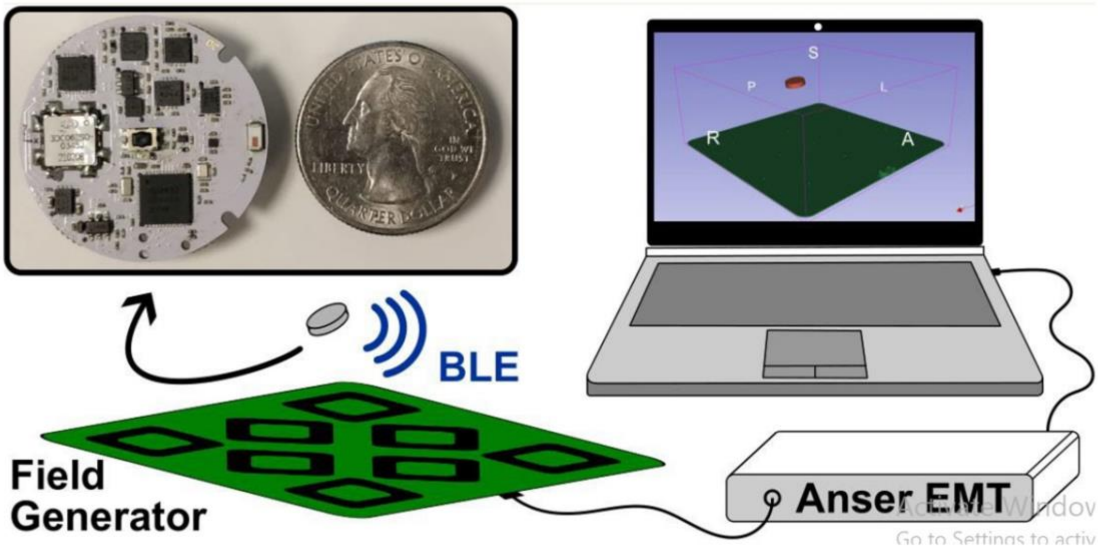


Figure 16: Future applications for magnetic navigation include wireless tracking in capsule endoscopy in patients across a broad range of gastrointestinal diseases (From DEEP FIELD project)



PULSE: Perception Ultrasound by Learning Sonographic Experience

The project explored the use of AI-based technologies to mimic more closely the actions of ultrasound operators. Novel machine-learning based computational models were built based on probe and eye motion tracking, image processing, and knowledge of how to interpret real-world clinical images and videos.

ERC Advanced Grant 2015

Alison Noble (University of Oxford, United Kingdom)

The ERC Advanced Grant PULSE (2016-2023) developed AI-based technologies for next generation of ultrasound imaging that make medical ultrasound more accessible to non-expert clinicians.

Noble and her team were pioneers in the use of deep learning in medical image analysis for image-based task automation (segmentation and object detection), and on how to advance clinical ultrasound using multi-modal video analysis. The project demonstrated how to predict where someone looks ("on average") and how to model hand-eye coordination in sonography to enable prediction of how to move a probe and where to look on the screen.

A key novel element was to use expert sonographer eye movement, probe movements and the spoken word of sonographers. AI-based models were built based on, not only the recorded ultrasound video, but also human perceptual information (as human knowledge). The underlying premise was that using eye tracking and probe motion information to inform image and video recognition algorithm design can help to build more useful machine learning solutions that more closely mimic human interpretation/actions.

PULSE was highly inter-disciplinary, involving engineers/data scientists and clinical researchers working closely together in all parts of the project, from acquisition system design to clinical data annotation, through to design of the clinical evaluation protocols and selection of the clinical tasks.

Video, gaze, probe motion and audio data were recorded for first, second and third trimester foetal scans in a real-world clinical setting and for multiple sonographers of different expertise. This diversity of data allowed also the team to develop automated analytic tools to study clinical workflow and to characterise scanning differences between individuals and experts/newly qualified sonographers for full scans and foetal echocardiography.

Building on the results of PULSE, Noble further developed an AI-assistive system to guide a user to find a standard mid-trimester foetal ultrasound imaging plane in the context of the ERC Proof of Concept Grant PURFECT (2021-2022). A series of pilot usability studies were conducted to understand how AI-assisted image plane guidance can assist a trainee in diagnostic imaging and give them reassurance just as a human tutor or more experienced colleague might do.

Alison Noble was a co-founder, director and senior consultant to the laboratory spinout Intelligent Ultrasound Ltd, which became in 2017 the Clinical AI division of MedaPhor PLC. The company was acquired in 2024 by GE Healthcare, and more recently in February 2025 by Surgical Science Sweden AB, one of the world's leading medical simulation companies.

Recent awards include the BMVA Distinguished Researcher award (2022), the Royal Society Gabor Medal (2019), and the MICCAI Society Enduring Impact Award (2019). Noble was awarded in 2023 a UKRI Turing AI World-Leading Researcher Fellowship on human-AI collaboration and federated learning for international research partnerships in healthcare imaging.

Noble was appointed as a Vice President and Foreign Secretary of the Royal Society in 2023.

Visit Alison Noble's website and PULSE website for more info.

4.5. Medical robots

ARS: Autonomous Robotic Surgery

Autonomous surgical robots can potentially carry out simple intervention steps, react faster to unexpected events, or provide assistance to physicians. Fiorini and his team have established a framework for the design and execution of autonomous robot-assisted surgical tasks, while developing prototypes to assist in prostate cancer biopsies.

ERC Advanced Grant 2016

Paolo Fiorini (University of Verona, Italy)

Autonomous robots can provide key support, assistance, and guidance to humans in surgical settings. For that purpose, robots must have sophisticated reasoning capabilities, be aware of their surroundings and be capable of a cognitive interaction with their human counterparts. The ERC Advanced Grant ARS (2017-2023) focused on modelling, planning and execution of autonomous tasks in robot-assisted surgery.

The project had significant scientific impact through key developments. The team developed “Surgic Berta” that was able to transform the text extracted from a Robotic Surgery manual into a sequence of logical expressions. The team also developed a new calibration method for an endoscopic camera, plus an algorithm that can track the positions of instruments and organs in an anatomic environment (“Semantic SLAM”).

The motions of the robotic arm were carried out via DMP (Dynamic Movement Primitive) that enabled learning the “shape” of the motions from very few examples. Finally, the team used simulation to test a procedure plan and to keep an updated image of the anatomical environment. Plus it also used the simulation as the background knowledge for the real actions. This new approach drove the development of DEFRAS, a cognitive architecture for autonomous tasks. Deep networks were trained to control the execution of complex tasks such as the tissue lifting.

The ARS project allowed for further applications done within the ERC Proof of Concept Grant PROST (2019-2021), which focused on surgery for percutaneous interventions such as prostate biopsy. The team built the PROST 1 prototype that reached Autonomy Level 1, that is, the device provided cognitive and manual assistance to the physician to improve the outcome of the prostate biopsy. Its success led to the founding of the company NeedIeye Robotics for its commercial development.

The PROST 1 prototype was further developed in the context of the EIC Transition Grant ROBIOPSY (2023-2026). The team is currently working on moving from TRL4 to TRL6, adding new features, and improving structure and readiness for early-stage cancer therapy.

In a following ERC Proof of Concept Grant PROCT (2022-2024), Fiorini and his team also explored Optical coherence tomography (OCT) for prostate cancer diagnosis. The system pinpoints the target lesion and analyses it through an AI and robotic-based imaging setup, which can visualise the lesions at the microscopic level in vivo, without taking any physical sample of the prostate. This solution was obtained by merging the AI-based target identification with robotic pointing developed in the previous PoC project PROST with a micro-OCT sensor capable to acquire images of the prostate through a needle at cellular-level resolution.

In the most recent ERC Proof of Concept Grant PROFTH (2024-2025), the researchers aim to advance robotics and AI technologies for focal therapies in prostate cancer using the robotic positioned developed during PROST. The idea is to improve the positioning of devices in the prostate cancer area that facilitate percutaneous cancer ablation. A digital twin of the pelvic area and algorithms for device positioning will help minimise tissue removal.

In 2024, Fiorini was granted a patent for a surgical device for transperineal prostate biopsy for a movable robot arm (EP3927241A1).

Visit Paolo Fiorini's website for more info.

Figure 17: Deep network training to execute a tissue lifting task. Training was done in simulation and then moved to control the real task with the surgical robot. (From ARS project)

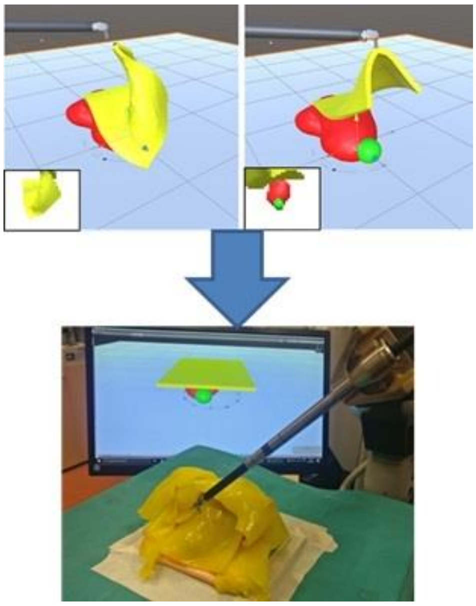


Figure 18: PROST 1 prototype

Figure 19: PROST 2 prototype

i-NANOSWARMS: Cooperative Intelligence in Swarms of Enzyme-Nanobots

Sánchez develops nanobot swarms capable of self-propelling using biocompatible fuels with key biomedical, enhanced drug delivery and medical imaging applications. The nanobots can penetrate human tumours and enhance drug accumulation in target cells.

ERC Consolidator Grant 2019

Samuel Sánchez Ordóñez (Institute for Bioengineering of Catalonia, Spain)

In 2012 Samuel Sánchez and colleagues in Dresden, Germany, developed the first nanomotors that moved using non-biocompatible fuels. In a further step, within the ERC Starting Grant LT-NRBS (2013-2017) Sánchez's team moved to Stuttgart and managed to make the nanomotor self-propel using biocompatible fuels, with the aim of transporting and delivering drugs in vivo.

Sánchez's research was also applied in another field within his ERC Proof of Concept Grant MICROCLEANERS (2016-2018). The project developed active self-mixing and multifunctional systems (microcleaners) capable of cleaning chemical and biological pollutants, such as pharmaceuticals, heavy metals and bacteria. Furthermore, Sánchez and team developed a wearable lab-in-patch monitor for non-invasive self-assessment of phenylketonuria (PKU) within another PoC LABPATCH (2018-2020).

Within his latest ERC Consolidator Grant i-NANOSWARMS (2020-2026), Sánchez and his team are working on a paradigm shift from individual "passive" nanoparticles towards swarming intelligence of "active" nano-systems. They are developing enzyme-powered nanobot swarms capable of self-propelling using biocompatible and bioavailable fuels. The project aims to demonstrate the applicability of intelligent nanoswarms for biomedical applications, enhanced drug delivery and medical imaging.

Sánchez's research group filed a patent on enzyme nanomotors in 2018 which was extended to WIPO/PCT (WO2020115124) during the first period of the Consolidator Grant. The patent is one of the first ones in the field of nanomotors with applicability in medicine and wide coverage in oncology.

Building on such work, Sánchez is further developing self-propelled nanoparticles within the ERC PoC MucOncoBots (2023-2025). Such nanobots can break down the mucus barrier while delivering anti-cancer drugs directly to the tumour site. This all-in-one solution enables more effective targeting of cancerous tissues while reducing the need for aggressive procedures and minimising side effects. In his next ERC PoC ORTHOBOTS (2024-2026), Sánchez is building nanobots designed to actively transport growth factors within the joints of patients suffering from osteoarthritis.

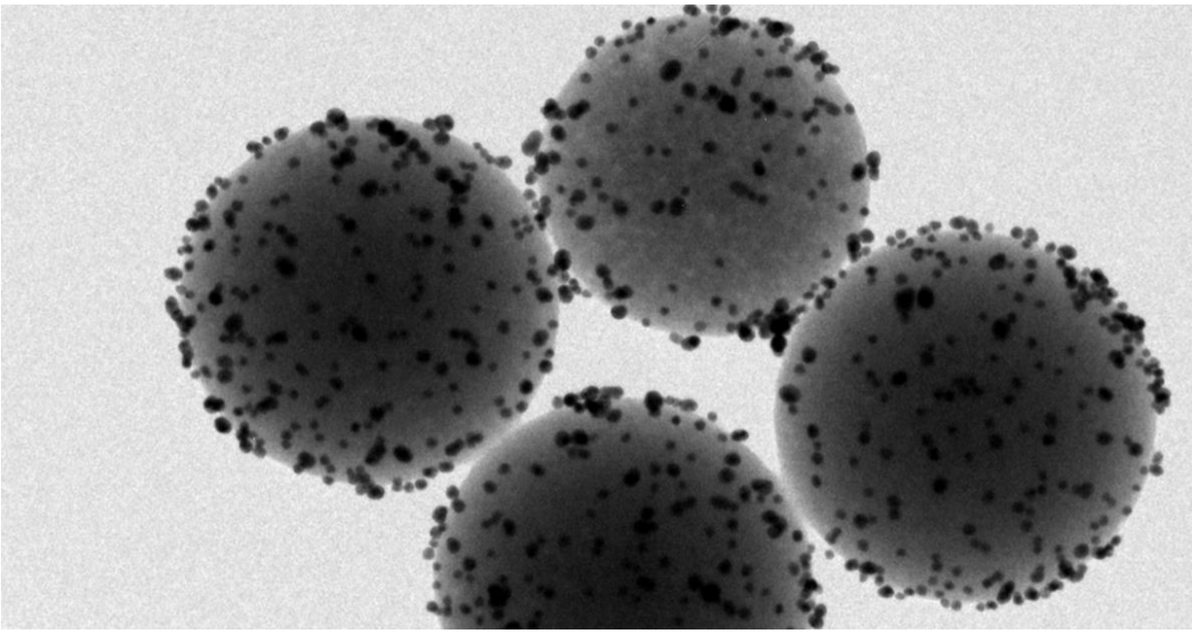
Given the interest in this technology from clinicians, private sector and investors, Sánchez founded in January 2023 a spin-off named Nanobots Therapeutics. It is a deeptech company focused on developing and commercialising the MotionTx platform. This technology enables the development so far of nanobots that penetrate bladder tumours and reduce their size by 90% in a single application.

Since its founding, Nanobots Therapeutics has raised more than €5 million EUR in public and private funding, with the goal to complete preclinical studies and move towards first-in-human trials in 2028. Investors included business angels such as ESADE BAN, Economistes BAN, College of Economists of Catalonia, Bridge BAN, Banco Sabadell's BStartup and Prous Institute for Biomedical Research. It also received 450k EUR grant in 2024 from the Spanish Association Against Cancer.

The results of i-NANOSWARMS have allowed the background knowledge for other EU-funded projects, such as Horizon Europe BioMeld project (2022-2025), 2 competitive projects from the Spanish Ministry of Science and Innovation and 1 from the Catalan Research Agency, projects funded by private foundations (CaixaResearch Health by La Caixa Fundacion) and 2 direct contracts with companies.

Visit Samuel Sánchez Ordóñez's website, a ERC video and a Cordis article for more info.

Figure 20: Nano motors (From i-NANOSWARMS project)



4.6. Personalised medicine

ExpoBiome: Deciphering the impact of exposures from the gut microbiome-derived molecular complex in human health and disease

The project aims to, for the first time, comprehensively identify microbiome-derived molecules and their effects on human physiology. The team is applying cutting-edge molecular approaches to microbiome samples and is integrating them with advanced computational biology and machine learning methods.

ERC Consolidator Grant 2019

Paul Wilmes (University of Luxembourg)

Changes to the human gut microbiome occur in several chronic diseases characterised by inflammation, including neurodegenerative and autoimmune diseases. The ERC Consolidator Grant ExpoBiome (2020-2026) is studying microbiome-derived molecules and their impact on the human immune system, for the development of diagnostics and therapeutic applications.

The project has made significant advances in the human microbiome field. The team developed currently the most comprehensive software tool on the pathogenic potential of a microbiome – PathoFact. It provides newly built databases and machine learning based approaches to predict virulence factors, bacterial toxins, and antimicrobial resistance genes based on metagenomic and metatranscriptomic data.

The team also developed a new protocol, exBioMolXtract, that provides a systematic account of human gut microbiome-secreted molecules by integrated multiomics. A new interactive online tool, the Expobiome Map, integrates the state-of-the-art on known interactions between the host immune system and microbial factors. It graphically shows interactions between microbial taxa, microbial molecules, human immune pathways and diseases, including in Parkinson's disease and rheumatoid arthritis.

ExpoBiome also developed an automated binning algorithm, binny, to recover high-quality genomes from complex metagenomic datasets. The algorithm improves existing approaches for the reconstruction of genomes from metagenomic data, which is crucial to link back biomolecules to their organism of origin and has recently been found to be best-in-class.

The team devised a model clinical intervention (therapeutic fasting and time-restricted eating) to reduce inflammation. A gut-on-a-chip technology (HuMiX) allows to monitor in real-time, with unparalleled spatial resolution, gut health and intestinal barrier's reaction to various stimuli.

When it comes to policy impact, during his ERC grant Wilmes was appointed "chargé de mission COVID-19" of the University of Luxembourg, co-speaker of the COVID-19 Task Force of Research Luxembourg, member of the Luxembourg Ministry of Health's COVID-19 Working Group on Science and Prevention and member of the Luxembourg Government-appointed expert group on vaccination. The COVID-19 Task Force was awarded the 2022 Science for Society Prize by the Fondation de Luxembourg for providing data and forecasts on a regular basis throughout the pandemic to inform key government decisions, while bringing evidence-based data to the public through press conferences and media interviews. A key outcome of these efforts is that Luxembourg had the lowest excess mortality due to COVID-19 in the European Union plus the United Kingdom in year 2020 and 2021.

The mass screening and contact tracing data allowed the identification of asymptomatic carriers, which have also allowed Wilmes' team at the Luxembourg Centre for Systems Biomedicine of the University of Luxembourg and partners from other national research institutions to study the impact of COVID-19 on the gut microbiome in asymptomatic-to-moderate COVID-19. They found that an increased infective competence in COVID-19, resolved using their PathoFact machine learning tool, may be linked to longer-term effects of COVID-19.

Building on AI-based molecular interaction modelling in ExpoBiome, Wilmes will explore if small proteins originating from gut microbes could serve as biomarkers for Parkinson's disease in a new ERC Proof of Concept Grant AMY-Dx (2026-2027). The aim is to develop the first microbiome-linked, blood-based diagnostic and prognostic test for a major chronic human disease, which could be a significant breakthrough in the early detection and management of Parkinson's.

Visit Paul Wilmes' website and CORDIS article for more info.

Figure 21: Accurately forecasting microbiomes over 3 years into the future (ExpoBiome project)

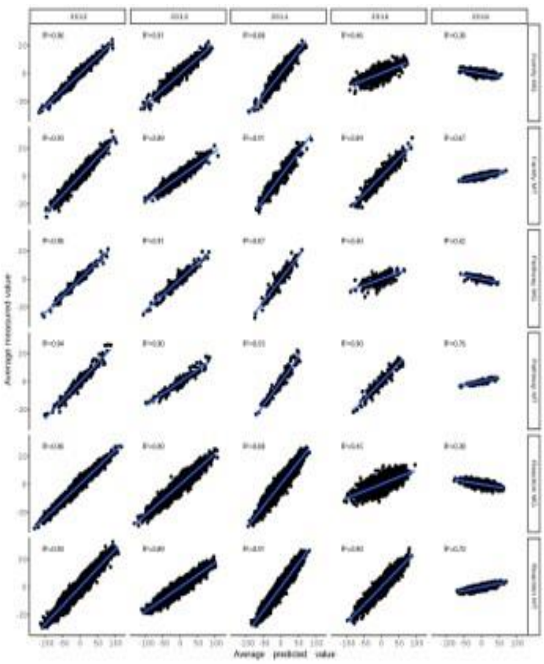


Figure 22: Machine learning & metagenomics (ExpoBiome project)

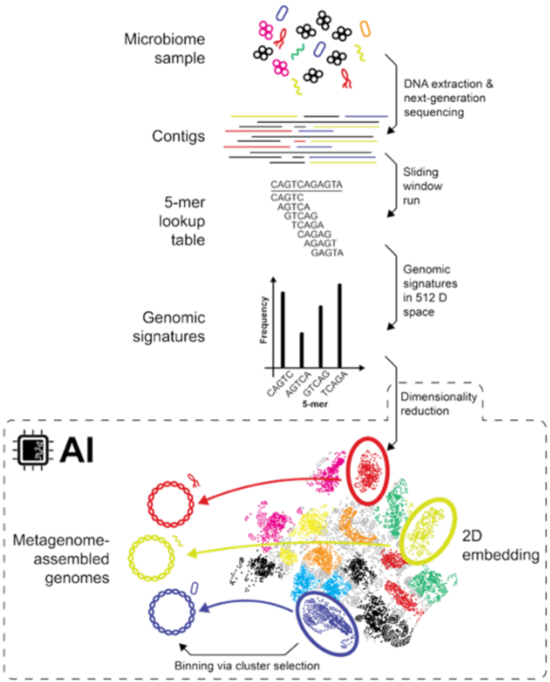
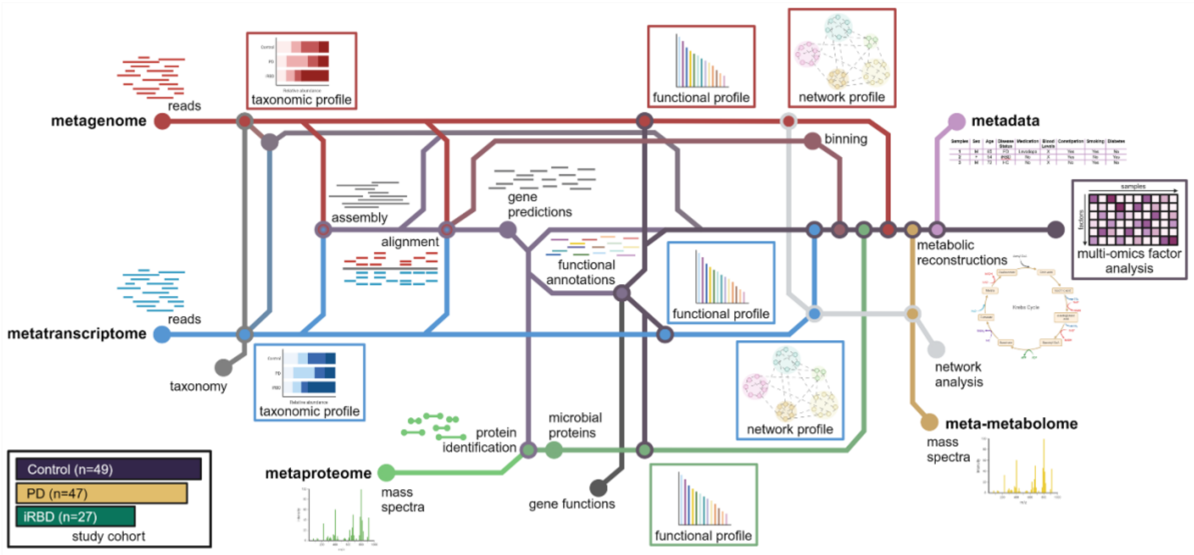


Figure 23: Multi-omics of the gut microbiome in Parkinson's disease (ExpoBiome project)



Brain Health Toolbox: Facilitating personalised decision-making for dementia prevention

The project worked on innovative strategies for Alzheimer's disease and dementia prediction and effective prevention. The team employed disease models and prediction tools for prevention and conducted prevention treatment trials, while bridging non-pharmacological and pharmacological approaches.

ERC Starting Grant 2018

Alina Solomon (University of Eastern Finland, Finland)

Dementia and Alzheimer's disease (AD) are a major public health challenge in the context of worldwide population aging. Early identification of at-risk individuals who are also most likely to respond to interventions is crucial. The ERC Starting Grant Brain Health Toolbox (2019-2024) worked on connecting dementia risk prediction with multimodal lifestyle interventions for risk reduction.

The team developed multimodal disease models and predictive tools, that is, with a broad range of risk factors and biomarker types included. A machine learning method was used to identify the most important contributors to an individual's overall risk level. This is crucial for early identification of individuals with high dementia risk and/or high likelihood of specific brain pathologies, quantifying an individual's prevention potential, and for longitudinal risk and disease monitoring.

Such risk/disease models and prediction algorithms were tested in prevention trials. The non-pharmacological interventions covered healthy lifestyle changes, that is, a combination of physical exercise, dietary advice, cognitive training, social activities and monitoring and management of vascular and metabolic risk factors (FINGER intervention model).

Project results were used for the World-Wide FINGERS (WW-FINGERS), the first global network of multimodal dementia prevention trials. This has facilitated harmonisation across trial protocols and joint analyses as more trials are conducted by network members, including in low/middle income countries.

During the Brain Health Toolbox project, a new multimodal prevention trial was designed, combining healthy lifestyle changes with pharmacological treatment – the FINGER 2.0 combination therapy model for dementia risk reduction. MET-FINGER was the first WW-FINGERS trial testing a FINGER 2.0 combination therapy model and provides a much-needed therapeutic approach for a large group of people at-risk for dementia who are asymptomatic and/or not eligible for new AD drugs.

In terms of policy impact, Solomon has collaborated with the World Health Organization (WHO) work group on tools for dementia risk assessment for risk reduction interventions and participated in meetings to develop the 2019 WHO Guidelines for Risk Reduction of Cognitive Decline and Dementia.

Building on the AI-related research of the Brain Health Toolbox, Solomon is now working in the PROMINENT project (2023-2028) funded by the Innovative Health Initiative (IHI) Joint Undertaking, a public-private partnership supported through Horizon Europe and COCIR, EFPIA, EuropaBio MedTech Europe, Vaccines Europe, BioArctic AB and Combinostics Oy. It aims to develop a digital platform for precision medicine offering prediction models that rely on various diagnostic data sources with the goal to assist clinicians in the evaluation of patients with possible cognitive impairment.

Solomon is also conducting related research via the AD-RIDDLE project (2023-2028), also funded by the IHI Joint Undertaking under a consortium with 24 academic and industry partners, healthcare providers, regulatory bodies, and patient organisations. It is developing a digital platform for precision medicine focusing on neurodegenerative disorders. It will give access to prediction models leveraging diagnostic data from multiple sources (imaging repositories, medical records, mobile devices).

Visit Alina Solomon's research team website for more info.

ICON BIO: Integrated Connectedness for a New Representation of Biology

By leveraging on increasing amounts of heterogeneous omics data, ICON BIO aims to enhance precision medicine through better patient stratification, biomarker discovery, personalised treatments, and drug repurposing. The goal is to revolutionise biomedical informatics and overcome key challenges in precision medicine.

ERC Consolidator Grant 2017

Natasa Przulj (Barcelona Supercomputing Center, Spain)

The ERC Consolidator Grant ICON BIO (2018-2025) project focused on developing explainable and sustainable AI methods to analyse multi-omic molecular data. Its work aimed to enhance precision medicine's ability to detect diseases early, identify drug targets, and repurpose existing drugs, particularly for incurable diseases like certain cancers and Parkinson's Disease.

The team developed some novel and unconventional approaches for extracting new medical information by integrating diverse omics data from publicly accessible databases, with applications in precision medicine. They advanced beyond the current state of the art by developing iCell, a prototype for integrating diverse cellular omics data, while also advancing biological data models and analytics.

They created new machine learning methods for multi-scale omics data integration and plan to release an open-source software package. They also developed innovative data science algorithms using hypergraphs and abstract simplicial complexes, and improved graphlet-based methods for analysing biological networks.

This work led to the ERC Proof of Concept Grant GENETTA (2020-2023) that developed a platform capable of analysing large amounts of heterogeneous multi-scale omics data, including subtyping of patients into risk groups and designing personalised treatment strategies. As part of GENETTA, the team explored avenues for transferring AI technologies, including the creation of a start-up (Graphlet Technologies), and further developing generative AI for personalised pharmacology, for which they are currently seeking additional funding. They expect to send their new precision compounds for synthesis and pre-clinical trials soon. The final aim is to commercialise and bring to public the new personalised medications.

Przulj received further support through TranSYS, a Marie Skłodowska-Curie Innovative Training Network (2019-2024). This training addressed skills gap in the emerging fields of systems and precision medicine by delivering a multidisciplinary programme across life and data sciences (covering genomics, bioinformatics, health informatics, statistics, data mining, systems medicine and ethics).

Przulj is Full Professor at Biomedical Data Science at University College London and ICREA Research Professor at Barcelona Supercomputing Centre. She also secured further support from the Mohamed Bin Zayed University of Artificial Intelligence (MBZUAI) in Abu Dhabi, where she currently holds a Full Professorship in Computational Biology.

Visit Natasa Przulj's websites at MBZUAI and ICREA for more info.

BugTheDrug: Predicting the effects of gut microbiota and diet on an individual's drug response and safety

This project developed an innovative computational framework that integrates genetic, dietary, and microbial data to predict an individual's drug response. By conceptually and technologically addressing the demand for novel approaches to the study of individual variability, BugTheDrug provided breakthrough support for progress in precision medicine.

ERC Starting Grant 2017

Ines Thiele (University of Galway, Ireland)

The overall focus of Ines Thiele's team at the Molecular Systems Physiology group at the Digital Metabolic Twin Centre, at the University of Galway in Ireland, is to improve human health through computational modelling applications.

The ERC Starting Grant BugTheDrug (2018-2023) was an interdisciplinary project that combined systems biology, quantitative systems pharmacology, microbiology, and nutrition. Its primary objective was to contribute to precision medicine by tailoring drug regimens to an individual's unique characteristics, including their gut microbiota, metabolic profile, and dietary intake.

One of the project's major achievements was the development of the Virtual Metabolic Human database (VMH), the first web-interface interlinking human metabolism, gut microbiome, nutrition, disease, and visualisation resources. The VMH has gained significant visibility and still attracts a large user base in the biomedical community.

A significant outcome was the creation of digital models that represent a crucial step towards developing digital metabolic twins. These models enable personalised predictions of drug responses based on customisable queries and input data, such as genetic makeup, diet, and gut microbiome.

As an example of such models, the sex- and organ-resolved human whole-body models, Harvey and Harvetta, capture the metabolism of 26 organs and six blood cell types, include 80,000 biochemical reactions in an anatomically and physiologically consistent manner, and can be parameterised with physiological, dietary, and metabolomic data. As part of the VMH resource, AGORA2 enables the modelling of microbe-microbe and human-microbe interactions, with 7,302 human gut microbes strain-resolved drug degradation. Before the whole-body models, the human metabolism could only be considered at an overall organism level, without specifically accounting for different sexes and organs. AGORA2 is also a significant advancement beyond the previous state-of-the-art because not only it represents a 10-fold increase of gut microbiomes captured within the resource, but it also accounts for the drug-metabolising capabilities for 98 drugs of the gut microbiome. Both the whole-body models and AGORA2 resource allow for seamless integration to enable computational modelling along the host-microbiome axis to allow a significant step forward towards digital metabolic twins.

Thiele's new ERC Consolidator Grant AVATAR (2024-2029) aims to develop a personalised modelling analysis framework that could lay the foundation for computer-guided diagnosis and treatment strategies. By combining an individual's genetic, metabolic, diet, and gut microbiome information, the AVATAR computational models will allow researchers to study how a person's unique biology responds to different influences, including disease and associated treatments. Ultimately, the models will predict the most likely diagnoses and most effective treatments for real-life intervention.

Thiele's team collaborates on other complementary projects, including Horizon Europe Recon4IMD (2023-2027) with a focus on inherited metabolic diseases, and MetaboAD with a focus on Alzheimer's disease, funded by the EU Joint Programming Initiative on Neurodegenerative Disease Research.

Visit Ines Thiele's lab website for more info.

5. Key challenges for AI in health

This chapter focuses on the key challenges for the development and adoption of AI in health, along a range of scientific, technological, economic, legal, cultural, social or other dimensions. It starts below with an expert view from Alfonso Valencia about the three main challenges that he observes through his research. Then an overview of the nine challenges identified from the interviews with 20 ERC researchers (from the previous cases studies in Chapter 4) are presented.

An expert view from Alfonso Valencia

ICREA Professor, Barcelona Supercomputing Center, Spain

From my perspective, the most profound challenge is the explainability gap. Current AI is not intrinsically able to provide the causal explanations we need. In medicine, we cannot trust a "black box" with a patient's diagnosis, and in biology, mechanistic interpretability is the ultimate goal.

The second big issue is data. Accessing medical data for research is incredibly difficult due to legal and regulatory hurdles, while ensuring it is high-quality and interoperable adds another layer of complexity. The implementation of the long-awaited European Health Data Space will be critical to providing a solution for using primary medical data in research.

Finally, we must solve the resource integration challenge. This means merging Europe's substantial computational resources, from EuroHPC and AI factories to new Gigafactories, with sustained capacity-building efforts and a level of European funding sufficient to tackle new problems in less conventional formats for both research and medical applications.

5.1. Interdisciplinary collaboration

Combining AI and other disciplines for healthcare presents numerous challenges, particularly in building shared understanding and developing research collaboratively from the outset. It is essential for **researchers with different backgrounds to co-design each phase of the research process, from beginning to end.**

For instance, integrating AI methods in a project can significantly impact data analysis. But it goes beyond: AI can transform the kinds of questions researchers can ask, fundamentally reshaping how studies are designed, and data collection is structured.

> *AI has the power to change the answers, but I think that what is most important is that AI has the power to change the questions. (…) AI can change the very way you design research in healthcare.*
>
> *Cristina Becchio, ERC PoC Grant KiD (Istituto Italiano di Tecnologia, Italy)*

However, creating productive collaboration between different scientific fields and practices is difficult. A major hurdle involves **domain knowledge**. For instance, AI specialists often lack familiarity with biological or clinical contexts, making it challenging to interpret brain data or understand patient symptomatology. Conversely, researchers with a biological or clinical background typically aren't trained in the mathematical and algorithmic thinking required for advanced AI.

This divide complicates both communication and implementation of AI in clinical settings. AI practitioners who haven't interacted with patients should be reminded of the human context behind the data. Also important is translating AI findings into formats that are accessible and meaningful for clinicians - avoiding overly technical language that hinders practical use.

To bridge these gaps, ERC researchers suggest that the EU should focus on **training engineers to engage more directly with the life and social sciences and collaborate closely with clinicians** to understand bedside clinical needs.

An example of an interdisciplinary design pursued by ERC grantee Alison Noble from University of Oxford is the **"learning to defer" approach**: AI makes decisions when confident but defers to human experts otherwise. While promising, such models raise further challenges, including balancing error rates and accounting for the complexities of human judgment and interaction. Here, behavioural scientists and psychologists can work together to improve joint human-AI decision-making considering established clinical guidelines but acknowledging at the same time the variability in human decisions.

Addressing these challenges requires robust interdisciplinary training programmes. These should immerse participants in the fundamentals of both fields, avoiding the temptation of shortcuts, and ensuring researchers are equipped to work effectively across domain boundaries.

> *AI has the potential to bridge the gap between data experts and healthcare professionals. It can translate complex data into clear, practical insights, ensuring that patient information is used responsibly and effectively to improve care. This requires AI specialists to be trained in health care problems, and health care workers to be trained in AI methods – to make sure we speak each other's language.*
>
> *Martijn van den Heuvel, ERC Consolidator Grant CONNECT (Stichting VU, Netherlands)*

5.2. Data quality and availability

ERC researchers face several intertwined challenges when using biomedical data. One major issue is the **limited availability of high-quality, long-term biological data**, such as proteomics, which are essential for creating robust models. Although measurement technologies are improving, the number of samples in many studies remains too small, posing challenges to model development. In his ERC ExpoBiome project, Paul Wilmes and team are generating microbiome-derived, unprecedented, high-resolution multi-omic datasets alongside building the necessary AI-based methods for data analysis, pattern discovery and modelling to bridge this gap.

Another challenge is **data fragmentation**. Biomedical information, ranging from drug responses and genetic data to clinical records, is often scattered across silos, making it difficult to access and combine. This lack of integration, especially when trying to merge diverse data types like genetics and clinical data, creates technical and infrastructural bottlenecks that slow down AI model training and validation.

Data availability is further complicated by **ownership and cost**. Some clinical data are proprietary, owned by companies, which restricts access. For example, one ERC project that developed robotic surgical systems has struggled to find the necessary datasets in Europe to train their algorithms.

Data harmonisation, or how data are combined and standardised, also varies greatly. National-level data may be well-organised and curated for broad statistics, but hospital-level data often lack such consistency and infrastructure, causing discrepancies and challenges in pooling information.

Finally, researchers highlight concerns about the **lack of clear standards** for applying AI in biomedical research. For instance, while randomised controlled trials follow strict guidelines to ensure reliability and reproducibility, it remains unclear how AI and machine learning approaches can meet these same standards, raising questions about the trustworthiness of AI-based findings.

Another issue here is that for clinical studies, researchers still using classical power calculations to estimate sample sizes. However, with **multimodal datasets and AI**, these approaches are no longer state-of-the-art. New frameworks are needed for designing clinical studies in the future.

5.3. Sensitive personal data

Researchers working with health data face several key challenges, especially around **accessing and processing sensitive information about individuals from different hospitals and countries**. Instead of sharing raw data directly, a different approach called “federated learning” can allow scientists to build partial models locally on anonymised data, then combine these models centrally. This method helps protect patient privacy and eases legal concerns about transferring data, enabling better collaboration without violating personal data protection rules.

Another major difficulty lies in i**ntegrating diverse types of health data**, such as genetics, metabolism, diet, and microbiome, in a way that respects privacy while still making meaningful predictions. Often, data is stored in separate, secure systems at each institution, which may not easily connect with the custom-made tools developed by researchers. To address such technical barrier, for example, ERC grantee Ines Thiele from University of Galway builds portable tools so they can run on collaborators’ systems without complex remote setups.

> *The need for large amounts of sensitive health data for model training often requires international collaborations. However, sharing and utilising sensitive data while ensuring privacy and secure handling in compliance with regulatory requirements remains a challenge.*
>
> *Laura Elo, ERC Starting Grant DynaOmics (University of Turku, Finland)*

Anonymisation, or pseudo-anonymisation (in most cases when dealing with health data), creates further complications. It is hard to follow up with patients for testing or validation because researchers can't identify or contact them. Additionally, when data formats differ between hospitals, transferring or using data consistently becomes a problem. Without patient consent, recontacting individuals for further studies or recruitment is nearly impossible, which slows down real-world implementation.

5.4. Clinical practice

Adopting AI in clinical settings raises issues of validation and trust. While computer models can predict medical outcomes with high accuracy, this doesn't automatically mean they are ready for real-world use. Clinicians often hesitate to rely on AI tools, especially "black box" systems like deep learning or large language models, because their underlying processes aren't always transparent.

In this regard, ERC researchers underline there must be **rigorous validation studies, transparent decision-making processes and careful integration into clinical workflows**. One strong concern is whether AI tools will disrupt existing workflows. Clinicians are cautious about adopting technologies that may complicate daily routines or make care harder to deliver. There is the need for iterative processes involving training, validation and testing involving data and clinical workflow integration.

> *Over the coming ten years, swarming nanomachines will evolve from scientific curiosity to a new class of living/moving therapeutics, capable of seeking out disease and treating it from within.*
>
> *Samuel Sánchez Ordóñez, ERC Consolidator Grant i-NANOSWARMS (Institute for Bioengineering of Catalonia, Spain)*

Another issue is that **healthcare professionals are not yet trained to evaluate or interact with AI**. So, trust can have very different meanings: some may over-rely on the technology, while others remain overly cautious. In some cases, healthcare practitioners are being asked to use AI tools without fully understanding how they work. This highlights the need to integrate AI literacy and usage into clinical education and practice.

One additional point underlined by ERC researchers is that **diagnosing medical conditions is challenging, and even human experts often disagree**. Healthcare decisions are often made based on a mix of evidence and intuition, with gaps in understanding why certain choices are made. Moreover, decisions in healthcare are rarely final, because they are also part of a patient's journey. Both the reality of medical diagnosis and the complexity of decision-making in real life need to be fully acknowledged.

5.5. Black box AI

A key challenge in applying AI in healthcare is the **need for transparency and interpretability, not just high performance**. Researchers emphasise that in some fields, or for certain purposes like understanding biological mechanisms, AI tools must be clear and explainable. Many existing AI systems are still black boxes, lacking transparency on how they are work, what training data was used, or how the outputs were generated. This also makes it hard for clinicians and researchers to trust such systems.

> *It's not always easy to determine how the model decides, how the model makes decisions. They are usually a black box. (…) predictive performance is very good but then the predictive model includes elements that have absolutely no clinical relevance. (…) so do we care how the model works if it works well? Yes, we do care how the model works because if it picks (…) like the year of referral to a clinic that's heavily dependent on the context of the healthcare. (…) then the model can very easily give a lot of errors and we will not know where they come from.*
>
> *Alina Solomon, ERC Starting Grant Brain Health Toolbox (University of Eastern Finland, Finland)*

One way to address this challenge is to openly publish methods and results, provide free access to models, and actively seek user feedback to improve transparency and reliability.

Explainable AI is also vital to obtain testable hypotheses. In that context, there must be a **tight coupling between AI and representative models** which allow testing of multifactorial hypotheses. For example, in the ERC ExpoBiome project, Paul Wilmes and his team developed an organ-on-a-chip model HuMiX that allows for the testing of such hypotheses whereby readouts then feedback into the AI models.

Another challenge is **ensuring AI's clinical relevance**. Drawing from his work, Andrea Ganna from University of Helsinki points out that it is easier when focusing on established clinical biomarkers. But when AI is predicting for instance a specific risk, like a patient's chance of developing cardiovascular disease, then doctors want to understand why a patient has a higher risk.

5.6. Regulatory frameworks

ERC researchers highlight several challenges in bringing medical innovations, especially AI and engineering solutions, from the lab to clinical use. One key difficulty is the **diverse legal and regulatory environments across countries**.

For example, ERC grantee Padraig Cantillon-Murphy from University College Cork highlights that, in Ireland, high litigation risks make clinical trials complicated, whereas in countries like France and Norway, the process is simpler. A notable example from his own experience is the French IHU in Strasbourg. Researchers can test devices in a pre-clinical facility on one floor (testing in live tissue), before moving to actual patient care on another floor, where you have the same imaging and surgical systems. This seamless setup facilitates moving systems from engineering labs to the clinical setting.

Another challenge involves **regulatory uncertainty**, particularly with evolving AI laws such as the **EU AI Act and the Medical Device Regulation (MDR)**. ERC researchers point out that it is unclear how adaptive or generative AI models will be evaluated. The lack of clear guidelines and interpretation across Europe means that even promising AI technologies face delays in clinical adoption. As an example, certification processes are especially difficult because experts in notified bodies often lack sufficient knowledge about AI, and the overlapping EU regulations add complexity.

> *How do you certify an AI algorithm? (…) You have to show the ground truth. But (…) ground truths are always subjective. (...) And then there is the other issue (…) you have a machine that potentially could learn. [But] if you're a certified machine, you cannot improve your code. (...) the data collected by an intelligent system that could be used for improving the system itself may violate some of the tenant of certification.*
>
> *Paolo Fiorini, ERC Advanced Grant ARS (University of Verona, Italy)*

5.7. Connections between academia and industry

ERC researchers emphasise several key challenges in **moving deep tech technologies from academic labs to industry**. One major hurdle is the economic aspect: **deep tech projects need large, long-term investments** that are often hard to secure in Europe. This struggle sometimes pushes innovations to the US, where funding is more accessible.

Another barrier is the **gap between academia and industry**, at least partially due to different mindsets and priorities. For example, ERC grantee Sarel-Jacob Fleishman from the Weizmann Institute of Science underlines it can take years to make academic results and methods recognised by pharmaceutical companies. Moreover, legal processes sometimes lasting over a year, such as negotiating non-disclosure agreements (NDAs) with large companies, can further delay collaboration.

> *I imagine a conclave inviting a select group of cross-disciplinary experts from both industry and academia for a number of days, explaining the capabilities and open questions each works on, and trying to see if we can actually start collaborating on areas that are of mutual interest.*
>
> *Sarel-Jacob Fleishman, ERC Consolidator Grant AutoCAb (Weizmann Institute of Science, Israel)*

Paul Wilmes from University of Luxembourg also stresses that for start-up creation, it can also take many months for standstill letters to be issued or term-sheets to be agreed to. In the US, institutions are typically much more proactive than in Europe in this regard and follow established processes.

Scientists also struggle to understand the **challenges faced by industry partners**, partly because companies often can't share their results publicly.

Plus, the **AI ecosystem is increasingly complex** as it involves many players, from academia, startups, to big tech companies. The rapid expansion of the field of AI in recent years makes it unclear who is or should take the lead or how best to combine these efforts for maximum impact.

5.8. AI talent and recruitment

The **competition to recruit and retain global AI talent** is highlighted by ERC researchers. For instance, unlike the US, Europe lacks "hubs" or "talent centres" where you can easily find or recruit top AI experts. Training is another issue: teams or organisations often must invest in developing skills themselves, or to be sure that incoming talent already has the necessary know-how. Still, new hires might not always possess the exact expertise needed and might require more training.

Recruitment is especially challenging at the PhD and researcher level due to **competition with private companies offering higher salaries**. To overcome this, fostering a positive, mission-driven workplace culture can be appealing. Making researchers feel part of a meaningful effort, such as witnessing the real-world impact on patients, can be a powerful incentive, one more difficult to find in large organisations.

5.9. Computing resources and tools

Access to advanced computing resources is also crucial. Interviewed ERC researchers emphasised the importance of **early connections with technical teams and supercomputing facilities**, both national clusters and major commercial providers like Google, Amazon, and Microsoft's Azure. For instance, access to powerful computing facilities, like the Euro HPC MeluXina based in Luxembourg, has greatly accelerated the work of ERC grantee Alexandre Tkatchenko.

Yet, **collaborations with private companies**, which provide vital IT infrastructure and AI tools, can be difficult to establish. These firms often prioritise their own commercial interests, making it challenging for academic innovators and researchers to use such tools in the longer term or beyond the proprietary environment and systems offered by these companies.

Another issue involves **open-source software tools** developed for instance in academic research projects. Without dedicated resources for maintenance and updates, the use of such tools becomes difficult.

6. Risks now and in the next 10 years

This chapter focuses on the present and future risks for the development and adoption of AI in health, ranging for instance from clinical reliability of AI-based models in health, bias in training data, opaque or black box algorithms, up to lack of AI expertise or knowledge. It starts below with an expert view from Alfonso Valencia about the main risks in the use of AI in health for the near and longer-term future. Then an overview of the eight risks identified from the interviews with 20 ERC researchers (from the previous cases studies in Chapter 4) are presented.

An expert view from Alfonso Valencia

ICREA Professor, Barcelona Supercomputing Center, Spain

Beyond the immediate and critical risks of amplifying biases and eroding trust through black box medicine, I foresee a significant systemic shift that presents its own challenges. The new technologies will make molecular and computational biology more accessible and automated. AI agents and robots will soon run and interpret large-scale experiments autonomously.

While the core scientific questions, like protein evolution or developmental mechanisms, will remain, this automation will trigger a massive migration of talent. Skilled researchers will shift from developing methods in a lab setting to implementing AI systems in clinical environments. The change can be problematic since there is a sizeable knowledge gap between the two areas.

In practice, we will be busy building better, trustworthy AI systems that provide mechanistic reasoning and clear provenance to combat bias and opacity, and at the same time managing a transition of computational systems and professionals towards more medical settings, to enter in the fabric of medicine without losing the roots in deep scientific understanding.

6.1. Accountability and responsibility

ERC researchers highlight several risks regarding AI and healthcare, especially when it comes to decision-making and patient safety. What if an AI system makes an error that leads to a patient's death, even if such systems make statistically fewer mistakes than human experts?

Some interviewees questioned how individuals may perceive such risks. In this regard, **generational differences** may emerge. Younger doctors, patients and legislators may be more open to embracing AI, and in the future, such changes may not be perceived as a problem given more AI-native generations.

Yet, a key concern is **accountability**: if the AI system or an algorithm in general gets it wrong, who is accountable? And how do doctors incorporate that into clinical decision-making? This issue is also related to the notion of **responsibility**. Current regulations often place final responsibility on humans, but some might argue that AI's consistency and capacity for reproducibility might make it preferable in certain cases.

Another issue identified is **contestability**, particularly when AI influences access to treatments. The lack of explainability may deprive patients of their right to be fully informed about how medical decisions are made and impair their ability to exercise their rights.

> *Who is accountable for AI-influenced clinical outcomes? What happens if healthcare professionals follow an AI recommendation that end up causing harm? What if they ignore an AI recommendation that claimed to help? Such questions need to be addressed before AI tools are deployed in the healthcare environment.*
>
> *Ines Thiele, ERC Consolidator Grant AVATAR (University of Galway, Ireland)*

6.2. Safety and monitoring

In the medium term, a concern was raised about the safe use of AI decision support systems in healthcare, plus the **lack of clear regulatory guidance for clinical approval**. Currently, there are no specific standards defining what makes AI decision support tools safe for clinical use.

One other issue is related to **dynamic, self-learning AI systems** that are continuously updating and improving. Policy makers may struggle with regulating such evolving systems, and ultimately to find the right trade-off between regulation and innovation.

Monitoring AI performance is another key issue. While **human oversight or the human in the loop** is sometimes necessary, constant supervision defeats the purpose of using AI, especially in overburdened healthcare systems. This raises the question of when and how to involve human experts effectively. Here iterative learning cycles with humans initially being in the loop are essential. The models get better also by making mistakes and by being corrected by humans.

ERC researchers also emphasise the need for **AI "stress testing"**, that is, ensuring systems operate within safe boundaries and don't behave unpredictably.

> *How do we ensure AI is safe for patients to be used and continues to be safe after deployment?" - because AI is trained on historical data, the data at some point might be outdated. So, when do you retrain a system? When do you update a system?*
>
> *Ben Glocker, ERC Starting Grant MIRA (Imperial College of Science, Technology and Medicine, UK)*

6.3. Bias and generalisation

One key issue is that **AI-based models often rely on limited datasets or are overfitted to particular datasets**, which can make them less accurate when applied to new or diverse patient groups. For example, an AI system trained in Central Europe may not work well in Southern Europe due to differences in genetics and demographics. This highlights the challenge of creating AI tools that are scalable and generalise across diverse populations. For instance, in his ERC ExpoBiome project, Paul Wilmes and team looked into the importance of lifestyle (diet, exercise) and the environment on the microbiome.

> *How can we really be sure that the AI will generalise to every scenario, when there is always a chance that it will encounter something that it has never seen before?*
>
> *Juan Eugenio Iglesias, ERC Starting Grant BUNGEE-TOOLS (University College London, UK)*

> *Data-centric paradigm: Your questions change when lots of reliable data becomes available, and so you can ask novel questions that you were not able to ask before; but you also need to assure that you can answer those questions rigorously; this requires AI methods that are intrinsically interpretable, so that scientists, industry, and society can trust the answers that used AI methods.*
>
> *Alexandre Tkatchenko, ERC Proof of Concept Grant DISCOVERER (University of Luxembourg)*

This issue of generalisation is related to the **bias embedded in the data**. Much health research data comes from Western countries like the US, Canada, and Europe, meaning AI systems may come up systematically with biased predictions and potentially amplify health inequalities. ERC researchers point out that bias isn't caused by AI itself but by the underlying data.

Efforts are underway to address these gaps. For instance, ERC grantee Ines Thiele from University of Galway has recently created APOLLO, the world's largest collection of digital microbes from multiple continents, age groups, ethnicities and body sites.

Yet, just training AI models on diverse data sets may not fix all the problems. Understanding how AI models make decisions is also crucial to ensure they use **clinically relevant information and deliver fair outcomes**. Although **balancing accuracy and fairness** is difficult, ongoing progress in AI research could offer potential solutions.

6.4. Interpretable and complex models

One of the risks identified by ERC researchers is the use of sub-symbolic or generative models like large language models (LLMs). Over-reliance on these black box systems should be avoided, considering their **lack of transparency**. Without access to the weighting criteria, their decision-making processes are hard to interpret mechanistically, making them difficult to audit, interpret or explain to clinicians and patients. It can also be an issue for rigorous **scientific validation of new research questions** raised or produced by such models.

Another related issue is **insufficient high-quality data** to effectively train advanced models. It limits their capacity to address specific clinical situations, which in the end limits their reliability and usefulness in a clinical setting.

Some ERC researchers also highlight the **unnecessary complexity** of some AI models leading for example to overfitting. The success of deep learning techniques has spurred their use even in cases where simpler or more interpretable models could be used such as for predicting the outcome of clinical interventions such as therapeutic fasting as in the case of ExpoBiome project. Also, simpler models offer the advantage of lower computational costs. Current AI-based models were also described as data and energy hungry black boxes, which suffer from hallucinations and cannot be understood or controlled.

> *In the emerging world's energy crisis, we need to rely on different AI paradigms, especially in health, that are sustainable, explainable and controllable.*
>
> *Natasa Przulj, ERC Consolidator Grant ICON BIO (Barcelona Supercomputing Center, Spain)*

6.5. AI expertise and skills

A major issue identified by ERC researchers is **limited expertise in AI**. Such insufficient understanding of AI techniques and tools may lead to **misinterpretation, over-reliance or reluctance**. Such lack of knowledge and literacy could contribute also to AI models that are ill-suited to different patient populations, which can compromise its clinical use or overall trust in AI-based approaches.

According to ERC researchers interviewed, education systems must adapt to meet **global competition**, especially as more economies invest heavily in AI training and become leaders in the field. To succeed, new generations should be encouraged to excel both in AI and healthcare, in a concerted effort to overcome the current skills gap. Without such **cross-disciplinary education**, medical professionals may find it difficult to fully design and use AI solutions.

> *There is a growing need for researchers, clinicians, and regulators with dual fluency in both AI and healthcare. Without investment in cross-disciplinary education, the workforce may struggle to design, validate, and govern future AI tools in medicine.*
>
> *Michael Menden, ERC Starting Grant COMBAT-RES (Helmholtz Munich, Germany)*

6.6. Integration of AI in healthcare workflow

One concern expressed by interviewees is that AI is evolving so quickly that professionals may lack the **necessary skills** to use it effectively and in ways that truly benefit patients. At the same time, we do not know yet exactly which skills such professionals need to use AI.

Another ERC researcher warns that the field risks becoming overly focused on technological progress for its own sake, drifting away from real clinical questions and biological grounding.

The potential danger of relying on **predictive models for disease risk, treatment responses, or disease progression** without ensuring their accuracy and adaptability, was also mentioned. The importance of maintaining clinical relevance and understanding the underlying workings of AI tools was clearly underlined. How to validate AI predictions in changing healthcare settings was also pinpointed as one additional risk.

> *There's a risk that we could be moving too fast and too slow (…) we need to learn fast about what skills actually make a person a good user of AI or not. (…) We don't really want bulky technology that might improve health care a bit but will be expensive and might stall organisations. (…) we need to take the social science side very seriously and focus on the design and the users of AI tools*
>
> *Hannes Ullrich, ERC Starting Grant ABRSEIST (German Institute for Economic Research/DIW Berlin)*

6.7. Harm and security

ERC interviewees underlined the potential for inducing harm when using such technologies, whether intentional or accidental. For instance, health data could be exploited for **insurance claims or sold to commercial companies**, raising ethical and privacy issues.

A more extreme form of harm or malignant use involves applying AI to accelerate **biological or chemical weapon development,** that is, to create highly toxic substances at an exponential speed. So far unexpected application areas, such as encoding malware in DNA and take control of a sequencing machine, must be planned for.

ERC researchers also highlight the need for **robust data governance and cybersecurity**. As AI systems increasingly depend on sensitive, real-world data such as patient records, there is a growing vulnerability to data breaches and misuse. Ensuring **compliance with GDPR and maintaining data sovereignty**, for instance, in federated or multi-institutional settings, emerges as a critical priority.

6.8. New directions in data

Building robust AI models for precision medicine requires vast datasets that often include sensitive health data capable of identifying individuals. This raises concerns about **data privacy, misuse, and re-identification**. A particular worry is that as AI capabilities advance, even data types once considered non-sensitive may become sensitive.

For example, only genomics data is nowadays considered to be intrinsically identifying. However, in the future, AI-based methods may plausibly enable the identification of individuals based on other omics data, or crossing simple clinical parameter with publicly available data such as social media profiles and posts. To prepare for this, it can be argued that all health-related data should be treated with the same safeguards currently applied to genomic information.

Another emerging issue involves AI-generated synthetic data, which mimics real patient data and can be particularly valuable in rare disease research, where few cases exist. However, it introduces new ethical and legal questions: **Who owns synthetic data? Who is accountable for its use?** Furthermore, under GDPR, individuals can withdraw their personal data, yet it remains unclear whether this extends to synthetic data derived from it.

> “*From the discovery of complex disease-linked patterns to modelling intermolecular interactions, AI-based methods, when applied correctly and under the premise of full transparency, hold tremendous potential for the development of revolutionary diagnostic, prognostic and therapeutic approaches.”*
>
> *Paul Wilmes, ERC Consolidator Grant ExpoBiome (Luxembourg Centre for Systems Biomedicine, University of Luxembourg, Luxembourg)*

7. Support for research in AI in health

This chapter pinpoints the types of support researchers in general need to develop their AI-based systems in health or exploit their innovation potential, including for example funding, partnerships and ecosystems, accelerators, facilities and access to equipment, human resources, legal advice, and regulatory sandboxes. Interviewees were also asked to consider links also with European initiatives such as the AI Act, the European Health Data Space, or the Medical Device Regulation. Eight types of support were identified from the interviews with 20 ERC researchers (from the previous cases studies in Chapter 4), as presented below.

7.1. Funding and investment

ERC researchers emphasise the need for **stable, long-term funding** to support the development and validation of AI-based solutions for health, including rigorous validation necessary for robust model development. The ERC is praised for allowing the **freedom to pursue frontier science**, that is, to explore directions that at the beginning might be tangential to the main research area. Coupled with an open reporting process, ERC funding is considered unique and extremely enabling for researchers.

However, continuous funding mechanisms, such as those provided by Horizon Europe, are seen as crucial to **translating early-stage innovations into clinical applications**. For instance, EIC Pathfinder was mentioned as an excellent framework for bringing academic labs and industry partners together to work on a specific problem.

Yet, a recurring issue is the so-called **"valley of death" between proof-of-concept and commercialisation stages**, where many promising projects fail due to lack of bridging support. For example, a one-year intermediary grant, for example, around 250 000 EUR, could help to sustain projects until the next funding.

Some interviewees also criticised Europe's current investment landscape for deep-tech innovation. In their view, it applies **short-term, conventional funding models** unsuited to projects requiring long-term, visionary investment. They stress that scientists are motivated by transformative ideas rather than easily marketable products. Even initiatives designed to nurture such type of innovation, like the European Innovation Council (EIC), often end up funding large companies and large academic institutions instead of emerging ventures.

Another issue was raised on the set-up of the EIC Transition funding programme. While EIC Transition projects often involve academic and industrial partners, there can be a misalignment between their goals and timelines. For instance, companies often have more urgency than academics to reach market readiness.

7.2. Infrastructure and computing resources

Researchers across Europe underline the **need for infrastructures and platforms** that can bridge basic and applied research, particularly for the clinical translation of AI-based health innovations. While the EIC is moving in this direction and the ERC showcases Europe's scientific excellence, researchers working at early development stages still need support to access **tools, data, and computational facilities**.

A concern is the shortage of **secure, high-performance computing environments** that can handle **sensitive health data**. Many existing AI infrastructures are designed for non-sensitive datasets, leaving researchers working with clinical or patient information constrained by restricted data access. Interviewees argue for well-curated infrastructures supported by **sustained funding and expert guidance** - for instance, local data specialists who understand country-specific contexts.

Secure and scalable computing infrastructure, as well as wet-lab and clinical trial support for validating AI-driven hypotheses, are essential. Yet, there is an issue in the **fragmentation between computing and laboratory infrastructure**. IT systems are often funded separately from benchtop infrastructure, making it difficult to integrate computational and experimental workflows.

ERC researchers also note that **secure data environments** often offer limited computing power, preventing large-scale AI analysis by one single researcher. This points towards a change of culture, that is, closer to lab-based groups where only a certain number of researchers are doing an experiment at any one time.

Looking ahead, scientists call for research setups capable of screening massive biological datasets and then feed the results of the experiments back into the training sets of the AI systems in terms of modelling and prediction. A critical point is to ensure that “wet labs” keep up with the “dry labs” (in silico).

7.3. Data

ERC researchers stress that **access to large, high-quality, and longitudinal health datasets,** also from healthcare systems and industry, is essential. The European Health Data Space (EHDS) is seen as a crucial step in this direction, as a shared framework for accessing and using health data across countries. However, interviewees caution that this will be a long-term process, and not a quick fix.

The need for **European sovereignty in health data and AI** was also mentioned. Some interviewees argue that Europe must be able to develop its own AI systems using data from its patient populations to ensure independence, trust, and alignment with European values. This vision extends from national efforts to broader transnational collaborations, supported by strong funding and strategic planning.

At the same time, large-scale data initiatives demonstrate how shared infrastructures can drive discovery while respecting ethical and legal standards. For example, the EBRAINS initiative is an open research infrastructure that provides access to extensive brain data sets, modelling and simulation tools, and high-performance computing resources. Researchers view such frameworks as **enablers rather than barriers**.

Despite these advances, some express frustration with **data governance procedures**, which are often slow and risk averse. They call for more balanced approaches that protect privacy while allowing responsible and timely data access.

7.4. Ecosystems and partnerships

ERC researchers expressed that realising the full potential of AI-based systems in health requires a **coordinated ecosystem** that brings together **funding, infrastructure, regulation, and talent development**. Success depends on **strong collaboration** between academia, industry, healthcare providers, policymakers, and patients, each contributing its own expertise.

Some call for **public-private partnerships** and closer cooperation with **regulatory bodies and legislators**, but without slowing down research too much. A recurring suggestion is to establish **“communities of practice”**, in which diverse stakeholders such as technologists, clinicians, legal experts, and patient representatives can jointly design solutions and share best practices.

A concrete recommendation was to find better ways to **connect people and information**, such as a **centralised European database** linking grants, research teams, and expertise. This would make it easier to find collaborators, for instance, a scientist searching for partners in AI for nanomedicine.

Creating **AI-for-science hubs**, inspired by major US initiatives, was also mentioned. Such hubs would combine advanced computing facilities with training programmes to help researchers apply AI to their own fields. Some interviewees stress that future generations of scientists must learn to use AI across disciplines, also warning that fields embracing data-driven collaboration might advance faster than those that do not.

7.5. Exploitation: from research to application

ERC researchers highlight **translating scientific discoveries into real-world applications** remains a major gap in Europe. **Stronger partnerships with industry and startup accelerators** are needed to support technology exploitation. Many scientists find engagement with industry challenging or intimidating due to limited exposure and support. In addition, universities often provide little guidance on founding or managing startups, from equity distribution to growth strategies.

A **shift in mindset or research culture** is also needed. Researchers often assume they can navigate entrepreneurship alone, yet running a company requires entirely different skills. ERC researchers call for more practical tools and training to equip aspiring scientist-entrepreneurs, helping bridge the divide between research and exploitation of results.

7.6. Interdisciplinarity

Researchers emphasise the need for **interdisciplinary collaboration**, advocating for funding that supports **teams combining AI experts, biomedical researchers, clinicians, and regulators**. Interdisciplinary teams or research centres would work best in physical locations.

Such collaboration should begin **from the earliest stages of model development**, so clinical insights guide AI design rather than being tested at the very end, thus ensuring their applicability to real-world health data.

Interviewees call for **greater diversity in computer science**, including more women and people from varied backgrounds who can bring broader perspectives to AI research.

7.7. Talent training and institutional support

ERC researchers emphasise that **investing in human capital** is critical for the long-term success and safe integration of AI innovations into healthcare. They call for **training programmes** that develop AI-literate clinicians and biomedically literate data scientists, from university degrees and PhDs to postdoctoral positions, ensuring a new generation of experts. Initiatives like the **European Health Data Academy** exemplify efforts to train the next generation of researcher in health data.

Creating **supportive frameworks for talent attraction and retention** was mentioned. Project-based research contracts are often precarious and less competitive than opportunities in other sectors. Interdisciplinary collaboration is also highlighted, bringing together AI specialists, clinicians, ethicists, and legal experts.

Interviewees stress the importance of **legal and regulatory support**, including intellectual property protection, GDPR compliance, and guidance on clinical liability, particularly for generative AI and digital twin technologies.

Also in their view, **research translation pathways** must be strengthened so promising research outputs can be validated and adopted in healthcare settings. For instance, it includes support for software development and maintenance, usability testing, and early engagement with clinicians and patients.

7.8. Regulation

ERC researchers highlight that **regulatory clarity** is necessary in Europe, coupled with **guidance and support** to help navigate complex regulations. For instance, the **fragmented and inconsistent application of GDPR** across countries makes it difficult for multi-country research consortia to collect and use clinical data.

Establishing **AI-specific regulatory sandboxes** was mentioned as an opportunity to allow developers to test and adapt their models in controlled clinical environments while engaging with regulators early in the process.

Linking **health data with socioeconomic data** is also seen as crucial for public-interest research. For some interviewees, the European Health Data Space is moving in the right direction, though broader adoption across countries is needed together with clear definition of what falls under public interest.

For other interviewees, the **Medical Device Regulation (MDR)** is seen as overly burdensome, expensive, and time-consuming (cf. new proposal from the Commission published in 16 December 2025). In their view, it is driving some companies to collect data and seek certification outside Europe, particularly in the US. In some cases, startups and established organisations must spend considerable financial resources to run small clinical trials to comply with the MDR requirements.

Methodology

In 2023-24, ERCEA has identified a portfolio of 1 048 ERC-funded projects on AI funded under the FP7, Horizon 2020, and Horizon Europe framework programmes, which are developing AI technology or systems, using AI in concrete applications, and studying its impact and effects.

ERCEA established this list of ERC-funded research projects related to AI (further described in Chapter 2 - "ERC frontier research on AI in health"), and at the intersection of AI in health, as follows:

- A first list was extracted from the European Commission's internal CORDA database and a keyword search of AI-related terms was conducted on projects' titles, abstracts and keywords. Additional ERC projects were identified through the ERC's in-house classification of projects "Mapping Frontier Research".
- Within this list, a keyword search using the European Commission's internal tool CORTEX was conducted in the policy area of AI in health. The relevant keywords were selected through a policy scoping from documents at European and International level. All projects were manually linked to this policy area or labelled as contributing to knowledge and solutions, based on the information available in the projects' abstracts, grant agreements and results.

For the in-depth analysis showcased in Chapter 3 – "Deep dive on AI in health", a list of 59 ERC projects in the topic of AI in health was drawn from this portfolio by ERCEA.B0 with the support of other colleagues with relevant expertise. The shortlist was drawn under the following criteria:

- Only H2020 projects to ensure the publication/release of outputs and potential impact.
- Exclusion of FP7 projects in order to focus the analysis on more recent outputs.
- Priority to projects closer to concrete applications or development of AI in health.

With the support of the Horizon Results Booster, an analysis on projects' results and impact was conducted as follows:

- In the first stage a preliminary overview of the 59 projects was based on desk research and data available on projects' documents (such as final reports, deliverables and grant agreements), CORDIS database, project and researcher's websites. Drawing from the UK Research Excellence Framework (REF), each project was assessed across qualitative and quantitative parameters, when relevant. The following were the quantitative parameters (in terms of number of): publications; research data sets and databases; toolboxes and/or models; clinical trials or studies; devices and products, including prototypes and its respective Technology Readiness Level (lower than 3, between 3 and 4 and higher than 4); patents granted or filed; business plan; policy relevant documents; prizes and awards; public engagement activities; and training events/demonstration events/workshops. The qualitative parameters were the following: impact on health and wellbeing; impact on policy and law; impact on the economy; and impact on the environment.

- In the second stage, further data was obtained through interviews (structured format) to 20 ERC grantees, which were conducted online (oral) or by email (written). Its selection was based on both exclusion criteria and golden criteria. The exclusion criteria were first applied: absence of results during the timeframe of the project; completion of the project more than 2 years ago (excluding the ones that acquired follow-up funding); and project in the first half of its duration. Afterwards golden criteria were used to further select the final projects: existence of one or more licenses; creation of a spin-off; existence of products and/ or prototypes; and presence of follow-up funds. Two projects were added for interviews due to its high policy impact. The final number of selected projects was 35, from which 20 grantees replied to a request for interview. Recordings and transcripts were analysed manually. The interviews formed the basis for some of the outcomes described in Chapter 4 - "Case studies", complemented with desk research on reports, projects' websites, etc. The views expressed in Chapter 5 - "Key challenges for AI in health", Chapter 6 - "Risks now and in the next 10 years" and Chapter 7 - "Support for research" originated entirely from these interviews.

The analysis on the synergies between the projects/researchers funded by the ERC and the European Health and Digital Executive Agency (HaDEA) in Sub-chapter 3.2 was conducted with colleagues from HaDEA B.2 Digital. The analysis included projects funded via Cluster 1 (Health) and Cluster 4 (Digital, Industry and Space), as from 2018 calls.

HaDEA colleagues designed the following methodology for Cluster 4 (that does not follow a programmatic approach to AI in health): 1) a set of keywords defining the scope of the 59 ERC projects on AI in health was the basis of a query in CORTEX, combining names, acronyms of the ERC projects and such keywords; 2) this first portfolio was created with the aim of finding ERC researchers in the Cluster 4 portfolio within projects addressing the scope of the corresponding ERC projects (and possibly making an explicit reference to the ERC project); 3) Over this portfolio a second query was defined with the complete names of the ERC researchers, using different written variations of their names; 4) a manual validation was done to ascertain the projects in which ERC researchers played an active role, or projects containing citations or references to the ERC researchers.

For Cluster 1 (that follows a health-challenge driven AI development), a list of topics and projects relevant to AI in health was provided by HaDEA. For H2020 topics, the following methodology was followed: 1) a portfolio was created in CORTEX with the corresponding list of funded projects; 2) a query with the complete names of the ERC researchers (and variations) was conducted; 3) a manual validation was done to ascertain if ERC researchers played an active role. For Horizon Europe topics: 1) a list of funded projects was extracted from CORDA, internal database of EU grants, with the relevant fields; 2) a search with the names of ERC researchers was conducted in the list to find correspondences under the list of researchers associated to each project.

For this report, only the projects in which the ERC researcher had an active role (as coordinator or beneficiary) are described in sub-chapter 3.2.

Under the Horizon Europe programme, the European Commission has delegated a new task to the ERC Executive Agency (ERCEA) to identify, analyse and communicate policy-relevant research results to Commission services. The ERCEA has developed a Feedback to Policy (F2P) framework for ERCEA to guide these activities, adapted to the specifics of the ERC as a bottom-up funding programme. This report is part of a series aiming to highlight the relevance of ERC-funded frontier research, for addressing societal, economic and environmental challenges, and thus its contributions towards key EU policy goals. This F2P series does not offer any policy recommendations.

More information: https://erc.europa.eu/projects-statistics/mapping-erc-frontier-research

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