European Commission

# Study on eHealth, Interoperability of Health Data and Artificial Intelligence for Health and Care in the European Union

## Lot 2: Artificial Intelligence for health and care in the EU

## Country Factsheets

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*Contact Christoph.KLEIN@ec.europa.eu*

*European Commission*
*B-1049 Brussels*

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Written by PwC

June 2021

Directorate-General for Communications Networks, Content and Technology
2021 EN

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# Abstract

The Country Factsheets present an overview of the current situation in each European Union (EU) Member State (MS) with regards to the development, adoption and use of Artificial Intelligence (AI) technologies and applications in the healthcare sector. The overarching aim of this work is to support the European Commission in identifying the current state of development and adoption of AI in the healthcare sector in each MS and identify any differences that might bring to light specific challenges and blockers to the wider adoption across the EU.

The Country Factsheets present an overview based on an analysis of the relevant legislation and policy framework around AI in each MS, the Research and Innovation landscape of each country in the area of AI in healthcare, as well as the presence of cross-border collaborations in research, the start-up ecosystem in each MS, as well as the awareness around AI technologies in the healthcare sector based on social media mentions in each MS.

While most EU MS are taking measures towards establishing strategies around the use of AI in healthcare, most initiatives focus on the research and innovation area with little activity in initiatives to promote adoption by the sector itself. In terms of research and innovation, the scientific output in the area of AI in healthcare is largely attributed to the larger EU MS which are also the most active in collaborating between each other and with smaller MS. Most collaborations take place between countries that share borders or have strong cultural ties and smaller EU MS benefit from collaborations with larger MS. The start-up ecosystem varies across EU MS and is mostly driven by private initiatives and support networks. Lastly, awareness around EU MS on AI in healthcare via social media and news sites are largely event-related with spikes in awareness coinciding with published articles or national-level initiatives appearing in the local press.

**8.9 Mio**[1]
**Total population**

**54.3**[2]
**DESI 2020** Index

**86%**
% of **internet users**

**2.0%**
**Population as a % of** EU27

**12**
**DESI 2020 ranking amongst** EU27

**66%**
% of population with at **least basic digital skills**

**66%**
% of **Open Data**

# AUSTRIA

## 1. Relevant legislation and policy framework

In November, 2018 the Austrian Council on Robotics and Artificial Intelligence published a white paper on the topic of "Shaping the Future of Austria with Robotics and Artificial Intelligence"[3] and recommended the involvement of the health sector in the implementation of AI as part of the Smart Governance cornerstone of the Austrian robotics and AI strategy.

Further emphasis was placed on the deployment of AI in the health sector to significantly improve early detection and treatment of illness, as well as Nursing assistance systems. Concerns over using data collected by public authorities (i.e. health data made available for research purposes) have been highlighted. An appropriate strategy considering citizens' interests that are worthy of protection should thus be developed.

Moreover, the "Artificial Intelligence Mission Austria 2030" was issued by the government in 2018 and provides the initial steps towards an official AI strategy.[4] OECD identified eight policy initiatives in terms of AI, focusing on sectors such as the automotive industry or "industry 4.0".[5] However, these initiatives do not specifically target the healthcare sector yet.

- The survey conducted as part of this study reveals the need for further regulation of the development and usage of AI-enabled tools in the healthcare sector. More specifically the participants would like to see the following policies/ regulations in place:
- Data protectection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Data protection Policies around the ethical use of AI;
- Policies around the ethical use of AI;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Policies aimed at the encouraging the deployment of AI technologies in healthcare.

1 Eurostat, 2020 data. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

2 Digital Economy and Society Index 2020, Country Report: Austria. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/austria

3 Cf. Austrian Council on Robotics and Artificial Intelligence: "Shaping the Future of Austria with Robotics and Artificial Intelligence", Vienna, November 2018

4 Cf. Bundesministerium Verkehr, Innovation und Technologie, Bundesministerium Digitalisierung und Wirtschaftsstandort: „AIM AT 2030", 2018

5 Cf. OECD.AI Policy Observatory: "Policy Initiatives for Austria", 2020. Retrieved from: https://www.oecd.ai/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23Austria

# 2. Research and innovation around AI technologies and applications in healthcare

**Scientific Papers**

| 2.0% | 15 |
|---|---|
| **%** in EU27[6] | **Rank** in EU27 |

**Patents**

| 0.3% | n/a |
|---|---|
| **%** in EU27[7] | **Rank** in EU27 |

Austria has made significant progress in the field of research and development and was characterised as a "top innovator" by the international innovation scoreboard in 2018 and contributed 2.0% of scientific output in the field of AI for healthcare amongst EU-27 in 2020.[8] There is a wide range of application areas, and similarly to other EU countries most original research is focused around image diagnostics, as well as systems targeting diagnosis and treatment decision support through medical record analytics.

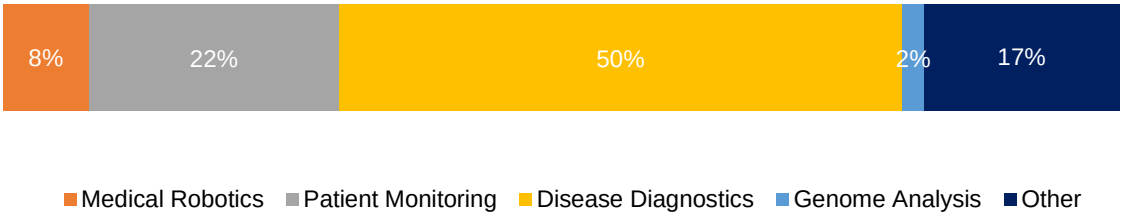



Figure 1: Areas of application in scientific papers

Several universities contribute to the scientific output, especially educational entities with teaching focuses on medicine and technology. The Medical University of Vienna, the Medical University of Innsbruck and the Austrian Institute of Technology Centre for Health contribute with cutting-edge studies on the use of AI neural networks[9] in neuro-oncology, machine learning techniques for cancer detection, as well as predictive and preventive medical approaches. Some scientific publications also originate from hospitals, such as the St. Anna Children's Hospital with research on automated diagnosis.

Research departments for Advanced Information Systems and Technology at the Austrian Institute of Technology, the Vienna University of Technology and the University of Applied Sciences Upper Austria have a strong research focus on technological aspects of AI.

6 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

7 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

8 Cf. Austrian Embassy Washington: "Austrian Innovation. Hidden Champions around the World", 2020. Retrieved from: https://www.austria.org/austrian-innovation

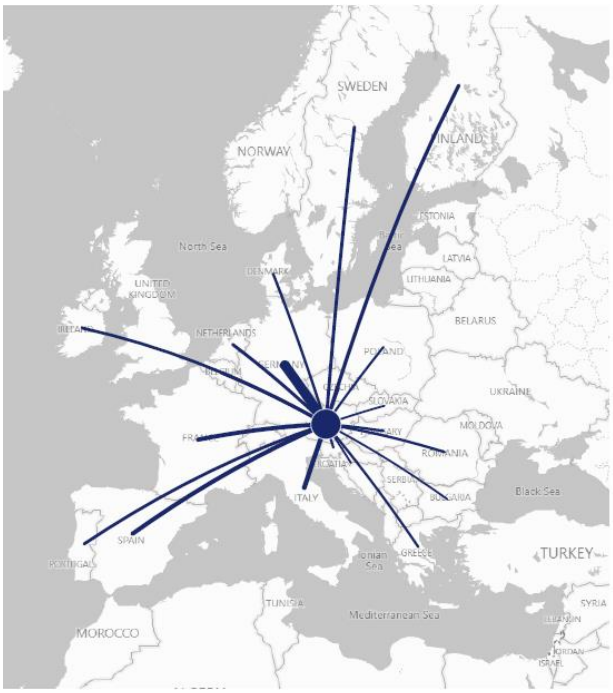
9 Artificial Neural networks or neural networks are computational algorithms. They are intended to mimic the behavior of biological systems composed of "neurons".

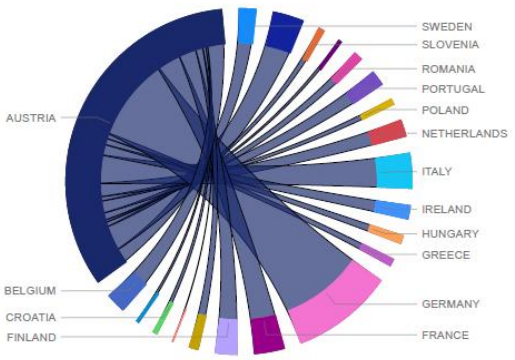
# Cross-border collaboration in research

| 10.7 | 17 |
|---|---|
| Multilateral score[10] | EU Collaborating countries[11] |

Austria actively collaborates with universities and research entities in other EU countries: We identified a particularly close collaboration with Germany; other countries include Italy, Spain, Finland and France.

Although no dedicated AI or robotics programme has been established yet, several programmes[12] cover topics related to collaborative robotics and Ambient-Assisted Living amongst others. Furthermore, the Austrian Society for Measurement, Automation and Technology established the National Robotics- Technology Platform (GMAR)[13] which aims to promote robotics, automation and AI technology and connect relevant international communities.




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Germany | 14.6 |
| Italy | 5.7 |
| Spain | 3.9 |
| Finland | 3.6 |
| France | 3.3 |

Figure 2: Volume of cross-border collaboration in research.

10 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

11 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

12 Such programmes in Austria include “Production of the future”, “ICT of the Future”, “ECSEL” and “Mobility of the Future”, cf.

13 GMAR Website. Retrieved from: http://www.gmar.at/

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The most important funding sources in Austria are the Austrian Research Promotion Agency (FFG) and Austria Wirtschaftsservice GmbH (AWS) which offer non-repayable grants, guarantees or subsidised loans. Both promotion agencies offer funding opportunities, information on possibilities for international cooperation and guidance on all stages of the start-up.

Organisations such as Austrian StartUps (AS), Austrian Angel Investors Association (AAIA) and Austrian Venture Capital and Private Equity (AVCO) form the supporting network of Austria's start-up ecosystem.[14]

The Austrian Startup Monitor and its initiatives help raise awareness and provide empirical insights regarding the Austrian start-up ecosystem[15]. Similarly, Austrian Start-ups, a platform for innovative entrepreneurship in Austria, enriches this ecosystem by building a vibrant community and large-scale change initiatives[16].

There are at least eight start-ups in Austria whose work is focused mainly on AI-enabled tools in the healthcare sector. AI-based platforms and software solutions are primarily being developed for disease monitoring and diagnostics, namely for diabetes, infectious diseases and heart diseases.

# 4. Awareness and use of AI technologies and applications in healthcare

Consistent with the findings on Austria's advanced legislation and digital literacy, the country displayed consistent online awareness of AI in the healthcare sector throughout the period of June 2019 until July 2020, with news mentions totalling 3,600. The most significant peaks occurred in January and May of 2020, accumulating 103 and 110 mentions respectively.

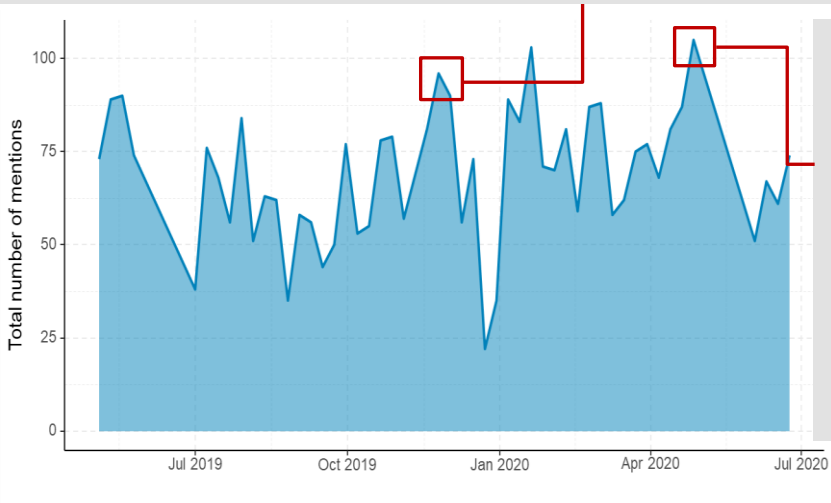
The first of which related to news surrounding the first healthcare member (Health Catalyst) of Partnership on AI, a coalition committed to the responsible use of artificial intelligence. Additional media attention surrounded the use of AI to accelerate clinical trials for a joint drug discovery program aiming to provide therapeutics for lung cancer treatment. The spike in May primarily focused on how the novel technologies can be used to mitigate the Covid-19 crisis. This included news mentions of telehealth providers using AI to offer low cost medical expertise, and the AI powered cancer screenings to aid hospitals strained by Covid-19 infected patients.

14 Startup Ecosystem Austria. Retrieved from: https://investinaustria.at/en/startups/overview.php

15 Austrian Startup Monitor website. Retrieved from: https://austrianstartupmonitor.at/en/

16 Austrian Startups website. Retrieved from: https://austrianstartups.com/

**January - February 2020: Health Catalyst joins Partnership on AI**, as first healthcare member, aiming to use its cloud-based data platform and AI powered analytics technology to improve to enhance health equity and patient empowerment. Evotec and Indivumed announce second **Joint Drug Discovery Program** to discover and develop first-in-class therapeutics for the treatment of non-small cell lung cancer, using **IndivuType's** powerful database and AI tools to accelerate clinical trials.



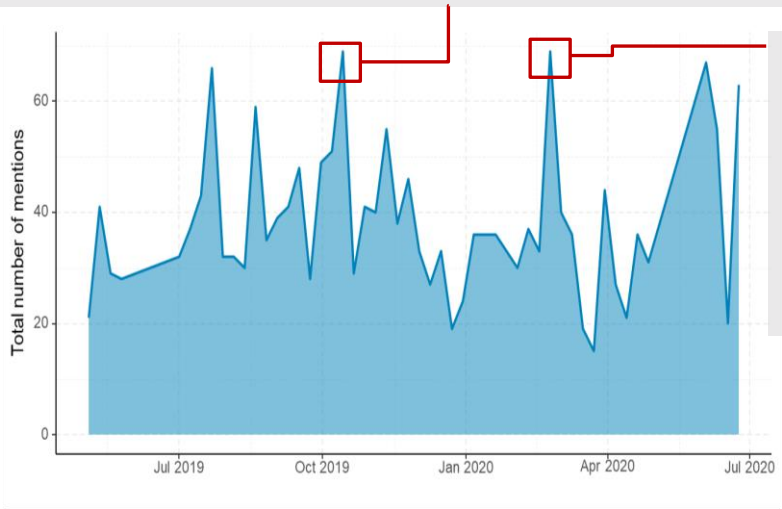

**May 2020:** Telehealth providers such as **Teledoc** and **First Medicine Corporation**, gained media attention through the use of AI and machine learning to provide low cost expert medical attention to people impacted by Covid-19. Additionally, **Andor** provides an AI powered cloud-based platform, which enables fast communication and access to patient medical data for healthcare institutions. **Digital reasoning** is using AI to provide cancer screenings at hospitals, which are have dedicated most of their capacities on covid-19 related treatments.

Figure 3: Trend of total mentions in the news

Mentions in social media followed a similar trend, accumulating 2,000 mentions, with peaks in October 2019 (64 mentions) and March 2020 (66 mentions). The first peak focused on the opportunities that arise from the integration of AI in the healthcare sector such as more efficient and accurate cancer detection and treatment, however mentions also expressed concerns regarding the ethics of AI in radiology.

The second peak provided additional details about the enhancement of radiology through the involvement of AI by improving the medical imaging exams and generating reports, which has subsequently reduced the number of students considering careers in the field. Finally, tweets by industry influencers claimed that AI will bring equity to the healthcare system, particularly for low-income countries.

**October 2019:** Social media mentions primarily focused on the **opportunities that AI brings** to different fields of the healthcare sector. These include service robots for rehabilitation, cancer detection and treatment and drug discovery. However, **concerns over the ethics of AI in radiology** were expressed.




**March 2020:** Twitter mentions focused on the use **AI in radiology**, more specifically for medical imaging exams and generating reports, as well as for Covid-19 diagnosis. Other areas of AI intervention include drug discovery, with MIT team **discovering an antibiotic through the use of AI.**

Twitter mentions are also related to **AI to bring equity in the healthcare sector** for low-income countries by addressing judgement and knowledge gaps.

Figure 4: Trend of total mentions in social media

**11.5 Mio**[17]
**Total population**

**58.7**[18]
**DESI 2020** Index

**89%**
% of **internet users**

**2.6%**
**Population as a % of** EU27

**12**
**DESI 2020 ranking amongst** EU27

**61%**
% of population with at **least basic digital skills**

**66%**
% of **Open Data**

# BELGIUM

## 1. Relevant legislation and policy framework

The "AI4Belgium" Coalition, a grassroots multidisciplinary team whose aim is to build a better Belgium, published a policy recommendation report in 2019 in order to position Belgium in the European AI landscape. The coalition prioritises effective, responsible and proactive data sharing among healthcare professionals. Healthcare and life sciences are particularly promising when it comes to maximizing the output from AI with regards to high-value-use cases and a better quality of life of Belgian citizens.[19]

"AI4Belgium" recognised that SMEs may find it more difficult to start working with often unfamiliar and costly AI technology. In response they created AI Lighthouses, which are training programs, large-scale events and social-impact projects in relation to AI. Specifically, the "AI4Belgium" Coalition aims at showcasing potential use cases and the positive social impact to the population of AI technologies in healthcare. AI-based advisory tools shall support doctors to improve patients' treatments plans, leading to better health outcomes. With regards to AI world-class data and talent attraction, the Belgian government encourages computer science and AI students to work on practical applications in healthcare.

In Belgium, AI strategies are broken down into an intra-Belgium multilevel governance approach, given the division of competences in the Belgian federal state. The Flemish government, for instance, has launched the Flemish action plan in 2019 to foster AI in Flanders. They identified three pillars for their action plan: The Flanders AI Research Program; The Flanders AI Implementation Program, and; Flanders AI Supporting activities. Within the research programme pillar, four strategic challenges will be addressed in the context of use cases or proofs of concept, in particular in the health domain[20]. Another example is in the Walloon Region. The DigitalWallonia.ai program was set up to accelerate the adoption of AI in Wallonia and the development of its Walloon ecosystem.

The Belgian coalition of experts emphasises the importance of ethical guidelines to support the use and the development of AI by building up public trust within the society. Aspects such as accountability, legitimacy, non-discrimination, respect for privacy and transparency should be respected during the development and use of any AI and data strategy in order to reach an effective regulatory framework.

17 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

18 Digital Economy and Society Index 2020 - Country Report: Belgium, Shaping Europe's digital future, https://ec.europa.eu/digital-single-market/en/scoreboard/belgium (accessed in December 2020)

19 Adeline Michaux, Antonio Cano et al. : « AI 4 Belgium », Report, p.28

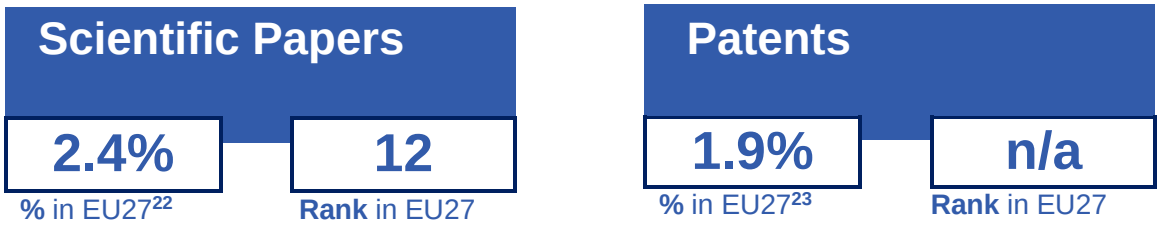
20 Cf. Flanders AI Research Program: "Investing in Artificial Intelligence All eyes on shaping the future", 2020. Retrieved online: https://airesearchflanders.be/

In the survey conducted as part of this study, founders of AI SMEs as well as research entities operating in the healthcare sector indicated that they would like to see the following areas of legislation/policy in place:[21]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Cybersecurity policies;
- Policies around AI testing and certification in the healthcare sector;
- Policies aimed at the encouraging the deployment of AI technologies in healthcare.

In addition to the legal and ethical conditions for AI, common standards should be developed to foster public-private partnerships and the cooperation between governments.

## 2. Research and innovation around AI technologies and applications in healthcare




Belgium contributes 2.4% of scientific output in the area of AI in healthcare amongst the EU-27. This is a significant output relative to Belgium's population and is largely supported by EU, National and Federal scientific grants.

The research output of Belgium in terms of applications of AI in healthcare comes mainly from the six research universities of Belgium: Katholieke Universiteit Leuven, Université Catholique de Louvain-la-Neuve, Université de Liège, Universiteit Antwerpen, Université Libre de Bruxelles, and Vrije Universiteit Brussel. They all have research groups around AI. Notably, the Interuniversity Microelectronics Centre (IMEC) also makes an important contribution to AI development.

The focus of a large portion of the scientific output is on diagnostic systems related to physiological monitoring and cardiology, medical image diagnostics for medical decision support, as well as genomics for personalised medicine. The above-mentioned research universities published a significant amount of research about neural networks in the domain of disease detection and prediction or for MRI assessments and automated quantification[24]. Machine learning approaches and deep learning methods are used to identify new biomarkers[25] or biometrics[26].

21 See survey results. Order of the results according to order of priority.

22 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

23 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

24 Automated quantification is a potential way of improving accuracy and reproducibility of routine measurements.

25 Biomarkers are often measured and evaluated to examine normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention

26 Biometrics are physical or behavioral human characteristics to that can be used to digitally identify a person to grant access to systems, devices or data. Examples of these biometric identifiers are fingerprints, facial patterns, voice or typing cadence.

Specific funding schemes for research institutes include the FWO[27] and FNRS[28] both of which have specific calls targeting the development of technology and innovation research around disease prevention and management. VLAIO, the Flemish Agency of Innovation and Entrepreneurship, invested more than € 41 million in AI-related projects in 2019, to enable their implementation in the industry. In the Brussels region, AI-related research and innovation is supported by the Brussels Region funding body, which is continuously expanding its support programs in this field. Over the past two years, they had a dedicated budget of 2 million.[29]

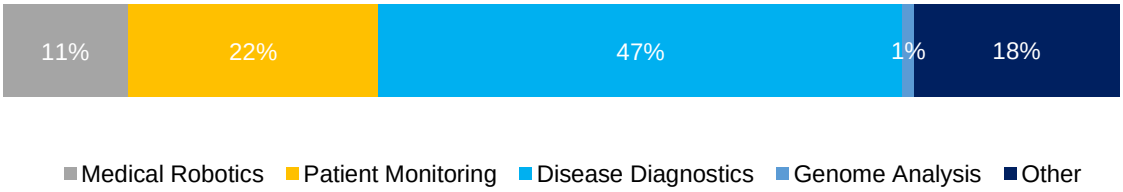



Figure 5: Areas of application in scientific papers

While initiatives and working groups have been established to promote the development and use of AI, like an initiative from the Royal Flemish Academy of Belgium for Science and the Arts[30], or the AI4Belgium initiative, no particular initiatives around AI solely in healthcare/medicine have been identified thus far.

The Flemish AI action plan currently sees four research challenges in AI which need to be addressed[31]:

- AI Driven Data Science: Help to make complex decision through data science;
- Deliver AI to the edge: Real-time and power efficient;
- Multi-agent collaborative AI; Interact autonomously with other decision-making entities;
- Human-like AI: Communicate and collaborate seamlessly with humans.

27 Cf. FWO Opening new horizons website. Retrieved from: https://www.fwo.be/en/ (accessed in December 2020)

28 Cf. FNRS website. Retrieved from: https://www.frs-fnrs.be/fr/ (accessed in December 2020)

29 OECD, Brussels Region Artificial Intelligence Policy, November 2020. Retrieved from: https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24907/

30 Royal Flemish Academy of Belgium for Science and the Arts, Artificial Intelligence. Retrieved from: https://www.kvab.be/en/standpunten/artificial-intelligence (accessed in December 2020)

31 AI Research Flanders, Investing in Artificial Intelligence - All eyes on shaping the future, website. Retrieved from: https://airesearchflanders.be/

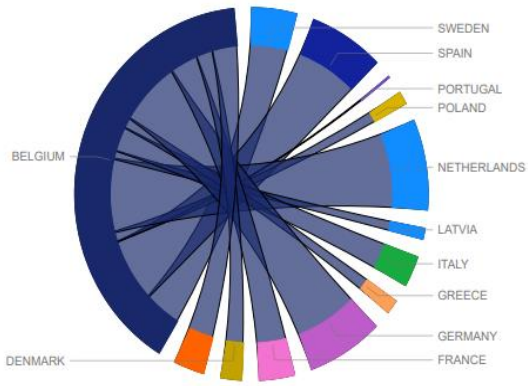
## Cross-border collaboration in research

| 10.7 | 17 |
|---|---|
| Multilateral score[32] | EU Collaborating countries[33] |

We identified at least 12 countries, with which Belgium collaborates in the area of AI in health. Neighbouring Germany and the Netherlands are the top collaborators.

The AI strategy of Belgium recognises the importance of collaboration between companies and research institutes, not only at the national level but also by integrating international communities. The strategy plans to position Belgium as Europe's AI lab, and thus create a confederation of Belgian laboratories and join other European initiatives (ELLIS, CLAIRE). Furthermore, in order to increase the international attractiveness of AI, part of the strategy includes organising large-scale events that showcase Belgian AI successes and attract new or foreign talent.[34]

The "Benelux Association for AI" (BNVKI) is an association between Belgium, Netherlands and Luxembourg that fosters research on AI and stimulates the application and education on AI in the Benelux Region through intense collaboration.


| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Netherlands | 8.3 |
| Germany | 7.4 |
| Spain | 7.2 |
| Sweden | 4.4 |
| France | 3.4 |

Figure 6: Volume of cross-border collaboration in research

32 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

33 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

34 Cf. OECD, Emerging technology regulation, November 2020. Retrieved from:https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24234

# 3. Current state of development of AI in healthcare

There is a strong start-up culture and network in Belgium which is supported by non-profit organisations such as Startup.be[35] and networking and incubation initiatives such as Startupfactory.be[36]. These organisations and initiatives have managed to create a strong support network and promote the establishment of innovative companies. A lot of Belgian health-tech start-ups are spin-offs that have emerged from research institutions.

In Belgium there are at least seven start-ups developing technologies around wearables, IoT and AI for medical decision support in healthcare. Four of those start-ups responded to the survey conducted in the context of this study. The survey results reveal that they work in quite different areas such as biomarker discovery for drug development, clinical natural language processing and data mining or treatments with Digital Therapeutics. To develop their AI systems and applications, start-ups use vital sign data[37], unstructured data, biochemical and imaging data sources that they either obtain through their own clinical trials/other data collection or openly available research databases. Although most respondents admitted to using open-source databases, they all seemed reluctant to share their own data.

The Belgian start-ups are expected to develop AI technologies that have an impact on aspects ranging from reduced drug development time for pharma and biotech companies to improved disease treatments and decision-making.

Less than half of all respondents to the survey[38] indicated receiving funding aid, at least 40% of which receive private funds. Only 20% appear to have received public funds made available by either the European Commission or national funding sources. The total sum from public funds amounts to less than € 100,000 in the past three years.

Amongst start-ups and research institutions surveyed, there is wide-ranging agreement on the following barriers related to the implementation and utilisation of AI systems by health professionals in the health sector:

- Lack of understanding of the technology;
- Lack of ease of use;
- Lack of IT knowledge and competencies;
- Lack of access to AI technology.

# 4. Awareness and use of AI technologies and applications

It was surprising to find that the general public has a relatively low awareness about AI technologies aimed at medical and healthcare purposes, considering Belgium's significant role in the European economy, and the overall high number of Internet users (89%) with high awareness of digital technologies. In any case, some news articles, published between June 2019 to July 2020, referred to predictive medicine and relevant progress in radiology.

Specifically looking at news mentions (890 in total), two peaks of publications come in quick succession during the fall of 2019. The first consisted of numerous national news sources publishing articles on an AI system which can predict cardiac incidents. Further attention in

35 Cf. Startups. Retrieved from: https://www.startups.be/ (accessed in December 2020)

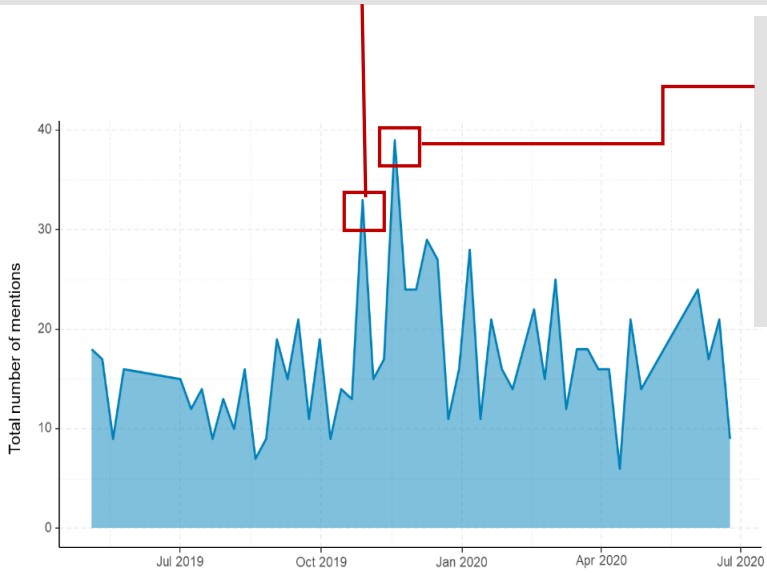
36 Cf. Startup Factory website. Retrieved from: https://www.startupfactory.be/ (accessed in December 2020)

37 Data recorded from the devices used to monitor a patient's vital signs

38 4/5 of the respondents represent start-ups, 1/5 represents a university.

late 2019 was placed on the use of AI and machine learning for the detection of various cancers.

**October/ November 2019:** Development of Belgian AI system that **can predict cardiac incidents** after a year of research by a start-up and the Free University of Brussels. This news marks a breakthrough for healthcare, is published by different national sources and shared various times on Twitter and Facebook.
Further publications make **AI breakthroughs in radiology** and a personalised digital assistant for gut health subject of discussion.




**November 2019:** Fields of AI, Machine Learning are linked to cancer research and diagnosis of depression. Particular attention is raised around early detection of patterns that lead to **liver cancer** with the aid of a computer model based on AI.

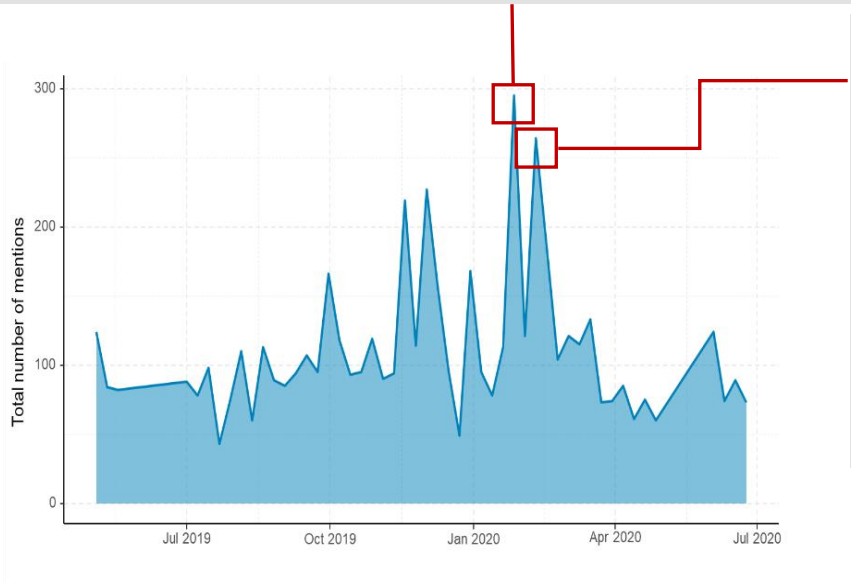
Other than that, purely informative publications on AI and its sub-sets, encompassing applications for health and other industries.

Figure 7: Trend of total mentions in the news

Social media better reflected Belgium's positioning in the European Union, with the Commission's Tweets on EU data strategy, policy and ethical perspectives for medical AI technologies raising awareness amongst Belgian internet users. The strong start-up culture and current development of AI in this field is reflected in posts about innovative initiatives by both start-ups and conglomerates.

Social media platforms reported strong activity surrounding AI and health, accumulating 5,700 mentions over the 13-month period. The period included contradicting opinions from influencers regarding the use of AI for diagnosis. On the one hand, there are concerns over who to blame if algorithms make mistakes in their diagnostics, while others claim that human biases need to be removed from medical decision making. The peak in February coincided with the European Commission's ambition to further integrate AI in various sectors, including health, while MedTech is presenting policy and ethics perspectives to facilitate the use of AI in healthcare.

**February 2020:** Social media attention around **Corti**, an AI based software used to for **real-time diagnosis** with high accuracy. Scepticism expressed regarding who to blame if the deep learning algorithms make a mistake in the diagnosis. While other influencers believe that AI is needed to remove the **biases in human medical decision making**. The launch of **Microsoft's new AI for Health** initiative as a part of their AI for Good program, was trending on twitter with Microsoft pledging € 40 Million to the project.




**March 2020:** The **EU Commission's** tweet, using the hashtag **#DigitalEU**, claiming that **AI is the main ingredient for innovation**, while identifying health as a key target sector, was the main talking point. Additional activity related to, MedTech presenting **policy and ethic perspectives** from the industry to facilitate the use of AI in healthcare, which is to be included in the EU Approach on AI and EU Data Strategy. US embassy in Brussels brought attention to a study by **University of Michigan,** explaining how **AI can successfully diagnose brain tumours.**

Figure 8: Trend of total mentions in social media

# BULGARIA

**7.0 Mio**[39]
**Total population**

**36.4**[40]
**DESI 2020** Index

**67%**
% of **internet users**

**1.6%**
**Population as a % of** EU27

**27**
**DESI 2020 ranking amongst** EU27

**29%**
% of population with at **least basic digital skills**

**57%**
% of **Open Data**

## 1. Relevant legislation and policy framework

The Ministry of Transport, Information Technology and Communications is responsible for creating a national AI strategy in Bulgaria. A first draft of this AI strategy, called "Artificial Intelligence for Smart Growth"[41], was released in 2020. It states that in the last two to three decades in the Bulgarian healthcare sector, a number of health information systems has been implemented which provide data management in individual departments or support the accountability of GPs, pre-hospital care professionals and medical establishments at the National Health Insurance Fund.

According to responses to the survey received from national authorities in Bulgaria, there is already national legislation in place that covers different areas, e.g. data protection rules regarding the use and exchange of health data for the purpose of AI analysis, cybersecurity policies, policies aimed at supporting research and innovation in the area of AI in healthcare.[42]

In the next decade (2021-2030), with reference to the Draft Strategy “AI for Smart Growth. Development Strategy of Artificial Intelligence in Bulgaria until 2030”, Bulgaria plans to create a National Health Information System, including a national system for electronic health records of citizens, electronic referrals and electronic prescriptions. This will allow the integration of health information systems to overcome their existing challenges of data sharing and implement AI technologies to simplify the cross-border exchange of health data.
The Ministry of Transport, Information Technology and Communications proposes the creation and maintenance of a National Point of Access that would ensure national and cross-border secure electronic exchange of health records (with medical and health data from performed treatments, therapies, research, and medical imaging) and electronic prescriptions. In order to overcome the burden of sorting through the data using manpower, the ministry plans to implement AI to learn and adapt to data that is protected under GDPR[41]. Another hurdle in medicine are resources prepared by hand-defined declarative conceptual knowledge, with names of concepts and relations in English. That is the Unified Medical Language System (UMLS23), which is freely available for Research. AI would support the creation of systems that "understand" these biomedical texts[41].

The Bulgarian Academy of Sciences suggests further fields of use of AI technologies in healthcare:[41]

- Lack of ease of use;

39 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

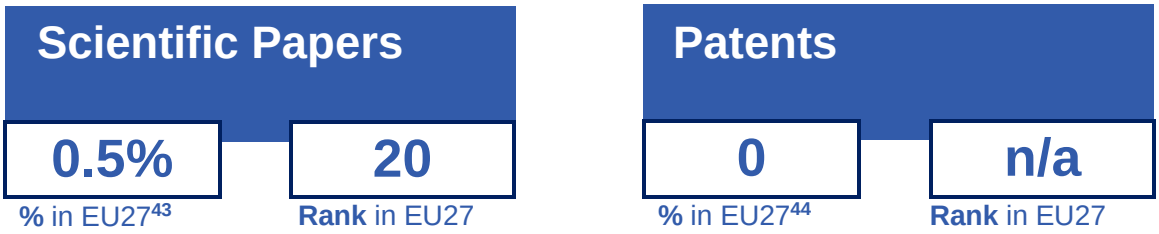
40 Digital Economy and Society Index 2020, Country Report: Bulgaria. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/bulgaria

41 Bulgarian Academy of Sciences, “AI for Smart Growth. Development Strategy of Artificial Intelligence in Bulgaria until 2030”, 2020. Retrieved from: http://www.bas.bg/wp-content/uploads/2020/07/Proposal-National-Strategy-AI-2030-24June2020.pdf

42 See survey results.

- The analysis of complex medical images such as X-rays, computed tomography examinations (CAT scan) and various screenings and tests;
- The detection of unknown patterns and correlations in the occurrence and course of diseases to improve early diagnosis, to finding better treatment for chronic diseases and to building a personalized treatment plan for each patient;
- The shortening of the process of creating new drugs;
- Automatic analysis of free text to quickly find relevant facts in scientific literature.

## 2. Research and innovation around AI technologies and application in healthcare




Bulgaria contributes 0.6% of scientific output in the area of AI in healthcare and ranks 21st amongst EU countries. Its scientific output is relatively small compared to its size. The overwhelming majority of publications come from the relevant faculties of the Technical University of Sofia and focus on medical imaging applications, as well as medical text processing.

Bulgaria is also preparing specific policy reports that focus on research[41]. Medical informatics fails to attract young Bulgarian computer scientists. There is a lack of competent specialists in this strongly interdisciplinary field likely because higher education institutions do not offer enough programmes in medical and health informatics. To make the field more attractive and to increase access to such programmes, the government plans on deploying innovative research approaches. The research would focus on original applications of AI machine self-learning in the field of healthcare[41].

In recent years, research around the area of AI in healthcare has already started gaining momentum thanks to the Bulgarian Institute of Sciences and the recently established Institute of Information and Communication Technologies[45].

43 Using Fractional Count (FC) method based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

44 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

45 Institute of Information and Communication Technologies, Copyright © IICT-BAS 2010-2020. Retrieved from: http://www.iict.bas.bg/EN/

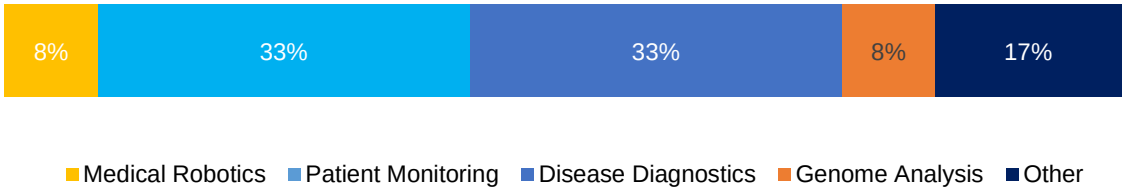



Figure 9: Areas of application in scientific papers

The Department of Informatics of the New Bulgarian University, the Institute of Information and Communication Technologies, the Bulgarian Academy of Sciences, and ADISS Ltd., have been at the forefront of the majority of research into AI in healthcare. They have published papers, either independently or in consort, on the following subjects:

- Improved digitalization of medical images;
- Attitutes towards telemedicine;
- Clinical Text Mining, Data Mining and Analytics, including its rules;
- Sleep and Mood Estimation Modules.

## Cross-border collaboration in research

**1.2**

**Multilateral score**[46]

**1**

**EU Collaborating countries**[47]

Another recent trend observed in the area of technology applications in healthcare is collaborations being established between technology research groups within universities and medical universities, such as the Medical University of Varna and the New Bulgarian University in Sofia. They have been collaborating with Macedonia, the Netherlands and Portugal on subjects such as Health-Related Quality of Life Process with Intuitionistic Fuzzy Estimation, Improving Activity Recognition Accuracy in Ambient-Assisted Living Systems by Automated Feature Engineering, ECG-Based Human Emotion Recognition.

46 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

47 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The start-up ecosystem in Bulgaria is currently supported by government-led schemes, such as the "Small and Medium Sized Enterprises Initiative"[48] programme for 2014-2020, launched by the Ministry of Economy with the aim to facilitate the access to financing of micro, small and medium-sized enterprises (SMEs). The programme, funded entirely from the European Regional Development Fund, offers MSME access to loans for investment in assets or working capital to strengthen their growth and development, as well as loans at lower than the standard interest rates.

Additionally, Sofia is now the location of venture capitals that are investing in the wider South-Eastern European region, e.g. accelerators, early-stage funds[49] and LAUNCHUB Ventures (seed fund)[50]. These ventures also list start-ups working in AI in healthcare in their investment portfolios.

Despite the promise of healthcare being one of the sectors in Bulgaria in which the AI technologies[51] will be of great use, the number of companies currently working in applications of AI in healthcare are still limited. Nevertheless, the number of companies in this sector is expected to grow as the healthcare ecosystem develops. In Bulgaria there are at least three start-ups engaging with AI technologies and application in the healthcare sector.

# 4. Awareness and use of AI technologies and applications in healthcare

National Bulgarian news sources brought little awareness to the application of AI in the healthcare sector, with the total mentions barely breaching the 200 mark. Their first peak (15 mentions) contained many news sources reporting on a prominent Bulgarian CEO criticizing the government's lack of a clear vision for the future of AI in Bulgaria, inhibiting the modernization of the healthcare sector.

During the second peak of 17 mentions, news sources covered the implementation of AI to cater to Covid-19 related issues, including a virtual voice assistance to connect infected citizens to emergency services.

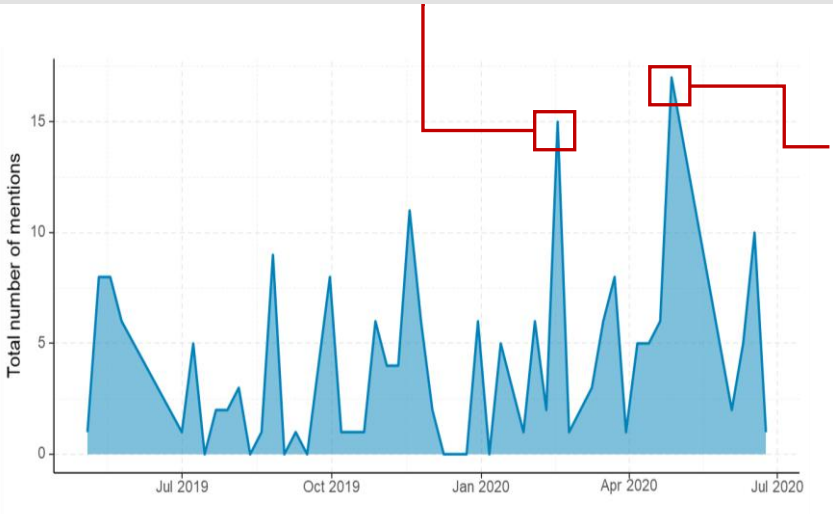
48 Cf. Republic of Bulgaria, Ministry of Economy, 2020,. Retrieved from: https://mi.government.bg/en/pages/op-iniciativa-za-malkite-i-srednite-predpriyatiya-2014-2020--263.html

49 Cf. Eleven, Retrieved from: https://www.11.me/

50 Cf. LAUNCHUB Ventures. Retrieved from: https://launchub.com/about

51 Artificial intelligence ecosystem in Bulgaria, 2019. Retrieved from: https://investsofia.com/wp-content/uploads/2019/06/Artificial_intelligence_ecosystem_in_Bulgaria_2019-SeeNews_and_Vangavis.pdf

**February 2020**: News sources reported the criticism of a Bulgarian CEO towards the **government's lack of vision, awareness and cohesion** when it comes to AI, claiming the healthcare sector, among others, cannot be modernized without a clear policy on AI.
Furthermore, the EC Vice President Vestager claims that **AIs interference in healthcare should be limited** with humans having the last word to alleviate the serious consequence which could occur from machine error.




**April 2020**: Social media attention was centered around the use of AI by a Tunisian engineering school to measure the **probability of a person being infected by Covid-19,** based on a lung radiography.

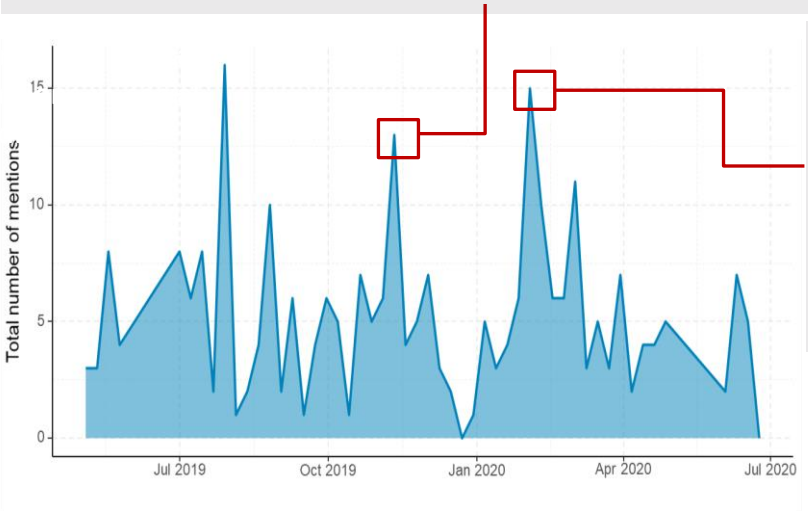
Other news relates to the use of AI for a virtual voice assistance, AlloCovid, helping victims of Covid-19 access emergency services or their GPs.

Figure 10: Trend of total mentions in the news

Similar to official news activity, Bulgaria's performance on social media platforms, pertaining to the intersection of AI and healthcare, was comparably poor to the rest of the EU member states. Garnering a total of 264 mentions over a one-year timeframe, their first significant peak arrived in November 2019, following an AI-themed conference in Sofia, with health-related topics playing a prominent role.

Shortly after displaying zero mentions towards the end of 2019, social media mentions reached its second peak in February 2020, coinciding with Microsoft's announcement of the AI for Health initiative, for which they pledge USD 40 Million. AI's potential interference in the fight against Covid-19 gained notable attention during the pandemic.

**November 2019:** Tweets and retweets around the AI conference in Sofia using the hashtag #SOPHIASUMMIT, where AI and health were key topics tackled.
**Skepticism** surrounding the **use of AI for diagnosis** because it is unable to justify decisions i.e. trace steps that lead to its conclusion. Attention from a law firm to help transform healthcare systems the cloud, data analytics, machine learning.




**February 2020:** Tweets about AI being able to track the speed at which the coronavirus spreads.

Tweets about the use of robotics for the treatment of Covid-19 infected patients and for **healthcare delivery in remote areas.**

**Microsoft** is launching **AI for Health**, an initiative that will utilize $40 million in grants to unite tech and public health.

Figure 11: Trend of total mentions in social media

# CROATIA

**4.1 Mio**[52]
**Total population**

**47.6**[53]
**DESI 2020** Index

**77%**
% of **internet users**

**0.9%**[54]
**Population as a % of** EU27

**19**
**DESI 2020 ranking amongst** EU27

**53%**
% of population with at **least basic digital skills**

**69%**
% of **Open Data**

## 1. Relevant legislation and policy framework

In 2006, the Croatian government introduced a comprehensive National Health Development Strategy for the period 2012-2020.[55] The first priority was the development of information technology and eHealth integration via standardisation and computerisation of the health system. The strategy also addressed elements of certification, change management and training, financing and legislation.[56] The National Health Care Strategy 2012-2020 includes a section on "Informatisation and eHealth", introducing an e-prescription and e-referrals platform as the first step, giving a solid foundation for further implementation of central Electronic Health Records for patients.

The government is currently working on a strategy around AI, including a regulatory framework. The latest version of the strategy was completed in May 2020 and is expected to be published soon[57]. Meanwhile, some private initiatives have been created, for example the Croatian AI Association (CroAI). They are a group of approximately 30 tech companies who focus on the development of human-centric AI. Additionally, they have published their own strategy and action plan in order to encourage the development of AI in the European Union as a review of the European Commission's White Paper on Artificial Intelligence.

CroAI is a member of the Government's working group for AI tasked with defining Croatia's future national AI strategy. CroAI extends recommendations on areas such as legislation and AI innovation, the need for a competitive EU-wide start-up framework and the crucial role of the state for the development of AI[58].

52 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

53 Digital Economy and Society Index 2020, Country Report: Croatia https://ec.europa.eu/digital-single-market/en/scoreboard/croatia

54 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

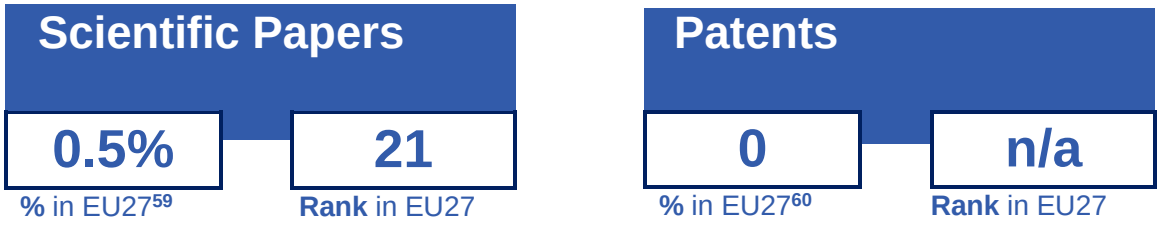
55 Cf. World Health Organization: "Global Observatory for eHealth: Croatia", 2016. Retrieved online: https://www.who.int/goe/policies/countries/hrv/en/

56 Ibid.

57 Cf. European Commission: "Croatia AI Strategy Report", 2020. Retrieved online: https://ec.europa.eu/knowledge4policy/ai-watch/croatia-ai-strategy-report_en

58 Cf. Croatian Artificial Intelligence Association, 2020. Retrieved online: https://www.croai.org/index_en/#about

# 2. Research and innovation around AI technologies and applications in healthcare




Croatia's output in terms of scientific publications in the area of AI in healthcare is relatively low with 0.5%, ranking 21st amongst EU countries.

Universities such as the University of Zagreb or the Department of Information and Communication Technologies at the Dobrila University of Pula are key contributors to this output. Furthermore, there is research being conducted by University hospitals such as University Hospital Centre Split or the University of Osijek.

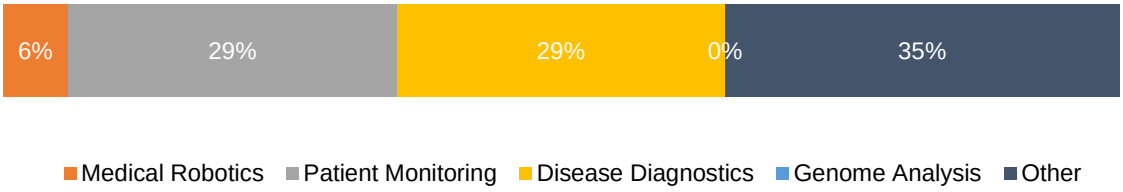



Figure 12: Areas of application in scientific papers

Croatia's contributions range from topics of gender estimation and activity detection to professional healthcare training. Other publications in the field of disease diagnostics investigate the use of AI technologies for smart home, classifications of medical indication patterns (i.e. asthma) and the support of health data analysis. Researchers also work in the

59 Fractional Count (FC) calculcated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

60 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

area of patient monitoring, i.e. performance evaluation of Fog-assisted IoT solutions for e-health applications[61].

Research on AI in health is supported by initiatives such as the Croatian Scientific Portal which consolidates available information in the field of science and promotes the importance of science in Croatia.[62]

## Cross-border collaboration in research

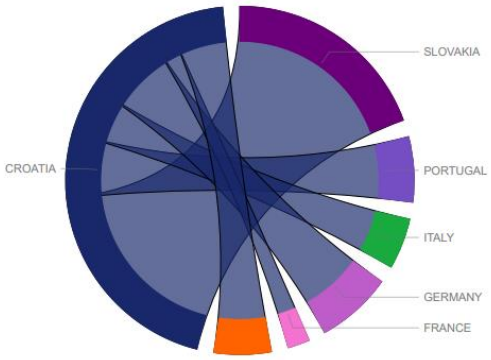
**1.6**

**Multilateral score[63]**

**6**

**EU Collaborating countries[64]**

Croatia ranks 20th in cross-border collaboration and is collaborating with at least six countries, mainly with its neighbour Slovakia, but also with Germany and Portugal.


| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Slovakia | 2.8 |
| Germany | 1.0 |
| Portugal | 0.9 |
| Austria | 0.8 |
| Italy | 0.7 |

Figure 13: Volume of cross-border collaboration in research papers

61 Fog computing extends the concept of cloud computing to the network edge, making it ideal for internet of things (IoT) and other applications that require real-time interactions.

62 Cf. Hrvatski znanstveni portal/ Croatian Scientific Portal, 2006 – 2009. Retrieved online: http://www.znanstvenici.hr/index_en.php

63 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

64 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Croatia's start-up ecosystem has not matured yet and the limited sources of support and a rather high level of bureaucracy seem to hamper its expansion[65]. ¨

Nevertheless, authorities at the state and city level have a variety of financial incentives and loan programs available. Overall, Croatia has 14 programmes, half of which are available to both Croatian and foreign business owners. Six of those represent non-refundable incentives, and several programmes were paused due to COVID-19).[66]

Start-ups within the healthcare sector are limited. We only identified one start-up that engages with AI-enabled tools. The start-up is a growth and development mobile app for children, with features such as access to paediatricians and specialists.[67]

# 4. Awareness and use of AI technologies and applications in healthcare

Overall, Croatia's online awareness is rather low compared to other EU Member States. This result correlates with Croatia's moderate percentage of people with basic digital skills and the early stage of formalisation of their national AI strategy.

During a one-year span from June 2019 to July 2020, Croatia totals a mere 73 AI/healthcare-related results through their news sources. As seen in the graph below, very few months breach the five-mention mark, with a slight uptick of news publications in late April/early March of 2020.

Predictably, the pandemic was the key catalyst bringing the intersection of AI and healthcare into the mainstream. A trending article highlighted the accelerating impact of AI on the drug discovery and development process, with the aim of finding appropriate drugs for the treatment of Covid-19 in the timeliest manner. With pharma companies directing their attention and resources primarily to developing Covid-19 related drugs, the use of AI has become pivotal in quickly gathering necessary data needed for the testing.

65 Cf. European Commission: "Start-up ecosystems in Southern EU", 2019. Retrieved online: https://ec.europa.eu/knowledge4policy/sites/know4pol/files/jrc113872startup_ecosystems_in_southern_europe_en.pdf

66 Marija Tkalec : "Government grants and loans for entrepreneurs in Croatia", 2020. Retrieved online: https://www.expatincroatia.com/government-grants-loans-entrepreneurs/

67 Cf. LittleDot, 2020. Retrieved online: https://littledotapp.com/en/

**May 2020:** The main focus of this peak was the ability of **AI to accelerate the drug discovery and development process**, especially in light of Covid-19. The use of AI helps gather relevant data in much shorter time frames in order to **provide the required critical mass**. Sipher, a bio-tech start-up, **combines AI with their "network medicine"** to identify 81 potential drugs which would contribute to the treatment of corona virus.

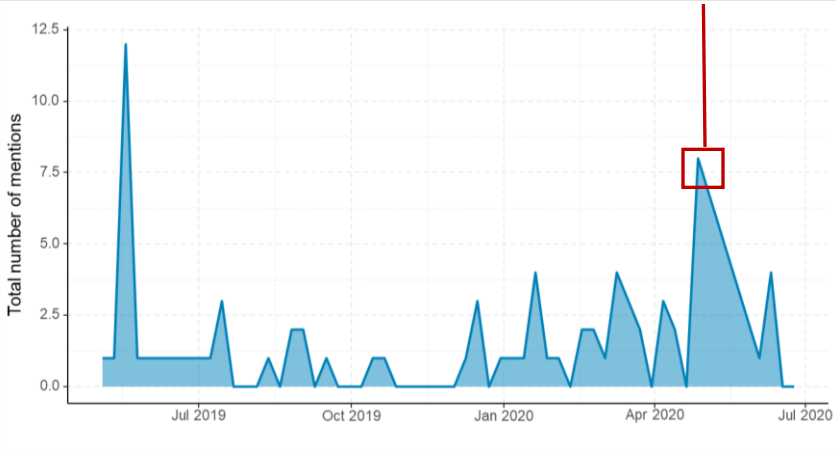



Figure 14: Trend of total mentions in the news

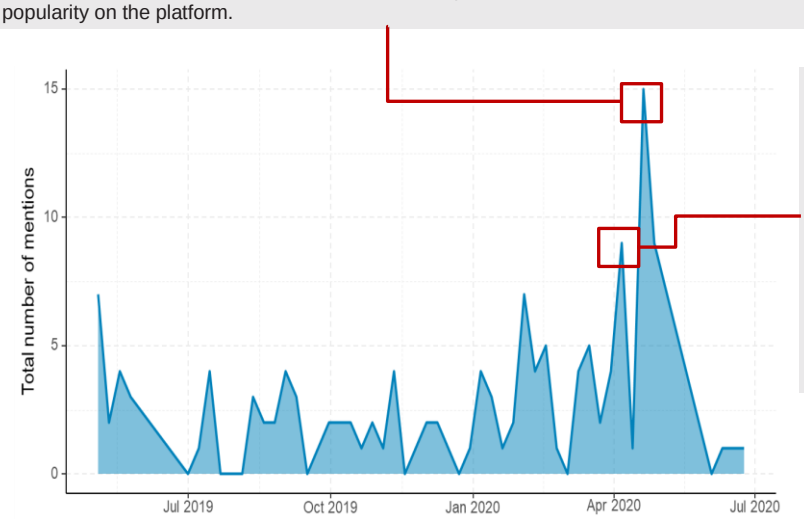
Although displaying larger activity compared to the news mentions, Social Media mentions concerning the use of AI in healthcare are similarly negligible, amassing to 137 total mentions in the designated 13-month time frame.

With the two spikes in quick succession during April of 2020, both being dominated by Covid-19 related tweets and retweets. The first, included technologies that could play a role in accommodating measures to prevent the spread of the virus, such as AI driven drones enforcing social distancing and holograms powered by augmented reality to be used by doctors for home-based medical consultations.

The second spike included strong support of AI in healthcare, predominantly through retweets which included a post regarding the collaboration of machine learning with antibody science for Covid-19 treatment discovery. Other messages specifically mention a Croatian software company that benefits from new machine learning methods to be used in a medical imaging project.

**April 2020:** The one-week spike, included numerous posts expressing positive sentiment towards using AI in healthcare, particularly in light of the Covid-19 crisis. This included a retweet regarding **machine learning collaborating with antibody science** on covid-19 treatment discovery.

Further retweets relate to **new machine learning methods used in the medical imaging project**, which accumulated strong popularity on the platform.




**April 2020:** The peak was dominated by tweets and retweets regarding the potential impact of AI to accommodate for the Covid-19 crisis, these included **AI powered drones** enforcing social distancing and doctors making house calls via **holograms powered by augmented reality**.

Additionally, an AI algorithm that can scan chest x- rays of Covid-19 patients for signs of pneumonia, was mentioned.

Figure 15: Trend of total mentions in social media

| | | |
|---|---|---|
| **888,000**[68] **Total population** | **44**[69] **DESI 2020** Index | **85%** % of **internet users** |
| **0.2%**[70] **Population as a % of** EU27 | **24** **DESI 2020 ranking amongst** EU27 | **45%** % of population with at **least basic digital skills** |
| | | **80%** % of **Open Data** |

# CYPRUS

## 1. Relevant legislation and policy framework

Cyprus is taking a number of steps to accelerate the digitalisation of health, including the uptake of AI technologies in the healthcare sector. In the last year the Ministry of Research Innovation and Digital Government as well as the specific Authority for Electronic Health were established.

The National Artificial Intelligence Strategy, which was approved in January 2020[71], mentions a number of additional actions planned to help the country become a leader in the field of AI. The strategy is based on four key pillars:

- Maximising investment through partnerships;
- Creating national databases;
- Nurturing talents and lifelong learning;
- Developing ethical and trustworthy AI in various sectors, including healthcare.

With respect to a legislative framework, the government of Cyprus is currently developing guidelines to ensure ethically sound and reliable developments in AI and is considering the creation of a National Committee on Ethical and Reliable AI to coordinate this work. Another step will be to develop a clear legislative framework to ensure the availability of data, as well as the protection of personal data such as health records.

The Cyprus Organisation for Standardisation (CYS)[72], which was established in 2002 under the jurisdiction of the Ministry of Commerce, Industry and Tourism, contributes to the development of international standards for AI. CYS even plans to establish a National Commission, which will be responsible for the introduction of AI standards in healthcare among other sectors of the Cyprian economy. The Commission would be also in charge of monitoring and contributing to the work of International and European Committees on AI.

The AI start-ups and research organisations working in the area of healthcare that were surveyed during this study identified the following areas in the legislation/policy with regards to the development and usage of AI-enabled healthcare tools that they would like to see in place:

68 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

69 Digital Economy and Society Index 2020, Country Report: Cyprus https://ec.europa.eu/digital-single-market/en/scoreboard/cyprus

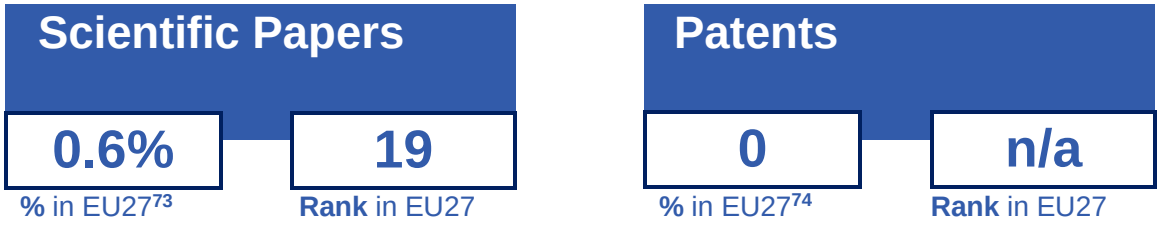
70 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

71 Cyprus Artificial Intelligence Strategy, https://knowledge4policy.ec.europa.eu/sites/default/files/cyprus_ai_strategy.pdf

72 The Cyprus Organisation for Standardisation, https://www.cys.org.cy/

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Cybersecurity policies;
- Safety and liability rules applicable to AI systems;
- Policies around AI testing and certification in the healthcare sector;
- Policies around algorithmic transparency;
- Policies around the ethical use of AI;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Policies aimed at encouraging the deployment of AI technologies in healthcare.

## 2. Research and innovation around AI technologies and applications in healthcare




Research output from Cypriot universities is significant with respect to the nation's size and overall research output, contributing 0.6% of scientific publications in the EU-27 in the period 2015-2020.

The main areas of AI research in healthcare are disease diagnostics with more than a 70% share of all scientific publications, with particular focus on imaging diagnostics. In more recent years, original work around precision medicine has also emerged from academics and researchers working in Cypriot universities and research institutes.

73 Using Fractional Count (FC) method based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

74 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

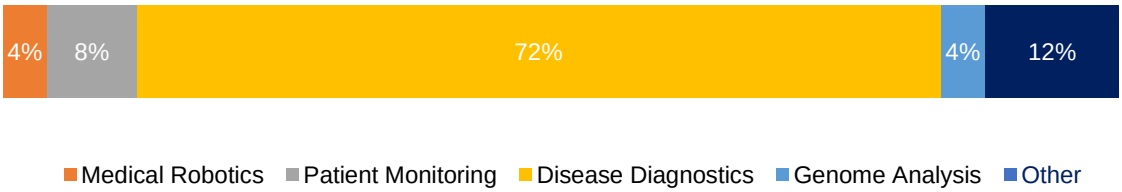



Figure 16: Areas of application in scientific papers

In recent years, the area of artificial intelligence in healthcare has been strongly promoted by big public and private universities. The establishment of three medical schools in Cyprus in the last few years has opened up a space for collaboration between academic institutions and hospitals, which in turn, has given a boost to medical research in Cyprus.

In addition to universities, the Cyprus Institute, home of the biggest supercomputing centre in Cyprus, is leveraging supercomputing facilities in order to create original work, focusing mostly on applications of AI in SPECT (Single-Photon Emission Computerised Tomography) imaging[75] for diagnostics. Additionally, the Cyprus Institute of Neurology and Genetics through its Bioinformatics and Systems research group, has been contributing original research in the area of precision medicine.

Local and European funding opportunities, as well as recent funding schemes by the Research and Innovation Institute in Cyprus, have given a boost to research teams working on AI in healthcare.

## Cross-border collaboration in research

**1.9**
**Multilateral score**[76]

**10**
**EU Collaborating countries**[77]

Cyprus actively collaborates with universities and research institutions in other EU countries. We identified Greece, Italy and France as some of the top collaborating countries with Cyprus in the area of AI in healthcare. Start-ups working in the area of AI in healthcare, that were surveyed for this study, also indicated close collaboration with research institutions in Cyprus.

The Cyprian government recognises the importance of cross-border exchange of expertise and is considering numerous actions to foster international collaboration. For example, there are mobility programs designed to smoothly relocate experts between research institutions in Cyprus and abroad[78]. Another idea being considered is a database of researchers and experts

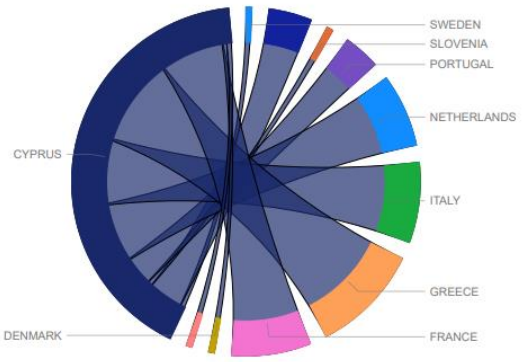
75 SPECT refers to a type of imaging test that produces 3-D pictures.

76 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

77 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

78 European University Cyprus, https://euc.ac.cy/en/academics/

in the field of AI, so that it would be easier to identify areas in which to attract researchers from abroad[79].
It is also worth mentioning that, since the financial crisis of 2013, few academics are returning to work for Cyprus Academic Institutions after their studies. A large number of Cypriot academics work abroad and contribute scientifically to the research generated in this area by other European, American and British universities.


| Top 5 EU collaborating Countries | Bilateral Score |
|---|---|
| Greece | 2.0 |
| Italy | 1.5 |
| France | 1.4 |
| Netherlands | 1.3 |
| Spain | 0.8 |

Figure 17: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Start-ups are the strongest innovation driver in the area of AI in Cyprus. This may be attributed to the favourable taxation conditions and foreign investment schemes which reward innovative start-up companies in Cyprus. The Institute of Research and Innovation also provides start-up-focused grants that produce a modest boost to a number of new organisations. Overall, they are outward looking, targeting international markets as the local market has its limitations.

A strong network of start-up-focused activities and innovation have contributed to the establishment of start-ups focusing on AI in healthcare. SEED, PRE-SEED and INNOVATE are funding opportunities started in 2019 by the Institute for Research and Innovation in Cyprus. Such local funding schemes have contributed at least 12% of their budgets into companies developing state-of-the-art healthcare technologies, including applications of AI in healthcare.

79 Cyprus Artificial Intelligence Strategy, https://knowledge4policy.ec.europa.eu/sites/default/files/cyprus_ai_strategy.pdf

There are over 20 health-tech start-ups currently active in Cyprus, five of which mention developing AI-enabled products. Four of these start-ups responded to the survey of this study, indicating that they work in the areas of patient monitoring technologies, disease diagnostics and medical robotics.

All the surveyed start-ups use data from openly available research databases, hospital Electronic Health Record systems as well as collect their own data via clinical trials. All start-ups indicated that they use vital signs datasets[80] (bio signs) and imaging data[81]. Some companies also mentioned other datasets, such as microbiology data, biochemical data and genome data. Three of the surveyed start-ups not only use open data, but also share their own data to open-source databases, which contributes to further research in this area.

# 4. Awareness and use of AI technologies and applications in healthcare

Cyprus is currently undergoing a big transformation in the area of healthcare, with the introduction of the General Health System (GHS/GeSY). It is a universal health insurance system that aims to provide health care coverage to all Cypriot residents. GeSY originally commenced in 2019 with the introduction of private doctors. The second phase started on the 1st of June 2020 with the inclusion of private hospitals. As a result, the uptake of new technologies, including AI, has not been a priority for the medical community while the country is navigating the challenges of a complete overhaul in the healthcare system.

Only one out of four surveyed start-ups indicated that their products are actively used by healthcare entities (specifically two). One more start-up indicated that their product was purchased by two entities but could not indicate their level of use. According to the surveyed start-ups, the main barriers related to the implementation and utilisation of AI systems by health professionals are a lack of access to technology and a lack of legislation. Unsurprisingly, a recent survey by the Committee for Health of the Parallel Parliament of Research, Innovation and Digital Government, signalled that the need for digital upskilling of healthcare professionals in Cyprus is an emerging issue.

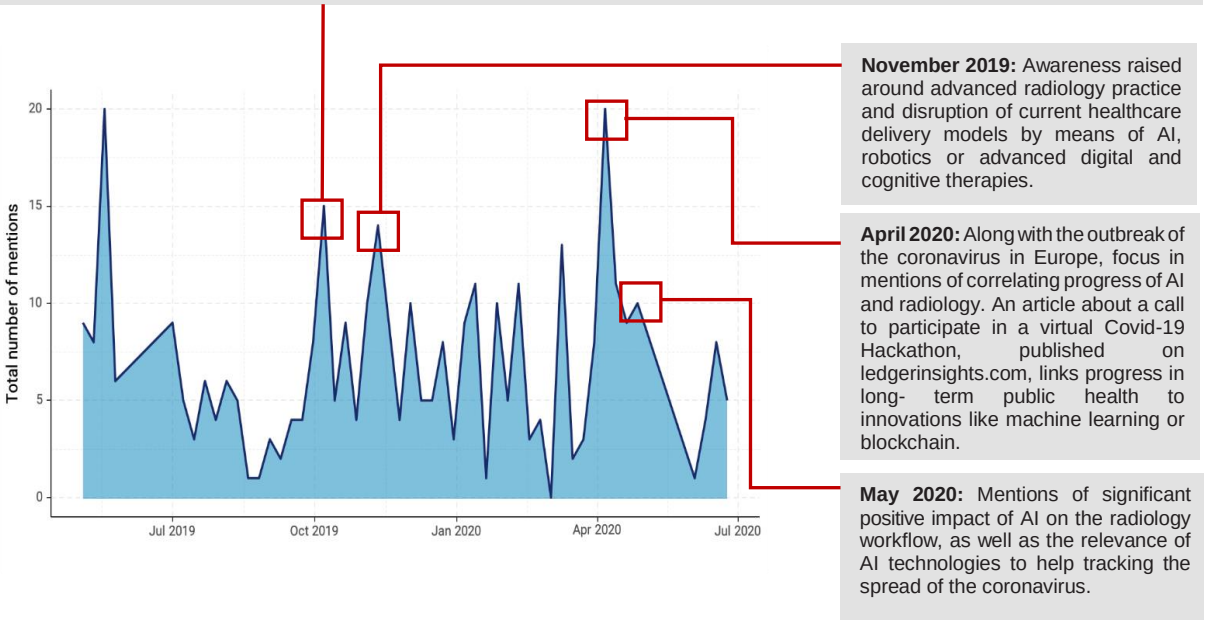
Judging by the percentage of internet users in Cyprus, one could surmise that about 85% would be interested in news activities surrounding the topic of AI. However, despite advanced research activities and a strong network of start-up activities in Cyprus, online news on AI and the healthcare sector are relatively low, with about 330 mentions in news articles between May 2019 and June 2020. Fragmented news results emanate predominantly from international sources.

In the autumn of 2019, news mentions experienced several peaks, highlighting advances in robotic surgery as part of the future of medicine, the use of decision support, and the relevance of AI technologies for radiology. Further news spikes appeared in relation to articles about the disruption of current healthcare delivery models by means of AI, robotics or advanced digital and cognitive therapies (see figure below).

80 Data recorded from the devices used to monitor a patient's vital signs

81 Imaging data sets collect thousands or more images and are used in various ways including training or testing AI algorithms.

**October 2019:** Discussions around advances in robotic surgery as part of the future of medicine and the use of decision support during the second week of October. Several articles stress the relevance of AI technologies for radiology, such as the international publication "Top Radiology Societies Issue Statement on AI ethics". It reveals leading radiological societies' statement on sharing benefits and challenges of AI amongst healthcare stakeholders whilst respecting human rights.




**November 2019:** Awareness raised around advanced radiology practice and disruption of current healthcare delivery models by means of AI, robotics or advanced digital and cognitive therapies.

**April 2020:** Along with the outbreak of the coronavirus in Europe, focus in mentions of correlating progress of AI and radiology. An article about a call to participate in a virtual Covid-19 Hackathon, published on ledgerinsights.com, links progress in long- term public health to innovations like machine learning or blockchain.

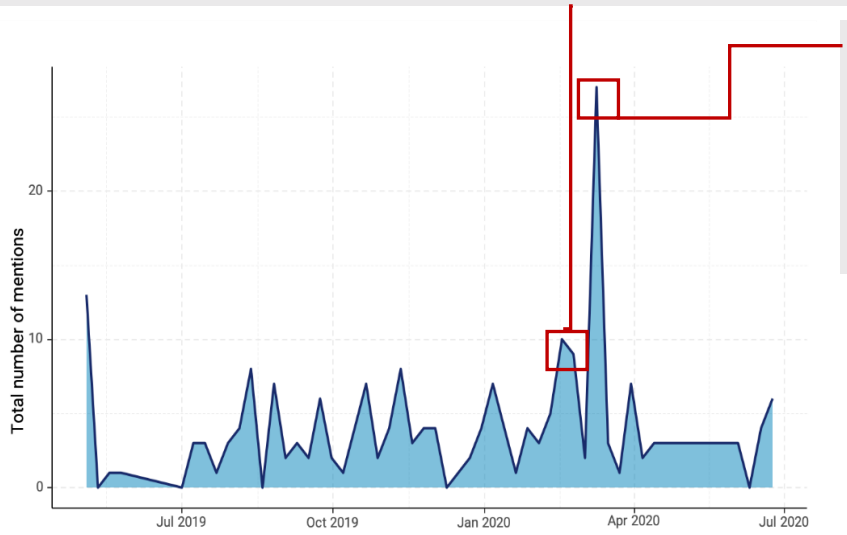
**May 2020:** Mentions of significant positive impact of AI on the radiology workflow, as well as the relevance of AI technologies to help tracking the spread of the coronavirus.

Figure 18: Trend of total mentions in the news

Social Media activities regarding AI and healthcare also generated a staggeringly low number of mentions (148), and engagements (216). Twitter is the main social network platform, with tweeters in Cyprus having some awareness of AI and Machine Learning in the fields of medical imaging and radiology images. After the outbreak of the Covid-19 pandemic, users have predominantly included hashtags like Robotics, Machine Learning, AI and Covid-19 in their tweets.

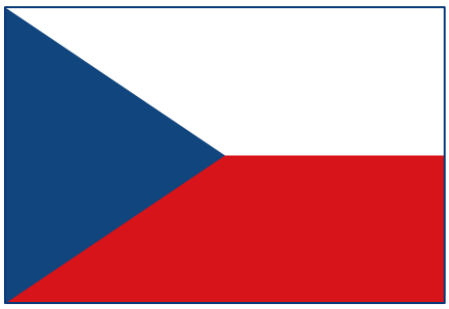
Heightened interest in Machine Learning for analysis of electronic health record data and cardiac imaging is reflected through shares on Twitter and reactions on Facebook. Cypriot users also show interest in how AI and big data techniques to control the spread of the coronavirus is utilised in Asian countries.

**February 2020:** Significantly low volume of Social Media activities in Cyprus with Twitter continuously being the main social network platform in 2020. Tweeters in Cyprus prove awareness of AI and Machine Learning in the fields of medical imaging and radiology images (10 mentions in the third week of February 2020).




**March 2020:** After the outbreak of the Covid-19 pandemic, users have predominantly included hashtags like Robotics, Machine Learning, AI and COVID19 in their Tweets. One Tweet, shared by several ac- counts, makes a robot helping doctors to fight the coronavirus subject of discussion; some awareness is raised around radiology.

Figure 19: Trend of total mentions in social media



**10.7 Mio**[82]
**Total population**

**50.8**[83]
**DESI 2020** Index

**85%**
% of **internet users**

**2.4%**[84]
**Population as a % of** EU27

**16**
**DESI 2020 ranking amongst** EU27

**62%**
% of population with at **least basic digital skills**

**64%**
% of **Open Data**

# CZECH REPBUBLIC

## 1. Relevant legislation and policy

The implementation of the Innovation the National AI Strategy by the government for 2019-2030 aims at making the Czech Republic a leader in innovation.[85] The strategy, published by the Ministry of Industry and Trade, lists a number of initiatives around the further development of healthcare, including the need to expand AI applications in healthcare. It emphasises the need to be involved in global activities focusing on testing and evaluation of data quality and performance of AI applications, like in healthcare.

The National AI strategy focuses on seven key measures with short-, medium- and long-term objectives and relevant tools laid out for all of them. An example in the health sector includes the implementation of AI applications and the creation of specialised workplaces for the evaluation of such applications. The implementation is expected to be complete by 2027. The strategy also stresses the need for the elaboration of AI pilot projects in public administration and healthcare, and the creation of specialised workplaces for evaluating AI applications for healthcare[86].

In the longer term, the AI strategy recommends the use of AI as part of providing health services, administration of medicinal products and optimising reimbursement processes. The National eHealth Strategy of the Czech Republic also recommends using AI to make predictions about cost development and to expand other data processing tools[87].

In the government's 2018 analysis of the development potential of AI in the Czech Republic, the health and social care sectors are listed as significant AI sectors corresponding to the number of projects and financial volumes.[88] A survey respondent from the Czech Ministry of Health indicated that there are currently cybersecurity policies in place around AI, but no other legislation[89].

82 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

83 Digital Economy and Society Index 2020, Country Report: Czechia, Shaping Europe's digital future, https://ec.europa.eu/digital-single-market/en/scoreboard/czech-republic (accessed in December 2020)

84 Eurostat, Population as a percentage of EU27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

85 Ministry of industry and trade of the Czech Republic, National Artificial Intelligence Strategy of the Czech Republic, 2019, p.8

86 Ministry of industry and trade of the Czech Republic, National Artificial Intelligence Strategy of the Czech Republic, 2019, p.8

87 Ministry of industry and trade of the Czech Republic, National Artificial Intelligence Strategy of the Czech Republic, 2019, p.8

88 Office of the Government of the Czech Republic, Analysis of the development potential of Artificial Intelligence in the Czech Republic, December 2018, p.23

89 See survey results.

# 2. Research and innovation around AI technologies and applications in health care

**Scientific Papers**

| 0.6% | 19 |
|---|---|
| **%** in EU27[90] | **Rank** in EU27 |

**Patents**

| 0 | n/a |
|---|---|
| **%** in EU27[91] | **Rank** in EU27 |

The Czech Republic contributes approximately 0.3% of scientific output in the area of AI in healthcare and ranks 25th amongst EU countries. Most scientific research is done in the domain of disease diagnostics. Key players in the scientific output of this area come from universities such as Brno University of Technology, St. Annes University Hospital, Charles University, Technical University of Ostrava and the Masaryk University. In the survey conducted as part of this study, the Czech Ministry of Health indicated universities and research centres receive public funding amounting to €500,000, €600,000 and €800,000 per year in 2016 to 2018 respectively.[92]

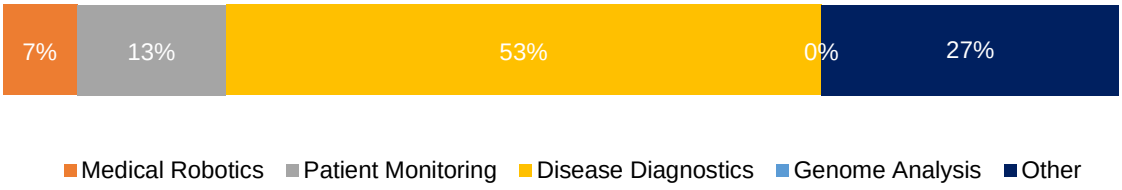



Figure 20: Areas of application in scientific paper

The most deployed computational methods are deep learning e.g. for intracranial error detection[93] or predicting responses to therapy in cancer. Other popular AI methods include a fully automatic CAD system development, as well as predictions in the field of gerontology.

**Cross-border collaboration in research**

| 7 | 16 |
|---|---|
| **Multilateral score**[94] | **EU Collaborating countries**[95] |

90 Using Fractional Count (FC) method based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

91 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

92 See survey results.

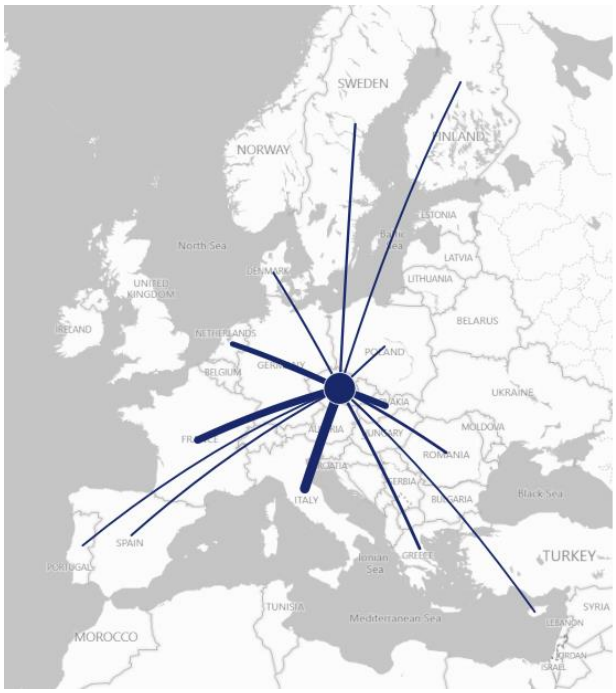
93 Using time-resolved deep decoding, it is possible to classify errors in various regions in the human brain

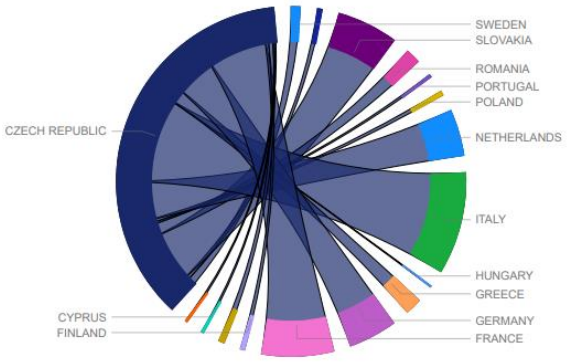
94 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

95 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

Within Europe, Czech Republic mostly collaborates with Italy, France, Slovakia, Germany and the Netherlands. To promote and concentrate science, R&D of AI technologies, the National AI strategy fosters close links between the Visegrad group MS[96], national, regional and EU research institutes, who are sharing knowledge and finding synergies with European Centres of Excellence and Testing Centres. Furthermore, there is an intention to include AI in the programme and preparation of the Czech Presidency of the EU Council in the second half of 2022.

The national AI strategy foresees the Czech-German Strategic Dialogue as a key to reaching its medium-term objectives. The Czech-German Strategic Dialogue is a cooperation agreement between the Czech Technical University and the German Research Centre for AI[97]. There are other important partnerships, such as the Czech-French Strategic partnership on digitisation or the Czech-Slovak partnership on dual education and industry 4.0.




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Italy | 5.0 |
| France | 3.6 |
| Slovakia | 3.0 |
| Germany | 2.4 |
| Netherlands | 2.3 |

Figure 21: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Czech Republic has not yet established a central coordinating body to support start-ups. However, there are efforts by CzechInvest to increase the availability of information to potent cross-border collaboration in researchial entrepreneurs.[98] They support incubation and

96 NB: Visegrad group (or 'V4' for short) refers to the alliance of four Eastern and Central European states, e.g. Poland, Hungary, the Czech Republic and Slovakia (Cf.DW: "This is how the Visegrad Group works". Retrieved online: https://www.dw.com/en/this-is-how-the-visegrad-group-works/a-47402724#:~:text=The%20Visegrad%20Group%20%E2%80%93%20V4%20for,for%20economic%20and%20political%20negotiations).

97 Government of the Czech Republic, Prime Minister Sobotka and Chancellor Merkel attend a discussion at the Czech Technical University about the results of a partnership in applied research. Retrieved online: https://www.vlada.cz/en/media-centrum/aktualne/prime-minister-sobotka-and-chancellor-merkel-attend-a-discussion-at-the-czech-technical-university-about-the-results-of-a-partnership-in-applied-resea-148020/tmplid-81/ (accessed in December 2020)

98 Startup Europe Network, Czech Republic. Retrieved online: https://startupeurope.network/ecosystems/cz (accessed in December 2020)

acceleration programmes, but they lack a comprehensive national concept for their establishment, development, and financing.

There are at least six start-ups in the Czech Republic whose work is focused mainly on AI-enabled tools in the healthcare sector and more than 25 available investors to hear the entrepreneurs out and support them financially. This help might come in the form of venture capital, pre-seed funding, crowdfunding, peer-2-peer loans, business angels, etc. Also, several means of consulting and mentoring are available through start-up networking sites such as "czechstartups.org"[99] and "mygatewayproject.eu"[100].

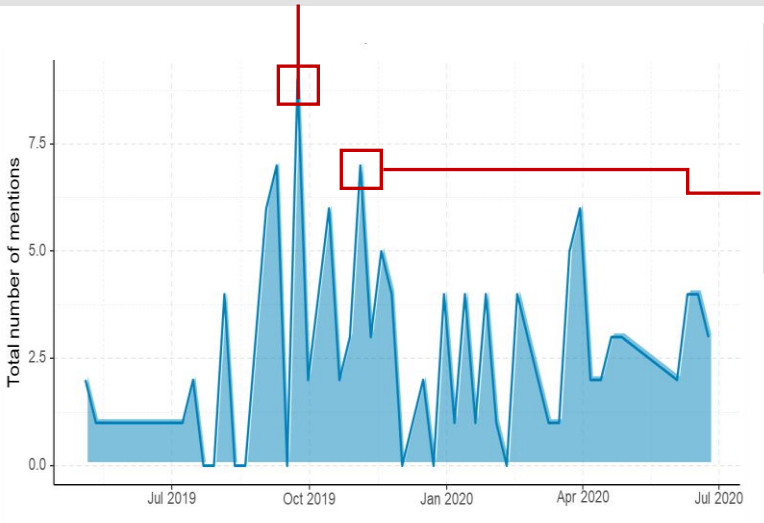
Nevertheless, in a 2018 analysis of the development potential of AI in the Czech Republic, written for the Office of the Government of the Czech Republic, it was stated that the Czech AI start-up scene falls short in the health and robotics sectors.

# 4. Awareness and use of AI technologies and application in healthcare

There was a total of 137 mentions over the 13-month period (June 2019 – July 2020). Czech news sources have directed very little attention to the emerging AI technology in healthcare. The graph below shows two spikes in the fall of 2019, each accumulating seven mentions. The first consisted of an article elaborating on the displacement of jobs through the rapid pace of automation, citing Harvard Business Review's claim that doctors would not be affected by this trend. At the national level, a Czech AI company successfully collaborated with a local hospital, pilot testing their AI algorithm used to prevent pressure ulcers.

The second spike pertained to articles surrounding a Czech-Israeli health conference where Israeli experts emphasised the critical need for AI in health. At the same conference, a Czech company presented their Parkinson-detecting software. At the European level, Facebook announced Paris as the next location where Europe's intention for further expansion of AI in the European healthcare market will be highlighted.

**September 2019:** An article on the rapid displacement of jobs through automation, attracted attention, with the HBR claiming that doctors would not be affected despite advances machine learning diagnostics. Further awareness was raised for the collaborative effort between GoodAI and Na Bulovce Hospital following positive pilot results regarding their **AI algorithm used to prevent pressure ulcers**.




**November 2019:** A Czech-Israeli health conference gained national attention with Czech company, Tesco SW, presenting a **Parkinson's Disease detecting software**. Additionally, Facebook's activity in the sector, through the establishment of an **AI lab in Paris**, received publicity while also displaying Europe's intention for the integration of AI in healthcare.

Figure 22: Trend of total mentions in the news

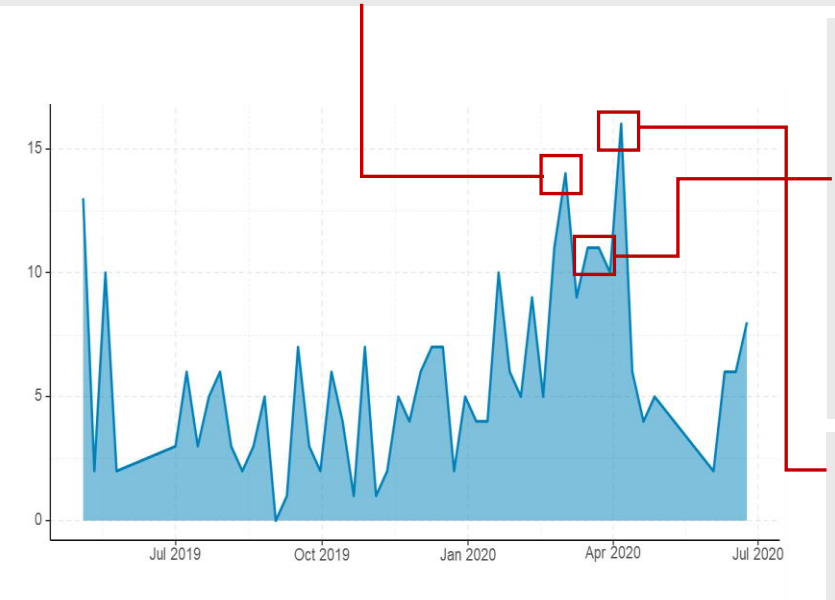
99 Czech Startups, Capital. Retrieved online: https://www.czechstartups.org/en/startup-ecosyste/capital/ (accessed in December 2020)

100 My Gateway, Startup Europe Initiative. Retrieved online: https://mygatewayproject.eu/ (accessed in December 2020)

In line with their news mentions, Czech Republic's social media mentions are similarly low, with the exception of three successive peeks during the spring of 2020.

The majority of social media mentions are derived from several key industry influencers. One such influencer posted about AI in health projects around the world, providing additional insight on the financial capital they have managed to raise. Unsurprisingly, the remaining posts were predominantly focused on the battle against the Covid-19 pandemic and the opportunities and benefits that arise from intervention through the means of AI technology.

**March 2020:** The peak showed strong activity from a key influencer who tweeted about various AI healthcare projects around the world, which included **Ada Health in Germany, Cera Care in the UK and K Health in USA**. Further detail was shared regarding the sizeable capital each of the above have raised for the development of their product.

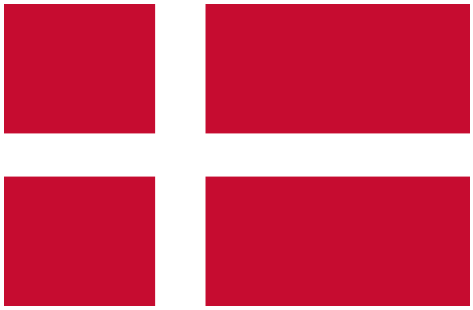



**April 2020:** AI in health activity on twitter was centred around Covid-19, with tweets and retweets regarding the opportunities and benefits that arise from the use of machine learning, through players such as **EIT Health**, in the battle against the virus.

Activity from a key influencer was present during the period, with mentions regarding **Ferrum,** a company that developed an AI driven system which **double checks radiology scans** in order to prevent medical mistakes.

**May 2020:** Awareness surrounding **Rally Health** using machine learning for enhanced personalized users' experiences. Retweets from an industry influencer dominated the activity. Their posts focused on the future of AI in healthcare, in light of Covid-19, and the main **barriers that would restrict its universal** acceptance.

Figure 23: Trend of total mentions in social media



**5.8 Mio**[101]
**Total population**

**69.1**[102]
**DESI 2020** Index

**95%**
% of **internet users**

**1.3%**[103]
**Population as a % of** EU27

**3**
**DESI 2020 ranking amongst** EU27

**70%**
% of population with at **least basic digital skills**

**78%**
% of **Open Data**

# DENMARK

## 1. Relevant legislation and policy

The Ministry of Finance and the Ministry of Industry, Business and Financial Affairs published the National Strategy for AI for Denmark in 2019 which lists 24 initiatives to be achieved by 2027.[104] In particular, the healthcare sector has been identified as one of the four priority areas, with 15 signature projects within health, social affairs, employment, and cross-sector case processing, to foster the use of AI.

In order to facilitate the development of AI technologies, the Danish Government is establishing the necessary data infrastructure. They are therefore planning to advance certain policy initiatives related to data infrastructure, including access to public sector data. Concretely, there has been a partnership between public and private actors, namely the Danish Health data and the Copenhagen Health-tech Cluster, to develop the "Data Saves Lives" initiative that aims to provide better use and access to Danish health data[105].

The national strategy for AI emphasises the fact that an ethical and legal framework must be implemented in order to consider issues such as the responsibility of decision-making, transparency and discrimination, amongst others. Therefore, the government has set up six ethical principles which will form the framework for future development and use of AI[106].

Multiple other initiatives, such as the Strategy for Denmark's Digital Growth, were previously launched by the Danish government in order to enhance the frameworks for strengthened digital competences and understanding technology as well as research into new technologies, including AI.[107]

In the survey conducted as part of this study, founders of AI start-ups operating in the healthcare sector indicated that they would like to see the following areas of legislation/policy in place:[108]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;

101 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

102 Digital Economy and Society Index 2020 - Country Report: Denmark, Shaping Europe's digital future https://ec.europa.eu/digital-single-market/en/scoreboard/denmark (accessed in December 2020)

103 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

104 OECD, Denmark's national strategy for artificial intelligence. Retrieved online: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24241 (accessed in December 2020)

105 Copenhagen Healthtech Cluster, Data Saves Lives. Retrieved online:https://www.danishhealthdata.com/about-us#:~:text=Copenhagen%20Healthtech%20Cluster%20has%20initiated,insight%20into%20diseases%20and%20treatment (accessed in December 2020)

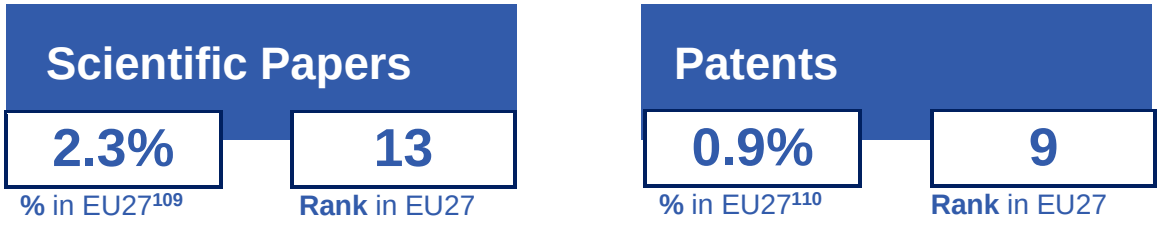
106 Danish Ministry of Finance and Ministry of Industry, Business and Financial Affairs, National Strategy for Artificial Intelligence, March 2019, pp.25-26

107 Danish Ministry of Finance and Ministry of Industry, Business and Financial Affairs, National Strategy for Artificial Intelligence, March 2019, p.45

108 See survey results.

- Policies around AI testing and certification in the healthcare sector;
- Policies around algorithmic transparency.

## 2. Research and innovation around AI technologies and applications in healthcare




Denmark contributes approximately 2.3% of scientific output in the area of AI in healthcare and ranks 13th amongst the EU-27 countries.

There is a wide range of focus application areas, and similarly to other EU countries, most original research is focused around image diagnostics, as well as systems targeting diagnosis and treatment decision support through medical record analytics. Many research projects are carried out in the field of neurology with the help of neural networks and deep learning, for example by means of deep convolutional neural network[111] or multi-task deep neural network[112] or by other machine learning methods.

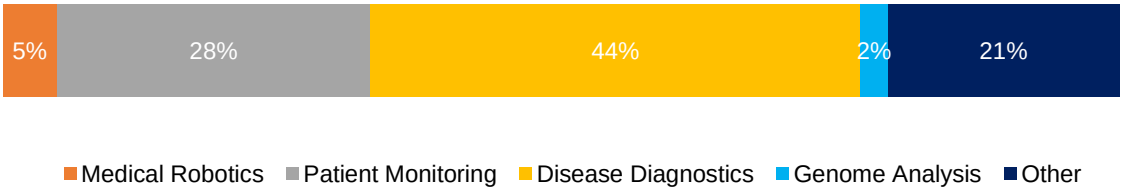



Figure 24: Areas of application in scientific papers

The SCIENCE AI Centre, at the University of Copenhagen, recognises the ability of AI to redefine research and innovation and aims to combine both research and education to develop AI techniques and applications in the field of sciences[113]. In addition to the University of Copenhagen, the Technical University of Denmark and Aalborg University are the largest contributors to AI research in Denmark.

In order to boost research and development into AI and its position in different business areas, in 2019, the Danish government decided to invest € 200 million in digital and AI research and

109 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

110 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

111 Convolutional Neural Networks are a branch of deep learning methods and are one of the most popular neural network architectures. They are extremely successful at image processing, but also for many other tasks (such as speech recognition, natural language processing, etc.).

112 Multi-task learning is a subfield of machine learning in which multiple tasks are simultaneously learned by a shared model.

113 University of Copenhagen, https://ai.ku.dk/ (accessed in December 2020)

pilot projects[114]. The Investment Fund Denmark, created by the Danish government and Danish municipalities and regions, has been established in order to foster the use of AI within the areas of healthcare, amongst others, and the dissemination of digital welfare solutions. In June 2020, 13 new projects were nominated to receive a total of approximately € 8.05 million[115].

The government wants to use AI technology to better address the current challenges in the Danish healthcare system which are, amongst others, chronic diseases that are becoming increasingly challenging, and hospitals which have to provide targeted diagnoses as well as high-quality treatment. Furthermore, there are increasing expectations concerning treatment and procurement of new medicine, and there is a growing need to monitor side effects and the effects of pharmaceuticals. To tackle these challenges, new, more accurate and effective tools must be found to carry out the tasks and deal with the challenges by means of AI technologies.[116]

## Cross-border collaboration in research

| 9.9 | 17 |
|---|---|
| Multilateral score[117] | EU Collaborating countries[118] |

Focusing on Europe, it appears that Denmark is collaborating most with the following five countries – Netherlands, Spain, Germany, Sweden and France — in the area of AI in healthcare.

To foster the AI-centric collaboration between Danish and international researchers and businesses, Denmark has set up innovation centres in eight cities to strengthen partnerships with research, higher education and business development in some of the world's leading innovation communities.

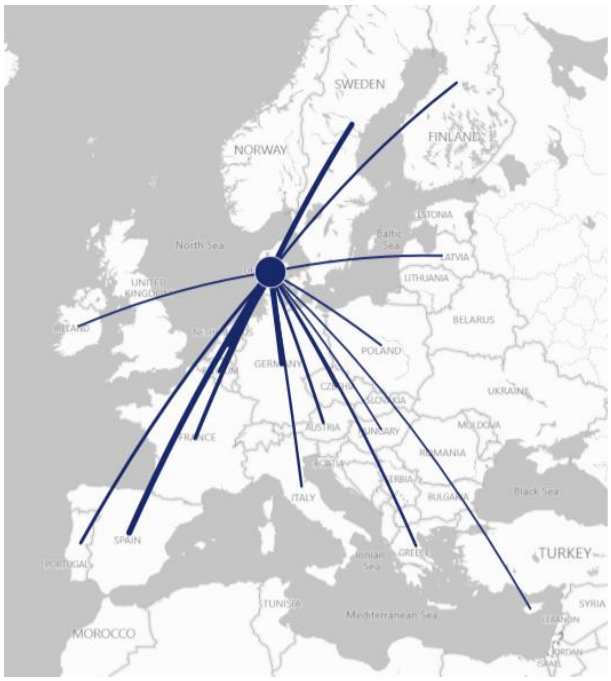
114 Gerard O'Dwyer: "Danish government injects €200 m into AI R&D". In: Computer Weekly, 17 July 2019, https://www.computerweekly.com/news/252466718/Danish-government-injects-200m-into-AI-RD (accessed in December 2020)

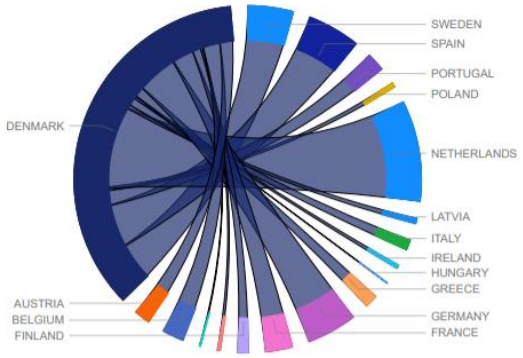
115 OECD, Project grants for public research, https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24241 (accessed in December 2020)

116 National Strategy for Artificial Intelligence, Danish Ministry of Finance and Ministry of Industry, Business and Financial Affairs, March 2019, p. 63

117 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

118 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Netherlands | 9.5 |
| Spain | 5.0 |
| Germany | 4.7 |
| Sweden | 4.3 |
| France | 2.6 |

Figure 25: Volume of cross-border collaboration in research

# 3. Relevant legislation and policy

Denmark ranks high in the number of AI start-ups in the Nordics. Healthcare is mentioned as one of the most dominant industries, next to IT, financial services and pharmaceuticals. We identified at least 10 start-ups in Denmark whose work is focused mainly on AI-enabled tools in the healthcare sector.

Danish start-ups tend to use their own data collection rather than working with openly available databases. Moreover, there is a strong tendency for collaboration on an international level, especially with hospitals across Europe.[119]

The Danish government indeed encourages the growth of high-impact start-ups through the specialised visa scheme which allows talented entrepreneurs (non-EU/non-EEA) to relocate to Denmark[120]. Moreover, Denmark nurtures talent not just through the government but also through seed accelerators and business angels. It has been ranked 1st for the ease of doing business for the period of 2012 to 2019.

Danish start-ups make use of funding, whether public or private, for instance via the European Commission or via other international funding initiatives. Three of the AI for health start-ups who were surveyed stated that their AI activities were governed by national legislation.[121]

119 See survey results.

120 Startup Denmark. Retrieved online: https://startupdenmark.info/about-program (accessed in December 2020)

121 See survey results.

However, only 0.4% of global AI start-ups are located in Denmark, whereas almost three quarters of Danish AI start-ups are located in Copenhagen[122].
The Danish Ministry of Finance and Ministry of Industry, Business and Financial Affairs has identified areas of improvement for the better adoption of AI in Denmark: They include common guidelines and an ethical framework for AI, accessibility to health data in Danish language as well as the upskilling of employees, amongst others.[123]
Furthermore, there is wide-ranging agreement amongst start-ups surveyed in the context of the study regarding the following barriers related to the implementation and utilisation of AI systems by health professionals in the health sector: [124]

- Lack of trust in AI;
- Lack of IT knowledge and competencies;
- Lack of ease of use.

# 4. Awareness and use of AI technologies and applications in healthcare

Given Denmark's high position in internet usage and Danish people's advanced digital upskilling, it is not surprising that Denmark's news sources displayed strong volatility. Periods of high activity were followed by subsequent lulls, resulting in 621 total mentions (see graph below).

Their first peak (26 mentions), during the fall of 2019, included news articles on the Danish Medicine Agency's plan to increase their medical devices capacity to accommodate for the newest innovations in the field, such as AI the and 3D printing, and simultaneously prioritising patient safety. Towards the end of the trial period, the activity levels spiked again, totalling 25 mentions.

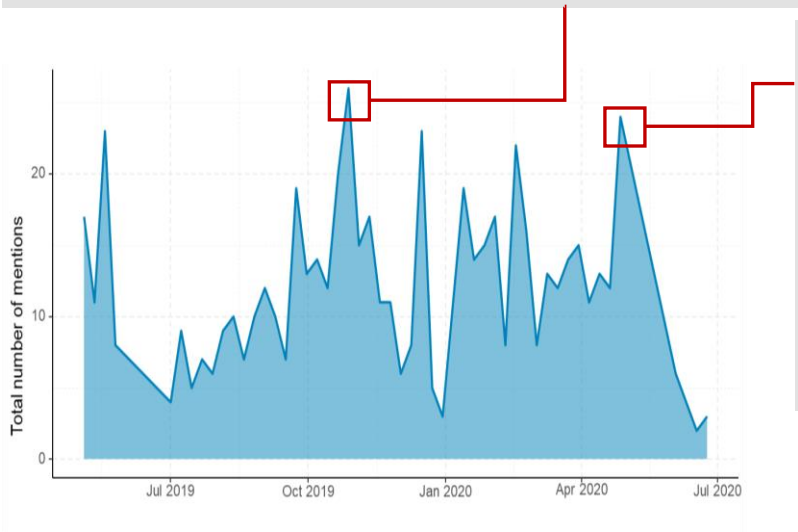
Given that the Covid-19 crisis dominated all news articles during the spring of 2020, unsurprisingly the implementation of AI to ease the negative consequences gained most attention from the media. Furthermore, the application of AI is deemed to be the future for medical diagnosis, with the ability of novel technologies to gather extensive information from thousands of medical journals for the latest insights about treatment and medicines.

122 McKinsey & Company, Innovationsfonden, An AI Nation: "Harnessing the opportunity of artificial intelligence in Denmark", pp. 34-35

123 Danish Ministry of Finance and Ministry of Industry, Business and Financial Affairs: "National Strategy for Artificial Intelligence", March 2019, p. 16

124 See survey results. Order of the results according to order of priority.

**October/ November 2019:** News mentions around reshaping R&D to a human-centred approach using Design thinking and Design doing to accommodate for breakthroughs in technology. For instance, the development of a new **surgical robotics controller**. **Danish Medicine Agency** is seeking to massively improve the capacity of the medical devices area through AI and **3D printing**, while prioritizing patient safety. Moreover, Amsterdam UMC uses the SAS Platform and AI solutions to **increase speed and accuracy of tumour diagnosis.**




**May 2020:** News article regarding researchers developing tests to detect coronavirus before patients become ill with covid-19, while also **identify at-risk patients** using AI to convert the data on patients' blood into biological fingerprints, which are translated into markers.

**AI deemed the future of diagnosis,** through computer programs scanning thousands of pages in medical journals for the latest knowledge about treatments and medicines.

Furthermore, AI used to improve medical imaging for **breast cancer detection**.

Figure 26: Trend of total mentions in the news

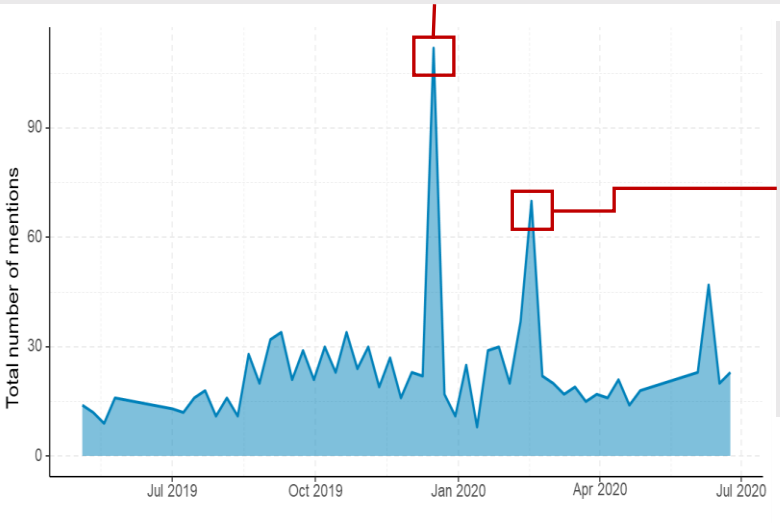
Awareness brought through social media around AI and health, doubled that of news sources with 1,200 total mentions. As seen from the graph below there are two clear peaks, the first of which occurred during December 2019, where a Danish start-up received significant attention regarding its AI voice recognition tool used to diagnose cardiac arrest cases over the phone.

The second peak included tweets relating to the latest breakthroughs in healthcare technologies, while consisting of posts from the Danish Medical Agency, claiming that AI will ct as an equaliser against current healthcare inequalities.

**December 2019:** The period included tweets regarding Danish startup called **Corti**, which developed an **AI voice recognition tool** that can help emergency services **successfully diagnose** 93% of **cardiac arrest cases** over the phone.

The use of AI to improve medical imaging in radiology gained significant mentions on twitter with labs, hospitals and tech companies all collaborating to achieve this end.

Furthermore**, DeepDream Algorithm** is using AI to spot signs of Cancer-causing viruses.




**February 2020:** #DigitaEU was trending on twitter following the European Commission's plan to further integrate AI in different sectors, including healthcare.

Breakthroughs in technologies such as **3D printing** for the creation of tiny blood vessels and **Augmented Reality** to enhance the operating rooms, were mentioned by influencers. Moreover, AI is claimed to **reduce healthcare inequalities**, while ensuring more time and attention to patients and citizens, according to the Danish Medical Agency.

Figure 27: Trend of total mentions in social media

**1.3 Mio**[125]
**Total population**

**61.1**[126]
**DESI 2020** Index

**88%**
% of **internet users**

**0.3%**[127]
**Population as a % of** EU27

**3**
**DESI 2020 ranking amongst** EU27

**62%**
% of population with at **least basic digital skills**

**67%**
% of **Open Data**

# ESTONIA

## 1. Relevant legislation and policy framework

Estonia's public sector started the implementation of the National AI "Kratt" Strategy[128] with 16 AI solutions that have been implemented or gone into testing as of May 2019. By the end of the year 2020, 50 "Kratts", or AI projects, were expected to be in use in the state with the ambition of making Estonia one of the main "digital hubs of the world"[129].

Kratts include a prediction model for the health of chronically ill patients and their treatment requirements. It is important to note that limited access to data within the public sector has been a setback for the implementation of AI in the healthcare sector of Estonia, leading to the launch of projects being hindered by the use of open field texts in electronic health records.

Fujitsu, an information and communication technology firm, has developed predictive device maintenance and health technologies in line with the implementation of Kratts in the private sector. Estonia foresees a need to further analyse the use of Kratts that are directly linked to the life and health status of the population. They will need to determine or categorise use cases of Kratts to establish a regulation base for the application of the principle of increased source of danger on a case-by-case basis.

Based on proposals by the Ministry of Economic Affairs and Communications and the Government Office, "Estonia's national artificial intelligence strategy 2019-2021"[130] was adopted at a Cabinet meeting in July 2019. This strategy was prepared in the context of the European Union's AI action plan. The national AI strategy estimates that €10 million will be invested by the government for its implementation. According to the survey conducted as part of this study, the Estonian Ministry of Social Affairs, Ministry of Economic Affairs and Communications and Estonian Health Insurance Fund indicated that from 2016 to 2019, €1.5 million were distributed per year to universities and research centres for the development of AI-enabled technologies in healthcare.[131]
There are several other AI-related policies that were initiated during the COVID-19 global pandemic, such as the automated chatbot "Suve"[132] that was integrated in various public

125 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

126 Digital Economy and Society Index 2020, Country Report: Estonia. Retrieved from:https://ec.europa.eu/digital-single-market/en/scoreboard/estonia

127 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

128 Cf. Republic of Estonia, Government office: Republic of Estonia, Ministry of Economic Affairs and Communications: "Report of Estonia's AI Taskforce"+, May 2019

129 Helen Wright: "50 kratt AI solutions to be in use in Estonia by end of 2020", 2020. Retrieved from: https://news.err.ee/1127545/50-kratt-ai-solutions-to-be-in-use-in-estonia-by-end-of-2020

130 KRATT Estonian Artificial Intelligence Deployment : "Estonia's national artificial intelligence strategy 2019-2021". Retrieved from: https://f98cc689-5814-47ec-86b3-db505a7c3978.filesusr.com/ugd/7df26f_27a618cb80a648c38be427194affa2f3.pdf

131 See survey results.

132 EEbot: "Suve", 2020. Retrieved from: https://eebot.ee/en/

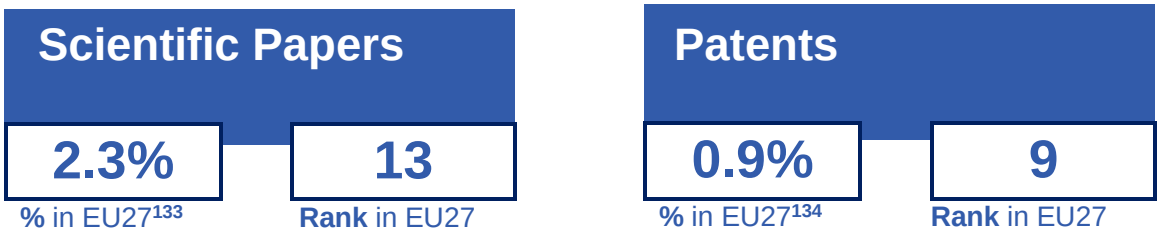
websites to provide reliable and official information. Nevertheless, there are no direct proposals or existing measures concerning health and AI.[130]

Estonia currently has national legislation in place regarding the storage and sharing of healthcare data and protocols around it.[131] The national authorities have set up an open data platform for the general public which may be used for the development of AI applications in healthcare. However, results from the survey reveal that legislation regarding the use of AI systems in healthcare is not in place.

In the survey conducted for this study, founders of AI SMEs operating in the health and care sectors indicated that they would like to see the following areas of legislation/policy in place with regards to the development and usage of AI-enabled healthcare tools:[131]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis,
- Policies around AI testing and certification in the healthcare sector,
- Policies around the ethical use of AI,
- Policies aimed at supporting research and innovation in the area of AI in healthcare,
- Policies aimed at the encouraging the deployment of AI technologies in healthcare,
- Safety and liability rules applicable to AI systems,
- Policies aimed at supporting research and innovation in the area of AI in healthcare.

## 2. Research and innovation around AI technologies and applications in health care




Although the structure and basis of Estonia's R&D system are well established in the Estonian Research and Development and Innovation Strategy "Knowledge-based Estonia 2014-2020"[135] and research policies are actively developed by the government, Estonia shows very low contribution in scientific output and no contribution in patents in the area of AI in healthcare, as compared to other EU-27 Member States.

The relatively immature regulatory landscape prioritises sectors other than healthcare (i.e. clean tech, finance for innovation)[130]. This appears to be a barrier to AI-related healthcare research.

133 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

134 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

135 Estonian Research Council: "Research landscape". 2020. Retrieved from: https://researchinestonia.eu/research-landscape-2/

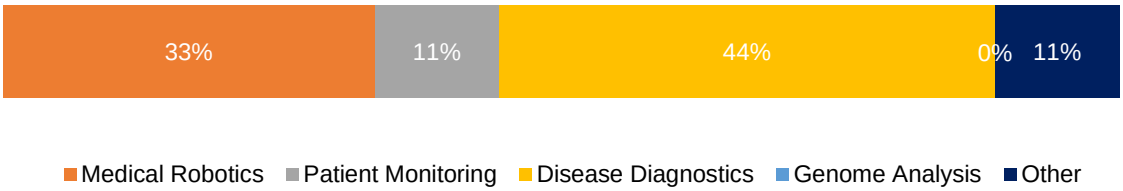



Figure 28: Areas of application in scientific papers

Notwithstanding, the research output concentrates on disease diagnostics (for example, Parkinson's disease, or deep-learning capabilities in knee osteoarthritis) and medical robotics (like for surgical purposes and vibro-tactile interactions[136]). The main contributor to this type of research are the Tallinn University and the Tartu University Hospital. The Tallinn University has published papers that originate from the Software Science and Information Technology departments.

The University of Tartu has a major focus on healthcare-related research. The university conducts large-scale genomic research.[137] Their dedicated lab at the Estonian Genome Centre in Tartu is working very closely with the UK biobank[138] and other similar projects in Europe with the aim of personalising healthcare. The Estonian ministries of social affairs and science and education are funding projects, including machine learning for personalised medicine, that are run by the clinic at Tartu University Hospital and North Estonia regional hospital to investigate the practical use of the research.

## Cross-border collaboration in research

| 0.4 | 2 |
|---|---|
| Multilateral score[139] | EU Collaborating countries[140] |

We identified a few cross-border research collaborations with research entities in Italy and Greece. The volume of collaboration is minimal due to the overall limited research output in the area of AI in healthcare. Notably, the Tartu University Hospital produced collaborative research output with foreign partners.

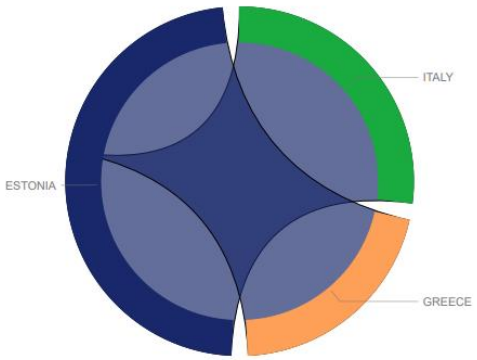
136 Improving interaction between a human and a device, when the device vibrates when touched or when transmitting information to the user.

137 Cf. Florin Zubascu: "Estonian researchers strive to personalise healthcare", 2019. Retrieved from: https://sciencebusiness.net/estonian-researchers-strive-personalise-healthcare

138 UK Biobank is a large-scale biomedical database and research resource. https://www.ukbiobank.ac.uk/

139 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

140 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.


| Top Collaborating EU Countries | Bilateral Score |
|---|---|
| Italy | 1.3 |
| Greece | 1.0 |

Figure 29: Areas of application in scientific papers

# 3. Research and innovation around AI technologies and applications in healthcare

The Estonian government's initiative for local start-ups is working with the different ministries and stakeholders, with the aim of connecting different sectors with the start-up community, mainly focusing on cyber and educational technology.

"Startup Estonia" is strengthening the Estonian start-up ecosystem by holding events and activities, by carrying out training programs for start-ups, by educating the local investors to attract foreign investments and by working on eliminating regulatory issues and barriers. "Startup Estonia" is also bringing entrepreneurs closer to investors, business angels, business incubators, etc.[141]

There are at least six start-ups in Estonia whose work is focused mainly on patient monitoring technologies, like AI-powered diagnostic platforms for physicians or an end-to-end communication platform between healthcare practitioners and insurers. In terms of the outcome at the end-user level, three of the start-ups surveyed expect improved patient care and health conditions. They reference examples like the detection of suicidal intentions or mental disorders, and the reduction of negative pregnancy outcomes, that further lead to patient empowerment.[142]

Most of the start-ups that participated in the survey conducted as part of this study use data from open databases and share their data to open databases. They use unstructured data (i.e. doctor's notes), vital sign[143] and genome data[144] and data extracted from wearables.

141 Cf. Startup Estonia: "Focus areas", 2020. Retrieved from: https://startupestonia.ee/focus-areas

142 See survey results.

143 Data recorded from the devices used to monitor a patient's vital signs.

144 Genome data is a broad term referring to sequenced DNA.

# 4. Awareness and use of AI technologies and applications in healthcare

There is wide-ranging accordance amongst survey participants about the lack of understanding of AI technologies and systems by health professionals, as well as a lack of financial resources in this field[145]. Some respondents further indicated that health professionals lack an underlying knowledge of IT and IT competencies. Nonetheless, start-ups in this area expect to see patient empowerment and an improved level of healthcare consultancy through the use of AI applications.

Estonia's limited research activities and scientific output are reflected in online news mentions across the analysed period (June 2019 – July 2020). With 33 total mentions, national news sources brought the Estonian people very little information surrounding the developments in the application of AI in health.

Very low overall awareness of the application of AI in health. One of the few relevant articles referred to the use of chatbot technology for AI health coaching on fitness applications by assessing patterns in the users' diet, activity and sleep.

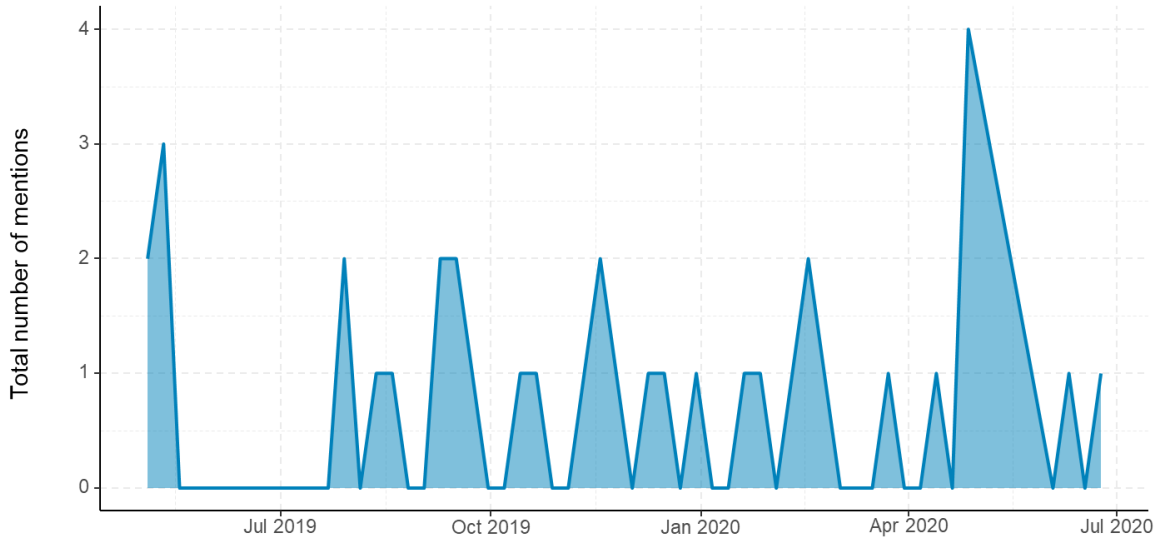



Figure 30: Trend of total mentions in the news

145 See survey results.

**5.5 Mio**[146]
**Total population**

**72.3**[147]
**DESI 2020** Index

**93%**
% of **internet users**

**1.2%**[148]
**Population as a % of** EU27

**1**
**DESI 2020 ranking amongst** EU27

**76%**
% of population with at **least basic digital skills**

**76%**
% of **Open Data**

# FINLAND

## 1. Relevant legislation and policy framework

Finland's strategy "Finland's Age of Artificial Intelligence", was published in 2017 by the Ministry of Economic Affairs and Employment, along with the broader "Artificial Intelligence Programme". They represent the country's efforts to becoming experts in AI and robotics. To encourage research and innovation in AI, the Finnish government has implemented several policy initiatives including the "Hyteairo" Program (artificial intelligence and robotics programme) to support the utilisation of AI and robotics in the health and well-being sectors.

Another initiative is the AI Business Programme, which was launched in early 2018 and focused on AI and the platform economy through innovation funding. The programme promotes the development of new business ecosystems and growth in Finland. It was supported by public funding of € 34 million and backed a total of 115 projects. The government organisation offers services for SMEs, start-ups, large companies and research organisations registered in Finland.

Finland's AI Programme 2019 aims to make Finland a leader in the application of AI where the health and well-being sectors are seen as key areas. However, the report emphasises that the adoption of AI and robotics in healthcare also depends on sectoral regulation and the attitudes among professionals, doctors and nurses towards AI technology. Equipment manufacturers and service providers in the sector must ensure that the new technology will earn the trust of both professionals and patients.

The Finnish Ministry of Social Affairs and Health participated in the survey conducted as part of this study. They indicated that, save for the storage and sharing of healthcare data (e.g. open data platform for the general public with data published by the National Institute for Health and Welfare (THL)), there is no national legislation in place regarding the use of AI systems in healthcare. The major barriers to the adoption of AI technologies in healthcare are believed to be the lack of legislation, as well as the shortage of skills and human resources at the national at regional levels.[149]

146 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

147 Digital Economy and Society Index 2020, Country Report: Finland, Shaping Europe's digital future. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/finland

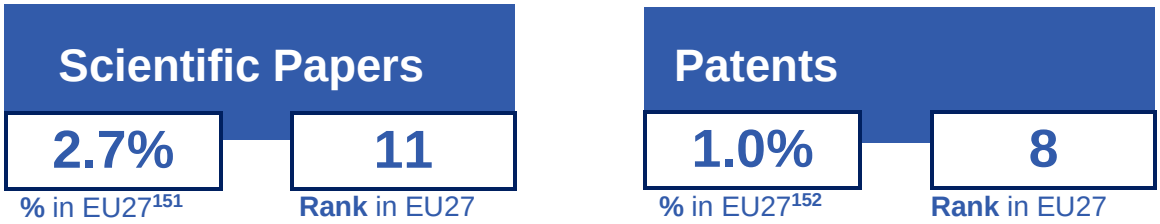
148 Eurostat, Population on 1 January, 2020,https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

149 See survey results.

Founders of AI start-ups operating in the healthcare sector indicated that they would like to see the following areas of legislation/policy in place:[150]

- Policies aimed at the encouraging the deployment of AI technologies in healthcare;
- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Cybersecurity policies;
- Policies around AI testing and certification in the healthcare sector;
- Policies around the ethical use of AI.

## 2. Relevant legislation and policy framework




Finland contributes approximately 2.7% of scientific output in the area of AI in healthcare, a high contribution relative to its population within the EU. Finland's scientific output in the area comes from universities, laboratories, research centres (such as the VTT Technical Research Centre of Finland Ltd.) and national institutes. There is a wide range of application areas, including medical imaging, diagnosis, and ageing.

Deep learning techniques are used, amongst other AI technologies, in automatic recognition of epithelial cells in breast cancers, in depression detection or in empowering healthcare IoT systems. Machine learning methods are applied to improved risk assessments for Down's syndrome or to the classification of Myocardial Infarction Conditions. Furthermore, neural networks[153] are deployed for heart sound anomaly and quality detection.

150 See survey results.

151 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

152 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

153 Neural networks are a set of algorithms, loosely modeled on the human brain, that are designed to recognise patterns.

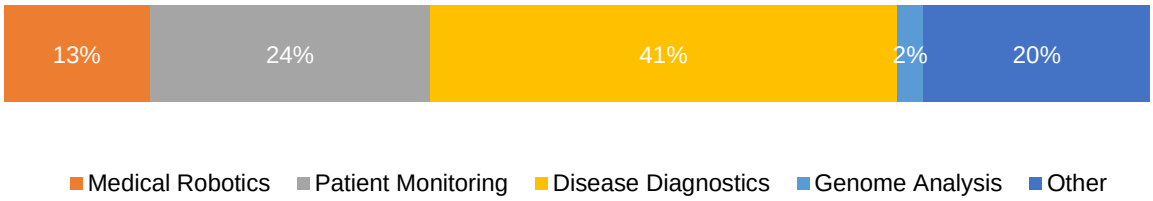



Figure 31: Areas of application in scientific papers

The Finnish Centre for Artificial Intelligence (FCAI) recognises the need for new AI technologies and currently operates seven research programs, each with multiple research groups[154]. Particularly, the FCAI "Highlight B" program focuses on the potential applications of AI in healthcare. Lastly, the Finnish governmental organisation, Business Finland, is responsible for offering funding for research, development and innovation activities.[155]

**Cross-border collaboration in research**

| 6.7 | 14 |
|---|---|
| Multilateral score[156] | EU Collaborating countries[157] |

We identified the following countries where we noticed a high volume of collaboration activity in the area of AI in healthcare: Sweden, Austria, Germany, Netherlands and Greece. In order to foster international collaborations in AI, the Finnish government introduced the AIPSE programme, to promote novel applications of AI in diverse science areas with a special focus on international collaborations[158].

Several Finnish universities are taking part in the international collaboration project INTERVENE[159], a joint effort to transform clinical research and precision medicine, which is being funded by the EU Horizon 2020 Research and Innovation program. This project aims to develop and implement novel genome-based disease prediction tools further used for prevention, disease diagnosis and personalised medicine of widespread and rare diseases. INTERVENE is being coordinated by the University of Helsinki, and brings together leaders in AI development, biobanks, clinical research, amongst others. Further project contributors from Finland are the CSC – IT Center for Science, the Aalto University and Helsinki University Hospital.[160]

154 FCAI research: need for new AI. Retrieved from: https://fcai.fi/research

155 Business Finland Website. Retrieved from: https://www.businessfinland.fi/en/for-finnish-customers/about-us/funding-information

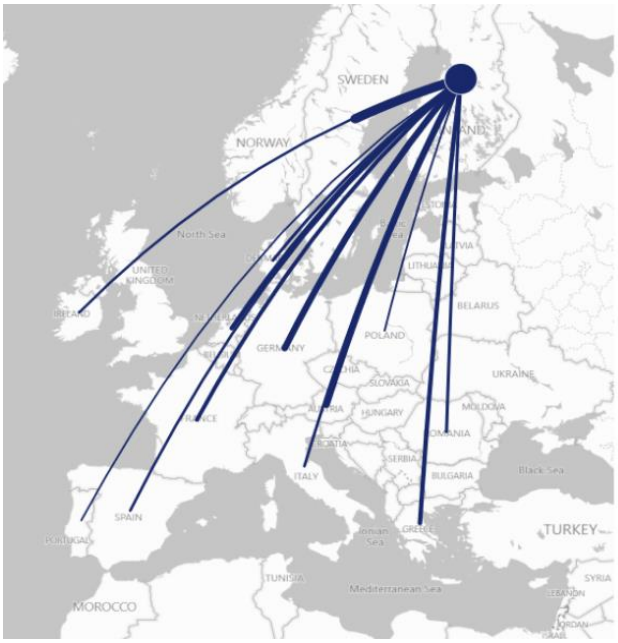
156 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

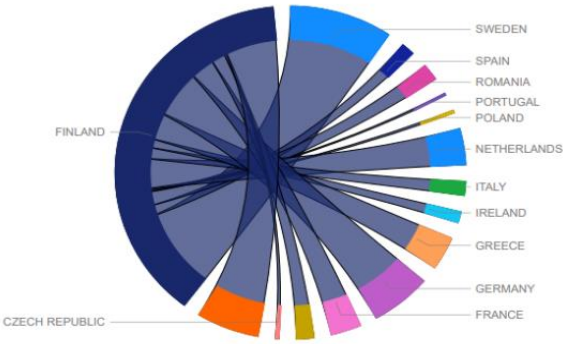
157 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

158 Academy of Finland, Novel Applications of Artificial Intelligence in Physical Sciences and Engineering Research (AIPSE). Retrieved from: https://www.aka.fi/en/research-funding/programmes-and-other-funding-schemes/academy-programmes/novel-applications-of-artificial-intelligence-in-physical-sciences-and-engineering-research-aipse/ (accessed in December 2020)

159 Cf. University of Helsinki: "Major EU project will harness AI and genomics for disease prevention". Retrieved from: https://www.helsinki.fi/en/news/health-news/major-eu-project-will-harness-ai-and-genomics-for-disease-prevention (accessed December 2020).

160 Ibid.




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Sweden | 5.9 |
| Austria | 3.6 |
| Germany | 3.5 |
| Netherlands | 2.2 |
| Greece | 2.0 |

Figure 32: Areas of application in scientific papers

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Finnish government provides direct support to entrepreneurs through the Ministry of Economic Affairs and Employment by subsidising their income during the estimated time required to get a business up and running[161]. Overall, Finland's vibrant start-up ecosystem is comprised of a supportive government, business angels and venture capitalists with established networks and associations and of initiatives such as the 'Finnish Startup Permit' which welcomes international growth entrepreneurs into the country[162].

There are at least 10 start-ups in Finland whose work is focused mainly on AI-enabled tools in the healthcare sector, such as automatic segmentation for radiotherapy or VR and AI-technologies for a healthier life. According to the survey conducted as part of this study, the start-ups are expected to produce outcomes mainly in efficiency to monitor and treat patients, thus saving time and effort. Two of the start-ups surveyed indicated that they are funded by both private and public funds which amount up to € 500,000.

# 4. Start-up ecosystem relevant to AI technologies and applications in healthcare

Thanks to Finland's high level of digital literacy, strong national AI-promoting initiatives, active governmental support of the start-up culture as well as the remarkably high rank of submitted

161 Cf. Miinistry of Economic Affairs and Employment of Finland, Start-up grant – support for new entrepreneurs. Retrieved from: https://tem.fi/en/start-up-grants (accessed in December 2020)

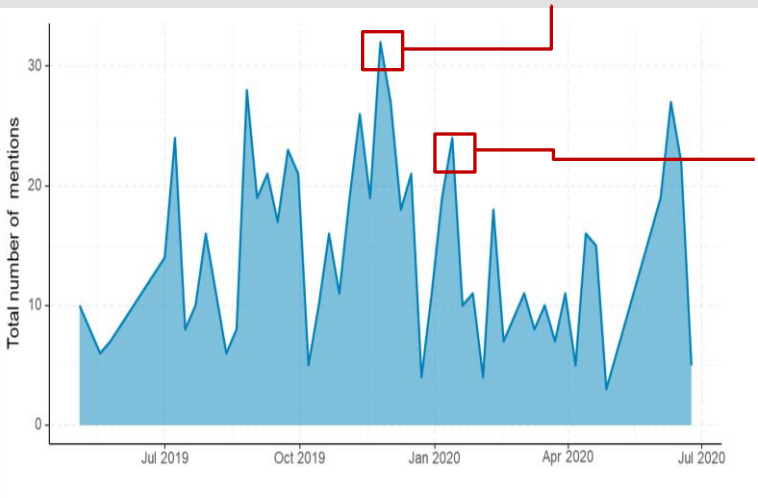
162 Cf. Business Finland, Finnish Startup Environment. Retrieved from: https://www.businessfinland.fi/en/do-business-with-finland/startup-in-finland/startup-environment/ (accessed in December 2020)

patents, the Finnish population is well versed in AI-related health topics. In light of a respectively low population, Finland proves to have a very strong online awareness.

Mentions through national news sources in Finland totalled 833 for the period between June 2019 and July 2020. The first peak, arriving towards the end of 2019, included news coverage of a collaboration between three university hospitals to conduct a study on an AI algorithm, used in ICUs, for the treatment of patients with severe traumatic brain injuries. News sources in the second peak displayed positive sentiment towards the adoption of AI and other novel technologies in the healthcare sector.

Further media attention was brought to two digital platforms, CleverHealth Network and Curetis Unyvero System, which both aim to advance the rapid digitalisation of the healthcare sector in Finland. For instance, CleverHealth Network[163] is a health technology ecosystem in which companies develop digital and AI-based health solutions and products to attract foreign investment to Finland. The company is working together with big international companies like Pfizer, General Electrics and Microsoft, amongst others.

**November/December 2019:** Following a collaborative effort between three university hospitals, a recent study presents the first AI based algorithm that may utilized in ICUs for treating patients with severe traumatic brain injuries. The peek included mentions of other applications of AI used to **forecast the risk of stroke**. Moreover, radiologists are using AI to identify majority of **lung cancer** changes and in turn offer more accurate diagnoses.




**January 2020:** News articles suggested a willingness to utilize AI and other technologies in healthcare. **CleverHealth Network** received mentions from news sources, a health technology ecosystem in which companies and health care experts develop better treatment solutions for Finns. Other national news outlets brought attention to **Curetis Unyvero System,** a fast and highly automated molecular diagnostic platform seeking to detect infectious diseases. The spike also consisted of serval published academic articles on advancements in the bioinformatics arena, including novels tools helping identify biomarkers for various medical conditions.

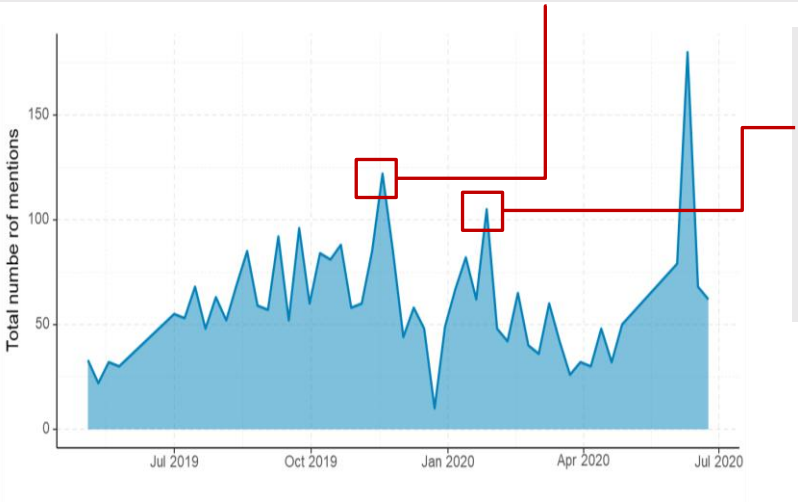
Figure 33: Trend of total mentions in the news

Social media platforms highlighted the implementation of AI technology in the healthcare sector, with mentions surpassing those of the news, totalling 3,300. The peaks of the news and social media mentions coincided with each other with both sets of peaks occurring during November to February. The first social media peak, accumulating 120 mentions, primarily focused on the conference held by the European Economic and Social Committee in Helsinki, centred around the impact of AI and other novel technologies on the wellbeing of citizens.

The second peak, reaching 100 mentions, was linked to the Finnovation2020 event, where AI solutions for health were presented by start-ups. Overall, influencers played a key role in raising awareness about the opportunities that AI is bringing to the healthcare sector.

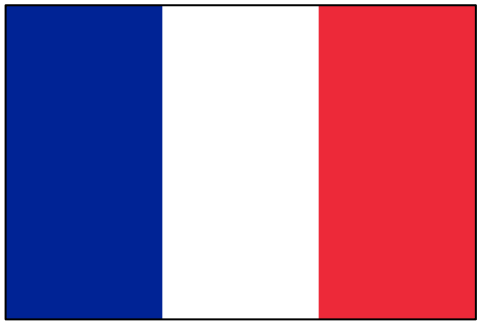
163 CleverHealth Network. Retrieved from: https://www.cleverhealth.fi/en/about-us (accessed in December 2020)

**November 2019:** Through tweets and retweets Influencers brought awareness to the beneficial impacts that will arise from the digitalization of the healthcare sector, including its ability to afford medical professionals more time with their patients. Additionally, a conference hosted by the European Economic and Social Committee (EESC) in Helsinki on centered around the impact of AI**, robotics and digital systems** on the **well-being of citizens** was the main theme of the twitter activity. The remaining posts related primarily to breakthroughs in AI technology enabling massive changes in healthcare while others expressed data security concerns in healthcare.




**January/February 2020:** Key sector influencers brought awareness towards the opportunities and benefits that will arise from **data mining in genomic vaults,** including better means to predict disease. **#Finnovation2020** event gained mentions on twitter, with startups aiming to transform healthcare through AI solutions. Other users mentioned AI and robotics solutions in the context of the Covid-19 outbreak.

Figure 34: Trend of total mentions in social media



**67.1 Mio**[164]
**Total population**

**52.2**[165]
**DESI 2020** Index

**87%**
% of **internet users**

**15%**[166]
**Population as a % of** EU27

**15**
**DESI 2020 ranking amongst** EU27

**57%**
% of population with at **least basic digital skills**

**89%**
% of **Open Data**

# FRANCE

## 1. Relevant legislation and policy framework

The French national AI strategy report "For a meaningful Artificial Intelligence", published by the mathematician Cédric Villani in March 2018, put forth five focus themes for the French AI strategy, one of which is the strategic targeting of the healthcare sector. Villani's report points out the relevance of capturing and structuring health data to advance research on AI applications in health and personalised medicine.[167]

Following these recommendations, France unveiled its AI strategy "AI for Humanity"[168], with a €1,5 billion budget and a focus on scientific excellence.[169] This strategy suggests targeting policy support for research and innovation to embrace major AI transformations in health. The responsibility for coordinating the research side of the "AI for Humanity strategy" has been given to the French national research institute for the digital sciences (INRIA). Their main flagship refers to leading and coordinating the establishment of '3IA Institutes'[170] that run projects in the fields of personalised healthcare and medical devices.

Moreover, as part of the revision of the bioethics law and in order to regulate ethical issues of the principle of Human Warranty of AI in health, the CCNE[171] has acknowledged the principle of the "Human Warranty of AI" (Opinions 129[172] and 130 of CCNE and Art. 11 of Bioethics bill) in 2018.

Stemming from a movement of proposals by academics, citizens and health professionals, this initiative aims at applying the regulatory principles of AI up- and downstream of the algorithm by establishing points of human supervision. Supervision can be exercised with the deployment of "Human Warranty colleges" bringing together doctors, paramedical professionals and user representatives that aim to ensure the ultimate review of medical records to bring a human perspective to the treatment options recommended by algorithms.

164 Eurostat, Population on 1 January, 2020,https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

165 Digital Economy and Society Index 2020, Country Report: France. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/france

166 Eurostat, Population on 1 January, 2020,https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

167 Cf. Cédric Villani: "For a meaningful Artificial Intelligence. Towards a French and European Strategy", 2018.

168 Cf. "AI for Humanity – French strategy for Artificial Intelligence", 2020. Retrieved from: https://www.aiforhumanity.fr/en/

169 Cf. ibid.

170 The 3IA institutes refer to four interdisciplinary AI institutes in selected public higher education and research establishments to foster nation-wide AI research.

171 Comité Consultatif National d'Ethique, French governmental advisory council on bioethics issues

172 Cf. Comité Consultatif National d'Ethique : « L'avis 129 contribution du CCNE à la révision de la loi de bioéthique est en ligne », 2018. Retrieved from: https://www.ccne-ethique.fr/fr/actualites/lavis-129-contribution-du-ccne-la-revision-de-la-loi-de-bioethique-est-en-ligne

While waiting for legal formalisation, the new principle of Human Warranty has been taken up in the European Commission's White Paper on AI[173] on February 19, 2020 (quoted as "Human Oversight").

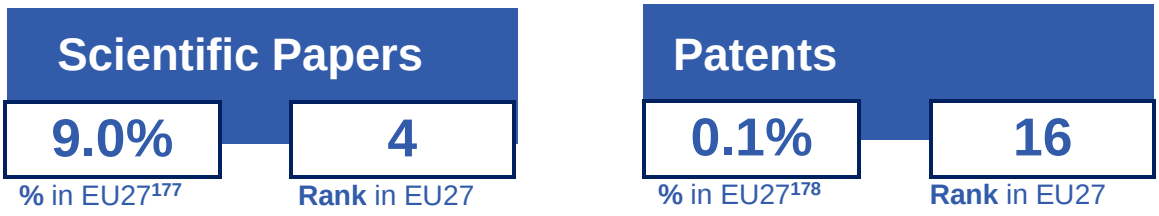
Respondents from the Ministry of Health that participated in the survey for this study acknowledged that there currently is not a national legislation in place regarding the use of AI systems in healthcare, nor any national storage and sharing of health data. The government of France is aware of their shortcoming and aims at promoting initiatives around open national health databases and new locally-developed AI-enabled technologies that are currently being tested at the national level.[174]

To address the storage and sharing of health data, the Health Data Hub[175] was set up in France that enables open access to health data for start-ups, medical technology companies and researchers. The hub provides the conditions to improve AI innovations in the area of healthcare and making healthcare systems much more productive and efficient.

In terms of areas for improvement, founders of AI start-ups operating in the healthcare sector indicated in the survey that they would like to see the following areas of legislation/policy in place:[176]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Policies aimed at the encouraging the deployment of AI technologies in healthcare;
- Policies around AI testing and certification in the healthcare sector;
- Policies aimed at supporting research and innovation in the area of AI in healthcare.

## 2. Research and innovation around AI technologies and applications in healthcare




With 9% of scientific papers, France is one of the major contributors to publications in the area of AI in healthcare, ranking 4th in the EU-27. However, according to the data sample used for this study, the number of applications for patents from French universities and organisations appears rather low, with 0.1% of patents granted to French authors.¨

173 Cf. Intelligence artificielle. Une approche européenne axée sur l'excellence et la confian. Retrieved from: https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_fr.pdf

174 See survey results.

175 Health Data Hub 2020. Retrieved from: https://www.health-data-hub.fr/

176 See survey results. Order of the results according to order of priority.

177 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

178 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

There are many research groups and institutes in France working on AI in healthcare, a notable example of which is INSERM[179], a public research organisation in France entirely dedicated to human health, promoting and supporting research. Their objective is to advocate for the health of all by advancing knowledge about life and disease, treatment innovation, and public health research.

Additionally, France hosts one of the world's biggest national health databases: the national system of medical and administrative data, SNIIRAM[180], which covers the various health insurance schemes. This database stores all medication prescriptions, descriptions of pathologies, and hospital procedures. However, this database is still not widely linked with medical information, but plans are underway to connect it with other medical information databases in order that further research and innovation can be developed based on high quality medical data.

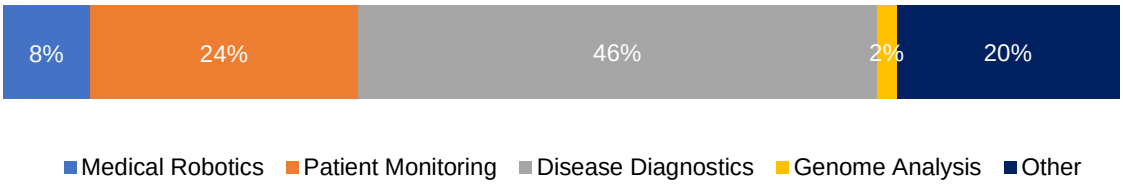



Figure 35: Areas of applications in scientific papers

The main subjects in publications are in the areas of disease diagnostics and patient monitoring. The University of Toulouse, University of Caen, University of Paris-Sorbonne and University Paris-Saclay are some of the contributors to the scientific output in France.

Another factor which is contributing to the high volume of research and innovation around AI in healthcare coming out of French universities is the presence of large University Hospitals which promote applied research and innovation around healthcare. A notable example is the Laboratory of Medical Informatics and Knowledge Engineering in eHealth (LIMICS). They lead AI-related projects with various hospitals around France. LIMICS focuses on projects around the use of AI in cancer management, namely the Desiree project[181] in collaboration with Assistance Publique-Hôpitaux de Paris (AP-HP)[182]. AP-HP is the biggest teaching hospital in Europe, federating 39 different hospitals and groups of hospitals mainly located in Paris and its suburban area.

There is also considerable output from the “Centre national de recherche scientifique (CNRS)”[183], a French state organisation and the largest fundamental science agency in Europe that is divided into 10 national institutes, the national health fund CNAM and University Hospitals (i.e. the University Hospital of Clermont-Ferrand).

179 Inserm Website. Retrieved from: https://www.inserm.fr/en/about-inserm

180 Le Sniiram est le système national d’information interrégimes de l’Assurance Maladie. Retrieved from: https://www.ameli.fr/l-assurance-maladie/statistiques-et-publications/sniiram/finalites-du-sniiram.php

181 Desiree website. Retrieved from: https://desiree-project.eu/

182 Assistance Publique Hopitaux d’Parishttps. Retrieved from: https://www.aphp.fr/

183 Cf. CNRS: “The CNRS”, 2020. Retrieved from: https://www.cnrs.fr/en/cnrs

# Cross-border collaboration in research

**31.1**

**Multilateral score**[184]

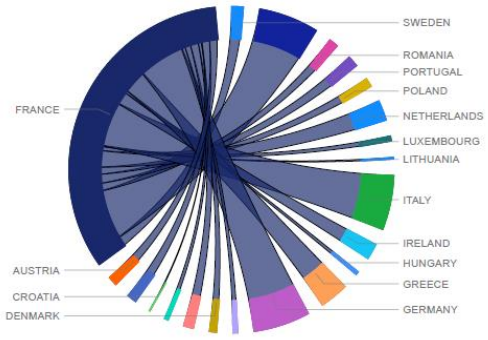
**20**

**EU Collaborating countries**[185]

Regarding the cross-border collaboration in the research area of AI in healthcare, France collaborates with at least 20 EU countries. The three major collaborators are Sweden, Germany and Italy.

Universities in France actively work with researchers from other countries. For example, the University of Sorbonne is involved in 35 projects, one of the biggest is MAESTRIA[186] (Machine Learning and Artificial intelligence for Early detection of Stroke and Atrial Fibrillation) that is a collaboration with 18 partners from different countries specialised in research and innovation.

The University of Sorbonne has a dedicated Sorbonne Centre for Artificial Intelligence (SCAI), a cross-functional structure capable of creating synergies between institutes or laboratory teams on national and international levels. As a structure of the Sorbonne University Alliance[187], the SCAI federates three faculties, such as the Medicine of Sorbonne University which emphasises research in the field of AI for health.


| Top 5 EU Collaborating Countries | Bilateral Score |
|---|---|
| Sweden | 21.3 |
| Germany | 20.1 |
| Italy | 19.3 |
| Greece | 10.2 |
| Netherlands | 7.2 |

Figure 36: Volume of cross-border collaboration in research

184 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

185 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

186 Cf. Sorbonne Center for Artificial Intelligence, 2020. Received from: https://scai.sorbonne-universite.fr/

187 Cf. Sorbonne Center for Artificial Intelligence: « About us », 2020. Received from: https://scai.sorbonne-universite.fr/public/about"

Cross-border collaboration with partners from the Greater Region are of particular importance: Founded in 2017 in Strasbourg, PRIeSM ("Plateforme Régionale d'Innovation en e-Sante Mutualisée")[188], promotes experimentation in innovative healthcare solutions based on patient data, bringing together different public and private stakeholders. PRIeSM launched a project named "INESIA", that was created to catalyse entrepreneurial energies with medical innovators from the Grand Est Region, i.e. in the context of COVID-19.

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

"La French Tech"[189], also known as the French Tech Mission, is a team of civil servants that are administratively part of the French government and provide support to start-ups around issues of policy, funding, marketing and program design. Located in France, the team consists of a strong network of investors, universities and innovation firms. The French Tech Mission provides schemes to attract foreign talent to France via the French Tech Visa scheme[190], which simplifies the launching of a deep-tech start-ups or investing in R&D.

In relation to AI in healthcare, the "AI for Health"[191] is a leading European AI-for-Healthcare initiative, taking place in France. Their aim is to link expertise from academic institutions with medical practitioners and technology firms so that European healthcare can be redesigned leveraging on AI.

The North-Eastern Grand Est region is playing a major role in the overall attractiveness of France for Healthcare AI start-ups. A major part of the attraction is the presence of BioValley France[192], an innovation and start-up cluster. They actively participate in developing projects within the health sector. The cluster supports its members in their R&D innovation approaches through access to national and international expertise (regulatory, clinical studies, etc.) and networking events.
Alsace BioValley is active throughout four main themes. They are drugs and innovative therapies, diagnostic, medical technologies and e-Health. Alsace BioValley has one of the highest concentrations of researchers and medical industry professionals in Europe, with 182 in the whole country and 143 in the Grand Est region, such as Roche, Biosynex, or Efficient Innovation.[193]

France hosts at least 22 start-ups whose work is focused mainly on AI-enabled tools in the healthcare sector. French start-ups in the field of AI for health are increasingly developing patient-centred applications. Three of these start-ups indicated in the survey that they receive public funding via national sources that amount up to €500,000.[194]

To develop AI for health technologies, French start-ups tend to use data from Open databases and appear reluctant to sharing their data.[195]
According to the respondents of the survey, the main barriers for the adoption of AI technologies in healthcare refer to the quality, suitability and funding of solutions. A specific health law should foresee budget allocation allowing national experimentation for use of AI in hospitals.[196]

188 Cf. Europe en Alsace: « Création d'une plateforme régionale d'innovation en e-santé ». Received from: http://europe-en-alsace.eu/projet/plateforme-esante/

189 Cf. La French Tech, 2020. Retrieved from: https://lafrenchtech.com/en/

190 As one of the most attractive R&D tax incentives schemes in Europe according to the OECD (cf. OECD, France, 2019. Retrieved from : https://www.oecd.org/sti/rd-tax-stats-france.pdf, France provides R&D tax relief through a volume-based tax credit – Crédit d'Impôt Recherche (CIR) – and an exemption from social security contributions for young and innovative firms.

191 Cf. Startupinside, 2020. Retrieved from: https://www.aiforhealth.fr/

192 Cf. Biovalley, 2020. Retrieved from: http://www.biovalley.com/

193 Cf. France BioValley, L'Innovation Santé, 2020. Retrieved from: https://www.biovalley-france.com/fr/

194 See survey results.

195 See survey results.

196 See survey results.

Other challenges identified relate to the implementation and integration of AI technologies into existing workflows, the lack of understanding of the technology, ease of use and trust in AI.

# 4. Awareness and use of AI technologies and applications in health care

The predominant positioning of France in research and the current state of development in this field is reflected in vivid online awareness about AI in health, with some 8,300 mentions in news over the last year and rather regular activity on this topic.

With findings on high research activities by French University Hospitals, technological innovations consistently trigger an increase in the number of mentions at several points of the year. An example is the peak in September 2019 that was the result of the announcement about investment in a new telepresence robot by the University Hospital of St. Etienne. As part of their paediatric clinic, this robot allows patients to connect remotely with relatives.

French news articles raise awareness about privacy and confidentiality challenges that come along with the use of Big Data in healthcare. Two other peaks of publications in January and July 2020 display wide interest in new diagnosis opportunities for breast and brain cancers or new therapeutic approaches combining AI and robotics.

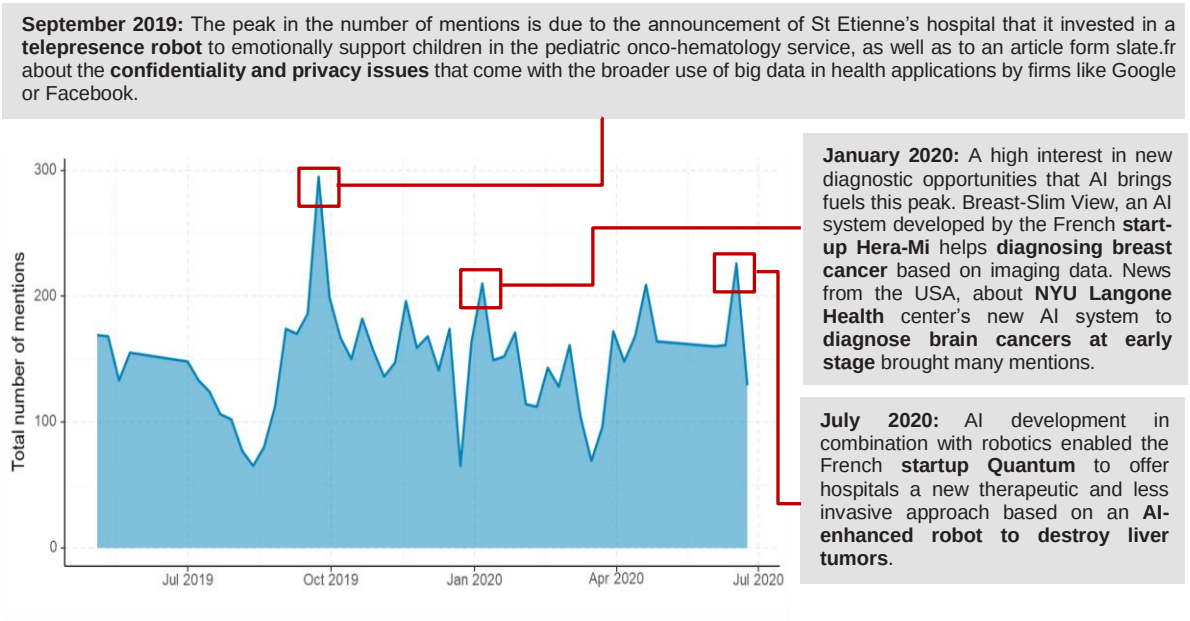



Figure 37: Trend of total mentions in the news

Activity related to AI in health was also consistently high on social media, with some 32,400 mentions over the last past year. There was an observable uptick in mentions since the French government has named several people to act as ambassadors for the development of AI and digital activities in France.

**November 2020:** The Leem, the French professional organisation for pharmaceutical firms, tweeted about the release of their study on key figures and applications of AI in healthcare.

The French Secretary of State for the Digital Sector tweeted about the importance of AI in healthcare applications as part of the **national strategy** to face the duopolistic situation with the USA and China.

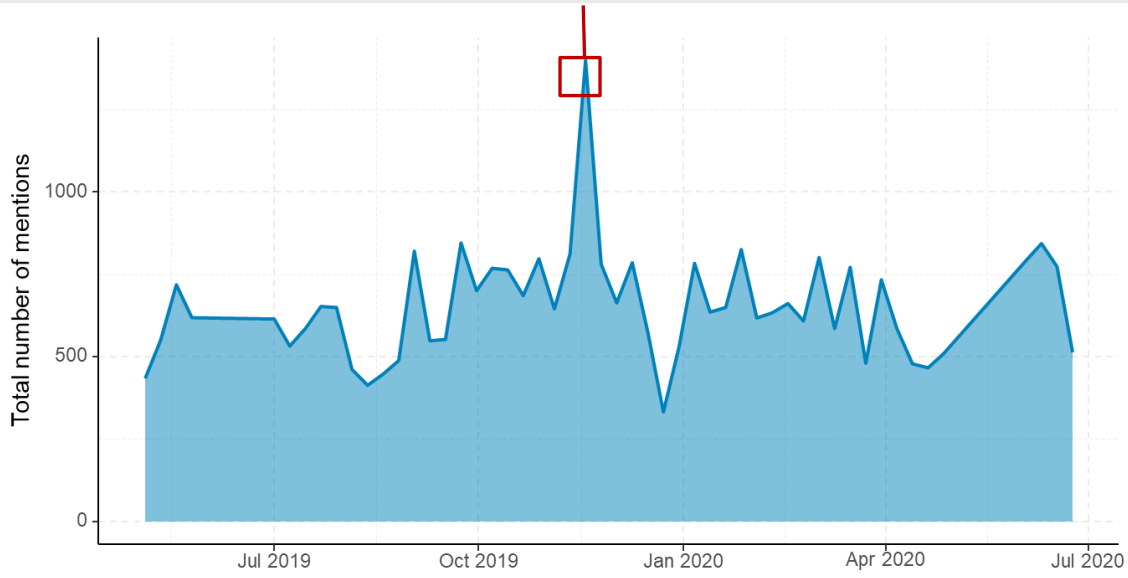



Figure 38: Trend of total mentions in social media

**83.2 Mio**[197]
**Total population**

**56.1**[198]
**DESI 2020** Index

**91%**
% of **internet users**

**18.5%**[199]
**Population as a % of** EU27

**12**
**DESI 2020 ranking amongst** EU27

**70%**
% of population with at **least basic digital skills**

**68%**
% of **Open Data**

# GERMANY

## 1. Relevant legislation and policy framework

On EU level, Germany has been chairing the EU Council from 1st July to 31st December 2020 and thus assumes an important responsibility: In addition to the management of the global Covid-19 pandemic, the Federal Government's key focus lies on promoting the use of big data and AI in the health and care sectors.[200]

Germany's national AI strategy[201] covers several fields of action, one of them is the "strengthening of research in Germany and Europe" to drive innovation. [202] With regards to aspects linked to healthcare, the Federal Government is eager to support the use of data in conformity with data protection laws, incorporate ambitions in terms of data integration centres at university hospitals, and fund initial and further AI specific training programs for healthcare professionals. The strategy addresses the use of health data to improve medicine and provide more personalized treatments, while continuously protecting patient data security.

When looking at AI technologies for health, the Federal Health Ministry's funding rules are embedded in this national AI strategy that aims at promoting "AI made in Germany" as a value framework on EU level.

On 28th October 2020, the German Bundestag's Study Commission on AI has presented its final report to the President of the Bundestag.[203] The assessment acknowledges the positive impact of AI applications on diagnostics and therapy, such as pattern recognition in health data used for prevention and monitoring (i.e. diabetes, heart disease), personalized medicine or chatbots in telemedicine.

197 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

198 Digital Economy and Society Index 2020, Country Report: Germany. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/germany

199 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

200 Cf. The Federal Health Ministry: "Das deutsche Gesundheitssystem. Leistungsstark. Sicher. Bewährt"(2020), Part of the eu2020.de programme

201 Cf. The Federal Government: "Nationale Strategie für Künstliche Intelligenz", 2020. Retrieved from: https://www.ki-strategie-deutschland.de/home.html

202 Cf. The Federal Ministry of Finance: "Strategie Künstliche Intelligenz", November 2018. Retrieved from: https://www.bundesfinanzministerium.de/Content/DE/Downloads/Digitalisierung/2018-11-15-Strategie-zur-Kuenstlichen-Intelligenz.pdf?__blob=publicationFile

203 Cf. Deutscher Bundestag, 19. Wahlperiode: "Bericht der Enquete-Kommission Künstliche Intelligenz – Gesellschaftliche Verantwortung und wirtschaftliche, soziale und ökologische Potenziale" (28/10/2020). Retrieved from: https://dip21.bundestag.de/dip21/btd/19/237/1923700.pdf

The “data availability and data use” action field for healthcare has also been specified by the Federal Government. Data may thus only be collected for specific purposes with strict standards for consent. Reponses to the survey reflect the planning of an open data platform.[204] An important issue consists in different data protection regulations and interpretations across the federal states.[205] To ensure a better interoperability between healthcare practitioners and research/academia, the Federal Government is already funding a wide range of projects linked to conformity with data protection rules and availability of big data for development of AI applications and medical IT equipment in hospitals.

Germany’s research funding is consistently focusing on the integration, analysis and interpretation of biomedical data.[206] With the aim to further investigate the potential of AI for healthcare, the Federal Health Ministry is intensively funding various research projects.

From March 2019 to May 2020, three big data projects in the indications of rare diseases, treatment of patients in emergency rooms and diagnostics of skin cancer were funded. One of the main initiatives called "Framework Announcement on Funding Priority: Digital Innovations for Improving Patient-Centered Healthcare"[207] is currently promoting projects on the topics of Smart Sensor Technology, Smart Data Use, Smart Algorithms and Smart Communication. These are supposed to exploit opportunities offered by AI technologies to illustrate the potential for health and nursing care.

Indeed, the Federal government constantly increases budgets for research on AI and the recognition of the importance of AI for the German economy is growing. In 2019, gross investments in Germany in the adoption of AI for healthcare amounted to around € 737.71 billions, and state investments in AI amounted to additional € 500 million.

In the future, Germany is supposed to have a much more progressive course in the application of AI and at the same time a strong promotion of applying institutions. For example, the last digitization law in the health care sector explicitly provides for the promotion of AI application in German hospitals (which is one out of ten eligible projects). The total budget of the fund amounts to around € 4.2 billion.

Regarding areas for future improvement, in the survey conducted in the context of this study, founders of AI start-ups operating in the healthcare sector indicated that they would like to see in place the following areas of legislation/policy:[208]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Policies aimed at encouraging the deployment of AI technologies in healthcare.

204 See survey results.

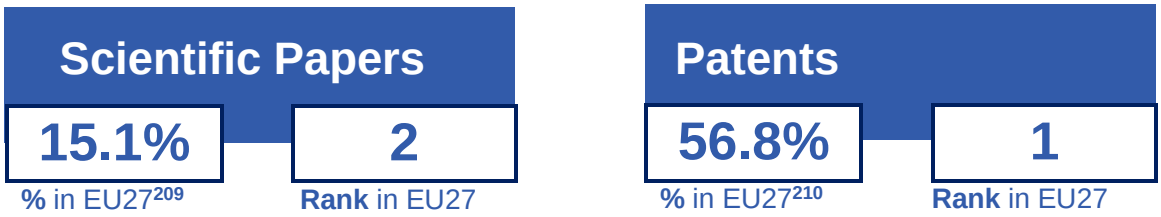
205 Cf. Chatterjea, S. Philips Electronics Nederland B.V., in: BigMedilytics: “Country specific infographics that summarise the relevant regulations for Big data technologies in the healthcare sector”, 2018.

206 Cf. Ibid.

207 Cf. The Federal Health Ministry: “E-Health – Digitalisierung im Gesundheitswesen“, 2020. Retrieved from: https://www.bundesgesundheitsministerium.de/e-health-initiative.html

208 See survey results.

# 2. Research and innovation around AI technologies and applications in healthcare




Germany is a major contributor of scientific output in the EU-27 in the area of AI in healthcare, contributing 15% of scientific papers and ranking 2nd in the EU-27 only after Italy. Most publications are in the areas of disease diagnostics and patient monitoring.

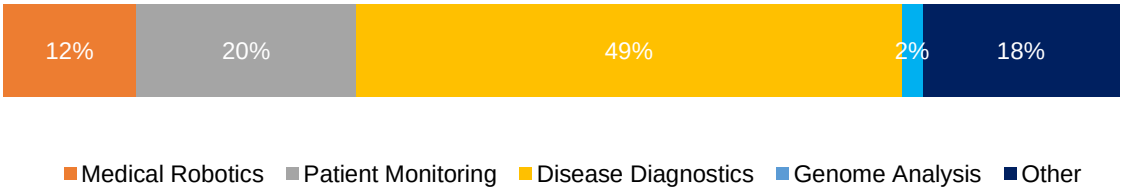



Figure 39: Areas of application in scientific papers

In terms of patent applications Germany is by far the biggest contributor to innovation between the EU-27, contributing 57.9% of patents. The majority of these are from healthcare corporations with a global outreach such as Siemens Healthcare.

The one-year intermediate report on progress with the AI strategy[211], issued by the Federal Government in 2019, shows some of the actions that have been taken since the introduction of the German AI strategy: Regarding research, the Federal Ministry of Food and Agriculture aims at promoting consumer protection through means of AI technologies. Furthermore, the Federal Ministry of Education and Research has developed digital progress hubs for health. A relevant example of investment into research in the field of AI in the medical context is given with the Helmholtz Medical Security, Privacy and AI Research Center (HMSP)[212].

The joint initiative of six Helmholtz Centers brings together leading experts from the fields of IT-security, privacy and AI/ Machine Learning, as well as the medical domain to develop enabling technology that provides efficient medical analytics while guaranteeing trustworthy processing of large-scale data sets, e.g. by means of memory-driven computing.

In Germany, the existence of large research institutes with focus groups on AI in healthcare, such as the Fraunhofer Society and the Max Planck Society (both of which contribute a large percentage of the scientific research output of Germany), is a contributing factor to the large scientific output by Germany in the area of AI in healthcare. The Fraunhofer Society,

209 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

210 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

211 Cf. The Federal Government: "Zwischenbericht: Ein Jahr KI-Strategie", 2020. Retrieved from: https://www.ki-strategie-deutschland.de/home.html?file=files/downloads/Zwischenbericht_KI-Strategie_Final.pdf

212 HMSP: "About HMSP", 2020. Retrieved from: https://hmsp.center/about.html

specifically its group for life sciences, has a Medical Translational Research and Biomedical Technology business unit that conducts a lot of research in the area of Innovative Diagnostics and Personalized Therapy, both of which are highly driven by AI technologies. The Max Planck Institute for Intelligent Systems in Stuttgart and Tübingen is also a hub for medical research using AI technologies with research groups focused in areas as diverse as bio-robotics and micro, nano and molecular systems.

Regarding publishers in the healthcare field, long-established large University Hospitals such as the Heidelberg University Hospital have research groups actively working on translational research in the area of AI in healthcare imaging for instance, using AI to analyse MRI images to evaluate the efficacy of personalized treatments for brain tumors.

In conjunction with this project, doctors and scientists from Heidelberg University Hospital and the German Cancer Research Center (DKFZ) described the huge potential of ML methods in radiological diagnostics.[213] It is also evident that the Federal Ministry of Education and Research (BMBF) recognizes the need for availability of data to foster research around AI in healthcare. Recently, the BMBF has implemented the Medical Informatics Technology Initiative[214] to merge data from clinical settings and research institutions, making it usable for different types of application. The initiative additionally includes funding programs for young researchers and ongoing projects and encompasses seven cooperative consortia so far.

## Cross-border collaboration in research


When looking at the position of the country in terms of cross-border collaborations for scientific publications, in 2020, Germany has collaborated with a total of 20 EU countries. A high-ranking multilateral score, placing the country in a 3rd position behind Spain and Italy, constitutes the relevance of cross-border collaborations in research especially with Netherlands, France, Italy, Austria and Spain.

Germany's research landscape in the field of AI for health has a wide outreach, and mainly comprises university hospitals (e.g. University Hospital Hamburg-Eppendorf, Heidelberg University Hospitals, University Hospital Frankfurt am Main), and universities with research focuses on technology, medical informatics and computer science (e.g. Department of Computer Science Technische Universität Darmstadt, Institute of Medical Informatics University of Lübeck).

Research entities in the Ruhr region, Saarland and Bavaria appear to be leading-edge with a high number of AI for healthcare-specialized institutions that are part of bigger networks: Concerning this regard, the Max Planck Society has contributed with considerable scientific output. Research on AI for healthcare is being conducted at the Department of Translational Research in Psychiatry at Max-Planck Institute of Psychiatry, the Max Planck Institute for

213 IDW – Informationsdienst Wissenschaft: „Prof. Alexander Radbruch leitet neue Klinik für Neuroradiologie des Universitätsklinikums Bonn", 2020. Retrieved from: https://idw-online.de/de/news747390.

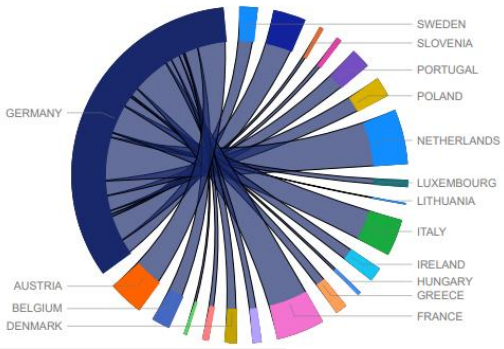
214 Cf. Medical Informatics Initiative: "Strengthening research and advancing healthcare", 2020. Retrieved from: https://www.medizininformatik-initiative.de

215 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

216 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

Biological Cybernetics in Tübingen or rather the Max Planck Institute for Informatics Saarbrücken.

Corporate research appears to be led by different Siemens entities in the federal state of Bavaria with co-publications issued by the Siemens Corporate Technology in Munich, Innovation Siemens Healthineers in Erlangen or rather Siemens Healthcare GmbH in Forchheim.


| Top 5 EU Collaborating Countries | Bilateral Score |
|---|---|
| Netherlands | 22.8 |
| France | 20.1 |
| Italy | 15.2 |
| Austria | 14.6 |
| Spain | 13.5 |

Figure 40: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Germany is the host of at least 40 start-ups whose work is focused on applications of AI in the healthcare sector. Despite the large number of start-ups, the majority of patent applications have been submitted by and granted to larger, already established, healthcare technology organisations.

The strong welfare system of Germany and attractive government schemes, as well as strong angel investor networks additionally support the development of start-ups and innovation output. One such example is the government-funded “INVEST – Grant for Venture Capital” programme which helps young, innovative companies to find someone to provide capital. Via this scheme, business angels get 20% of their investment reimbursed tax-free if they invest at least €10,000 in start-ups.

Other schemes which have supported the development of innovative companies and start-ups in Germany in the area of AI in healthcare include the publicly funded EXIST start-up grant scheme, which supports researchers and students in preparing and implementing their research-based start-ups, supporting them from the business plan stage right up to the actual product or service launch. A number of federal-based schemes are also available which contribute to the development of technology transfer and innovation culture in Germany, such as the BMBF’s SME-focused funding scheme which commenced in 2020, providing funding

and implementation support around research, development and use of Artificial Intelligence methods, specifically for SMEs[217].

Regarding national funding sources, out of the overall gross investment (€ 737.71 billion) in the adoption of AI for health, only around € 450 million were invested by industry in German AI start-ups.[218] Regarding national funding sources, out of the overall gross investment (€ 737.71 billion) in the adoption of AI for health, only around €450 million were invested by industry in German AI start-ups[203].

Survey participants from start-ups have indicated that they were obtaining data for the development of AI applications in healthcare through means of own collection via clinical trials or other data collection. Types of data used by SMEs for the development of AI applications include pathology data and imaging data and most start-ups are actively collaborating with other research institutes, companies or healthcare delivery centres for the translation of AI-related research into healthcare applications.[203]

# 4. Awareness and use of AI technologies and applications in healthcare

Results from the survey show that 52% of German patients use Google, Ada Health or other algorithms to check on their symptoms before a visit to the doctor.[205]

In accordance with the high percentage of internet users (91%)[219], Germany proves high online activity in this emerging field. Mentions through news and social media total 14,200 respectively 24,400 results.

It appears that the investment into innovative technologies and health-tech start-ups reflects German citizens' interest in such emerging technologies for medical purposes. Overall, users refer notably a lot to developers of AI technologies, such as the Dutch multinational conglomerate corporation Philips.
As regards to perceived added value of such innovations, Germans particularly discuss prevention, clinical decision support, machine learning and robotics for ambient assisted living as well as discovery of new drugs through means of AI.

Yet concerns about safety of health-related data and ethical responsibility of AI-based decision-making tools in medicine are raised amongst the German population. Both news sources and social media posts bear out these overall tendencies.

The comparatively high online awareness in German news is centered around two peaks of publications thru November until December 2019 (between 435 and 471 results for peaks). Numerous articles mention the rapid progress in clinical trials, machine and deep learning. Consistently over the period, German news sources include articles concerning the launch of innovative technologies by health technology conglomerates and health-tech start-ups.

Robotics and machine learning in the field of ambient assisted living, disease prevention and prediction are covered in news publications during November and December. Germany's considerable contribution to research on disease prediction models and the future role of AI for health and well-being can also be retrieved from results in news. Overall, Germans express themselves positively about the impact on precision and personalized medicine. Recent progress has been achieved in various application areas, e.g. robotics for elderly care and

217 Bundesministerium für Bildung und Forschung: „Bekanntmachung", 2020. Retrieved from: https://www.bmbf.de/foerderungen/bekanntmachung-2876.html

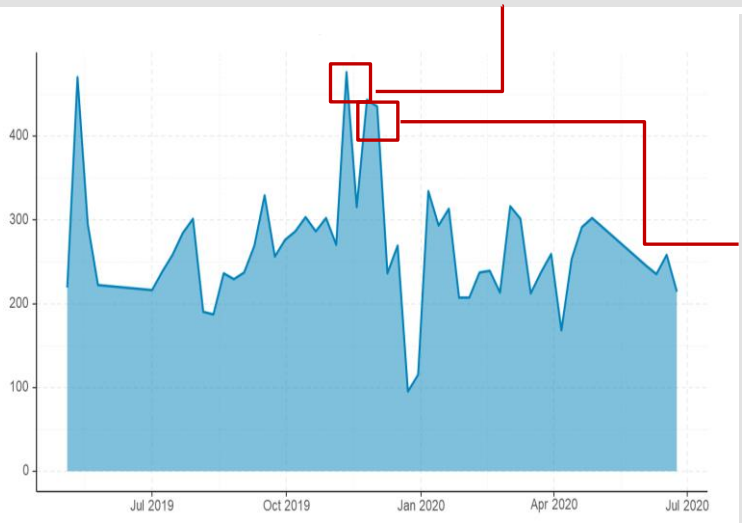
218 See survey results.

219 European Commission: "Index für die digitale Wirtschaft und Gesellschaft (DESI) 2020." Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/germany

nursing support, improved radiology through means of digital radiography and medical imaging and diagnosis of diabetes.

**November 2019:** Google improves AI and machine learning in healthcare through unauthorized access to millions of patient data. Research bringing breakthrough in clinical trials and revealing relevance of **AI-assisted decision-making in clinical practice;** yet concerns about ethical responsibility are raised. Several mentions of AI-based innovative technologies and solutions by tech companies and health-tech start-ups, i.e. Philips' cloud-based HealthSuite Digital Platform. **Reservations are yet raised about safety of healthcare data** that is stolen or held for ransom, highly affecting small health-tech companies.

Numerous mentions of promising leverage of AI imperative on healthcare industry that was raised during International Health Forum in Bangkok. Mentions of proven **positive impact on precision medicine** through rapid progress in AI, e.g. prevention of bowel cancer, or support of nursing staff through robotic technologies.




**November/ December2019:** Predominantly, German newspapers discuss the value and use of innovations in **robotics and machine learning** in the field of **ambient assisted living and disease prevention**. Awareness is raised around the launch of IntelliSpace AI Workflow Suite by healthtech leader Philips created to get insights from a range of patient data. German news cover different types of progress in robotics in care, improved **diagnosis of diabetes**, digital radiography and medical imaging, overall resulting in **better precision medicine**.

News in Germany further include matches of research in machine learning and deep learning models for disease prediction.

Particularly high awareness is raised around **GE Healthcare's New Imaging Tech & Intelligent Apps** allowing a cleared collection of AI algorithms embedded on a mobile X-ray device.

AI can fundamentally transform patient experience; several articles discuss the future of AI in medicine.

Figure 41: Trend of total mentions in the news

Germany furthermore displays a particularly high awareness through mentions in social media, especially throughout Twitter that appeared to be very popular amongst Germans to exchange about latest innovations in the context of Covid-19.

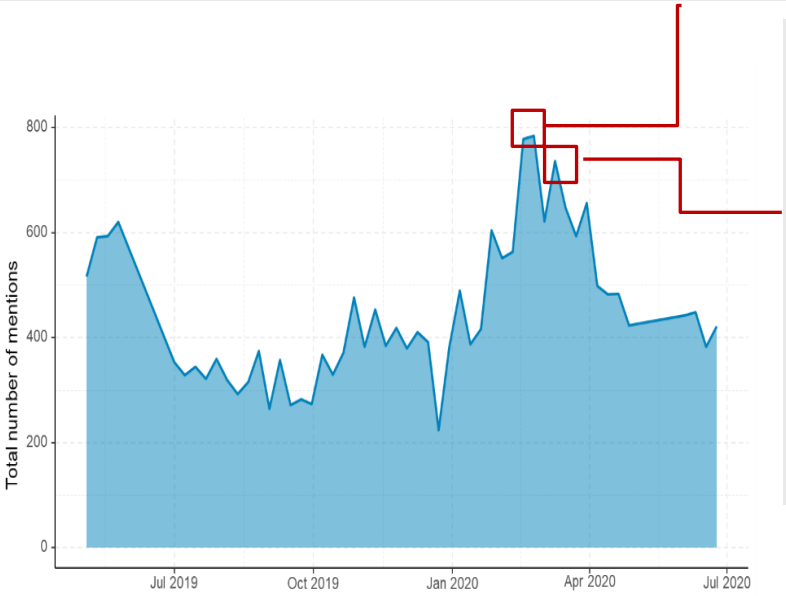
Peaks of mentions in social media stand out in Mid-February until beginning of March, as well as Mid-April 2020 in the context of Covid-19. German tweeters take an interest in AI for health-related events in Germany, and repeatedly mention a European campaign that brings 5G, cloud and AI technology for diagnosis, prevention and protection forward.

**February 2020:** Consecutive peaks include high activity by the influencer account "HubofMachineLearning" that posts about the progressive use of AI on **clinical decision support**, coronavirus alerts, telemedicine, **discovery of new antibiotics** or food-based cancer-beating molecules. This influencer also mentions the capability of Chinese hospitals that deploy AI to help diagnose diseases, e.g. Covid-19.

Regarding medical terms, there are several mentions of novel **3D printing methods** to create blood vessel structures. Further, AI yields progress in antibiotics, **medical imaging** to precise cardiovascular diseases and new ways of using AI in **mental health** are discovered. Some users address **ethical concerns**.

Notably, several posts refer to talks and speeches at congresses as well as **events in that field** taking place in Germany. Also, there are posts around the discussion of opportunities and challenges of AI in medicine at the German Bundestag.

Hashtags used during this period include AI, imaging, genetics, precision medicine, machine learning, bioinformatics, robotics.




**March - April 2020:** With 939 mentions, results show positive connotation between AI and healthcare, mainly related to support of nurses, analysis of health status and behavioural patterns, Covid-19 treatments and the **impact of quarantine measures on its spread**. A Tweet about a European **campaign by Huawei** is retweeted several times: Online users show awareness around how 5G, cloud and AI are transforming the medical field, with particular emphasis on **diagnosis, prevention and protection**.

High activity by influencer account "HubofMachineLearning" with Tweets about identification of new antibiotics through means of AI and predictions of future direction regarding AI technologies.

Figure 42: Trend of total mentions in social media

**10.7 Mio**[220]
**Total population**

**37.3**[221]
**DESI 2020** Index

**74%**
% of **internet users**

**2.4%**[222]
**Population as a % of** EU27

**25**
**DESI 2020 ranking amongst** EU27

**51%**
% of population with at **least basic digital skills**

**66%**
% of **Open Data**

# GREECE

## 1. Relevant legislation and policy framework

Greece has yet to publish its AI strategy, which the government aimed to develop by the end of 2020, together with a corresponding action/implementation plan on AI. The main vision is to effectively combine the knowledge of the academic and research community with private firms in charge of the production and implementation. They hope this kind of collaboration will boost the Greek economy and investments. According to the Ministry of Digital Governance[223], Greece has already initiated the mapping of AI initiatives across sectors at the national level, as well as opened discussions with all relevant stakeholders at academic, research and operational levels, towards the effective combination of knowledge-research-production pillars.

The National Centre for Scientific Research "Demokritos" hopes to develop into a centre of excellence, becoming a point of reference for certain AI technologies. They strive to connect researchers, scientists and AI professionals with business experts from a wide range of industrial sectors and use emerging technologies to accelerate innovation[224].
Initiatives around the establishment of a Data Centre for the Greek government are underway and will serve as a basis for the support of AI initiatives, once the national strategy is published.

In terms of the healthcare sector, the National Health System of Greece has initiated a lot of strategic actions around the Digital Transformation of the Healthcare sector, presented in June, 2020[225], which amongst others, include the use of data-driven decision support systems, as well as the utilisation of Big Data in healthcare delivery using machine learning and Artificial intelligence.

The digital transformation of Greece is driven by the Digital Transformation Bible (DTB), a forthcoming reference document which includes AI as one of the main "strategic intervention axes". The elaboration of a national AI strategy constitutes one of the major interventions in the document[233].

220 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

221 Digital Economy and Society Index 2020, Country Report: Greece, Shaping Europe's digital future. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/greece (accessed in December 2020)

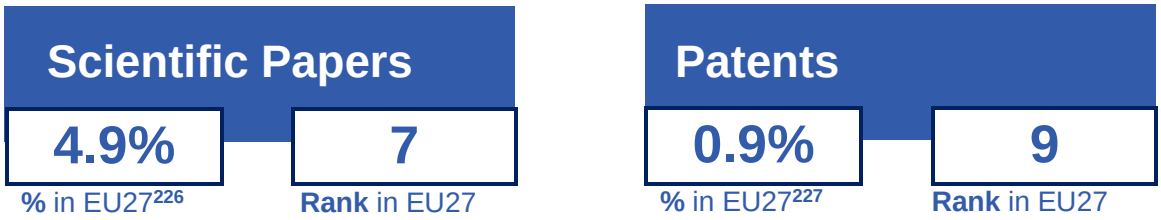
222 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

223 OECD, Greek national strategy for AI. Retrieved from: https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-26788 (accessed in December 2020)

224 OECD, Artificial Intelligence Center of Excellence, October 2020. Retrieved from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-25135 (accessed in December 2020)

225 HealthIT conference. Retrieved from: https://www.healthitconference.gr/ (accessed in December 2020)

# 2. Research and innovation around AI technologies and applications in healthcare




Greece contributes approximately 4.9% of scientific output in the area of AI in healthcare. The scientific contribution of Greece is disproportionately big with respect to its population. This trend is mainly driven by the large number of academics and research groups working within large and small research institutions in this field.


Figure 43: Areas of application in scientific papers

Notable research into AI applications in healthcare include centres within the National Technical University of Athens, University of Crete, Aristotle University of Thessaloniki and the University of Ioannina. Notably, there are a number of independent research centres such as the Biomedical Research Foundation Academy of Athens, the aforementioned National Centre of Scientific Research "Demokritos" and the Foundation for Research and Technology – Hellas (FORTH).

There is a wide range of application areas, and similarly to other EU countries, most research is focused around image diagnostics, as well as systems targeting diagnosis and treatment decision support through medical record analytics.

Deep learning methods are deployed, for instance, for Automatic MRI Cardiac Multi-Structures Diagnosis or Liver Biopsies by means of convolutional Neural Networks Diagnosis and machine learning techniques in the domain of asthma diagnosis, chronic obstructive pulmonary disease or in MRI.

226 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

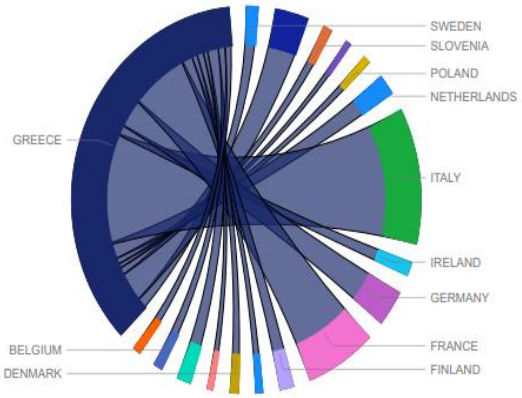
227 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

# Cross-border collaboration in research

| 19.5 | 17 |
|---|---|
| Multilateral score[228] | EU Collaborating countries[229] |

We identified at least 17 EU countries with which Greece collaborates on AI in health research. Some of the top collaborators are Italy, France, Spain, Germany and the Netherlands.

One of the factors fostering active collaboration with other countries is the organisation of various events and conferences that bring researchers together. For example, during the 7th Annual international Conference on Health & Medical Sciences (2019) a stream on "Artificial Intelligence in Smart Biomedical and Healthcare Systems, AISBHS" was organised. AISBHS brings researchers and developers from different countries to present their most recent research, outputs and ideas in all areas of artificial intelligence, knowledge engineering and machine learning, as well as in the fields of medicine and health care[230]


| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Italy | 17.9 |
| France | 10.2 |
| Spain | 4.8 |
| Germany | 4.7 |
| Netherlands | 2.7 |

Figure 44: Volume of cross-border collaboration in research

228 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

229 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

230 Athens Institute for Education and Research. Retrieved from: https://www.atiner.gr/hscart (accessed in December 2020)

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

There are at least three start-ups in Greece whose work is focused mainly on consumer robotics, drug repurposing and import and distribution of medical equipment.

Despite the financial crisis that Greece has been experiencing for the best part of the past decade, it has set up an energetic tech scene with start-ups that are aimed at driving attention towards the country and attracting foreign funds. EquiFund, the investment platform created through the collaboration of the Hellenic Republic and the European Investment Fund, is expected to be the main source of funding for high-potential start-ups with expectations of investing around EUR 1 billion by 2022[231]. In addition, Elevate Greece, the official platform for the Greek start-up ecosystem, is the first stop for in-depth information regarding the field. It aims to identify and support start-ups and thus, turn Greece into a global innovation hub[232].

In terms of potential areas for improvement, results of the survey conducted with start-up representatives show the need for more scientists to work in the area of AI in healthcare. Survey respondents also expressed that better image analysis of clinical tomographic data is required by some working in that area.

# 4. Awareness and use of AI technologies and applications in healthcare

Regarding awareness raised across online news and Twitter, overall Greece displayed strong awareness regarding AI and its subsequent integration in health. 1,100 mentions were accumulated solely through national news sources and additionally managed to breach the 50 mentions mark three times during a 13-month period from June 2019 to July 2020.

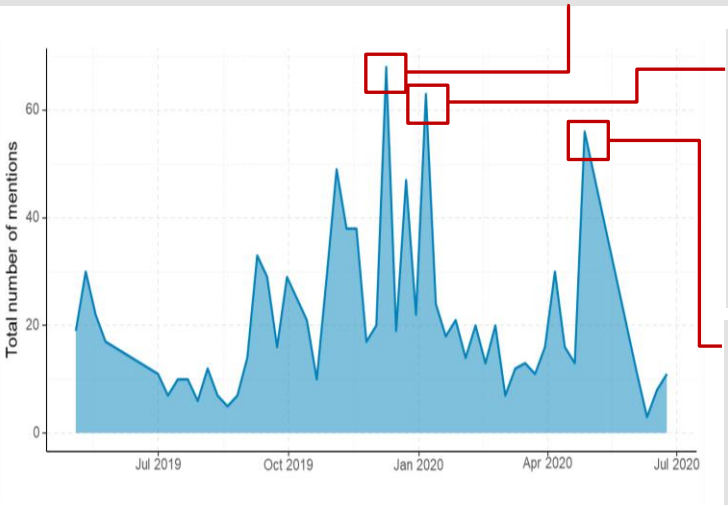
Their first and highest spike occurred towards the end of 2019, with 68 mentions. The news was primarily centred around a government initiative translated to “Rebrain Greece”, aiming to repatriate Greek scientists through subsidies and further developing their digital skills to prepare them for the upcoming disruptions caused by AI in sectors such as health.

The second peak followed at beginning of 2020 and saw strong media coverage of Toyota’s city of the future plans. The plans include AI powered sensors built into homes to monitor the health of the inhabitants. The final peak was strongly associated with the Covid-19 outbreak, with telehealth and AI enabling helplines receiving numerous mentions. Consistently throughout the entire period there were mentions concerning breakthroughs in AI technology and its new applications in health.

231 BCG – The Boston Consulting Group, Greece’s startup ecosystem – A prime opportunity for economic growth, April 2018, .3

232 Elevate Greece. Retrieved from: https://elevategreece.gov.gr/ (accessed in December 2020)

**December 2019:** Majority of the mentions from the Greek news sources was related to the government initiative "Rebrain Greece" aiming to repatriate young Greek scientist while targeting the development of digital skills to cater to the integration of AI and other technologies in key production sector, such as healthcare. Mentions of using AI and deep learning to build virtual 3D models of patients' hearts for safer and more accurate diagnosis, while other forms of AI have been used to scan patients for urgent/life threatening conditions, to subsequently be immediately diagnosed by radiologists.




**January 2020:** News articles on AI infiltrating the healthcare labor market with AI technology currently able to read X-rays and ultrasounds, while robots soon to be used in nursing homes. Toyota gained national attention through their city of the future plans including with sensors powered by AI, **monitoring health** and physical wellbeing inside homes. Other applications of AI in health mentioned during the period, pertained to the almost real time, highly accurate diagnosis of brain tumors.

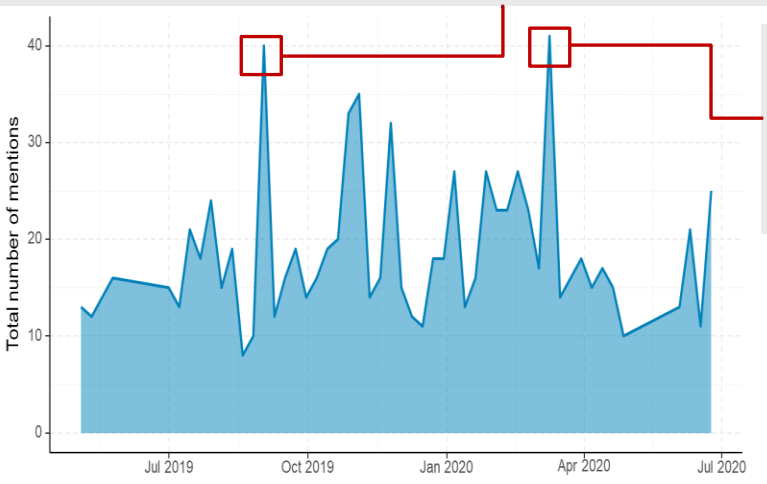
**April/May 2020:** The peak correlates to mentions regarding the use of AI for the mitigation of the Covid-19 outbreak. **Telehealth** and AI enabled helplines from France received strong coverage, while other AI technologies used to predict clinical risks associated with Covid-19.

Figure 45: Trend of total mentions in the news

Complementing the news mentions, Greece shows substantial awareness throughout social media platforms, reaching just under 1,000 mentions. Influencers play a dominating role in the Greek social media landscape surrounding AI and health, raising added awareness through popular hashtags, like "healthtech" and "medtech". Both peaks (September 2019 and March 2020) surpassed the 40-mention mark and included tweets about the most recent breakthroughs in the intersection of novel AI technology and the healthcare sector.

The second peak, however, concentrated more on tweets relating to the Covid-19 outbreak, specifically some tweets were directed at the WHO with users seeking to gain more information as to when AI might be implemented in healthcare sectors.

**September 2019:** The peak included high twitter activity from influencers, consistently using hashtags such as **#healthtech and #medtech**. Numerous tweets brought awareness towards the latest uses of AI for health-related activities, ranging from **drones delivering organs for transplants** to AI softwares predicting the optimal treatments for cancer patients.




**March 2020:** Tweets and retweets during one-week spike related to the Covid-19 outbreak, with influencers offering insights on how AI and big data can help. Other tweets raised questions on whether **AI will make the healthcare system more expensive** and potentially undermining people's values and human rights.

Figure 46: Trend of total mentions in social media

**9.8 Mio**[233]
**Total population**

**47.5**[234]
**DESI 2020** Index

**80%**
% of **internet users**

**2.2%**[235]
**Population as a % of** EU27

**20**
**DESI 2020 ranking amongst** EU27

**49%**
% of population with at **least basic digital skills**

**32%**
% of **Open Data**

# HUNGARY

## 1. Relevant legislation and policy framework

Hungary has adopted a new AI strategy for 2020-2030 which sets out several sector-specific goals that will position the country high in the global value chain[236]. When in 2018 the Hungarian AI Coalition was founded, which acts as a partnership between the government, academia and practitioners, they were already anticipating such governmental goals.

"Data-driven healthcare" is one of the sector-specific goals of the AI strategy, with the aim to use all available data to support AI research and innovation, AI applications in medicine and AI tools to improve the efficiency of health administration and management. Moreover, the strategy aims to promote "Health consciousness in a digital world" by informing and educating Hungarian citizens on the use, benefits and possible dangers of digital healthcare schemes.

According to their AI strategy, Hungary wants to relocate as many research centres of international organisations using AI technology as possible to Hungary, based on an attractive regulatory environment and high-quality research.

As a result of the international connections of the Hungarian research network (i.e. the extension of CERN's data centre to Budapest[237]), Hungary also offers available computing capacities that are currently complemented with high performance computing capabilities. The broad portfolio of the regulated electronic administrative services (REAS-s) is similarly an advantage that facilitates the transition to digital administration for public administration actors, standardises legally-adopted technologies and creates economies of scale[238].

## 2. Research and innovation around AI technologies and applications in healthcare

**Scientific Papers**

| **1.0%** | **16** |
|---|---|
| **%** in EU27[239] | **Rank** in EU27 |

**Patents**

| **0** | **n/a** |
|---|---|
| **%** in EU27[240] | **Rank** in EU27 |

233 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

234 Digital Economy and Society Index 2020, Country Report: Hungary. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/hungary (accessed in December 2020)

Hungary contributes approximately 1.0% of scientific output in the area of AI in healthcare. This is a relatively low contribution compared to the proportion of Hungary's population within the EU. Notable institutions which enable these contributions include the University of Debrecen, Obuda University and University of Szeged, hospitals such as St. John's Hospital in Budapest and the Hungarian Academy of Sciences.

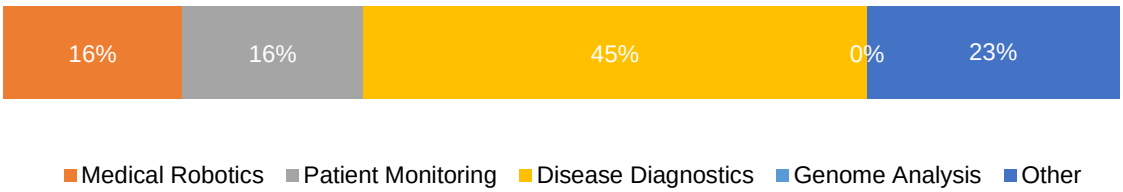



Figure 47: Areas of application in scientific papers

In Hungary, AI is most represented in the field of disease diagnostics. Machine learning is used for prediction and illness detection, breast cancer or multiple sclerosis. Deep learning is applied to improve medical image processing in various medical areas. These research activities adhere to the key aims for AI research and development of the Hungary's AI strategy, which states that the preservation of human health through medical imaging is one of the key priorities.

## Cross-border collaboration in research

**0.9**
**Multilateral score**[241]

**13**
**EU Collaborating countries**[242]

Cross-border research projects are in most cases conducted with either France, Germany, Slovakia, Italy or Austria. Overall, Hungary collaborates with quite many countries in the area of AI, partially thanks to the Hungarian AI coalition, which launched an AI portal to support networking and increase visibility of AI efforts in the country. Via the portal, AI developers can showcase local case-studies to foster collaboration and raise awareness within the country.



235 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

236 Ministry for Innovation and Technology, Hungary's Artificial Intelligence Strategy 2020 – 2030, May 2020, p. 36

237CERN, "CERN inaugurates data centre extension in Budapest", June 2013: https://home.cern/news/news/computing/cern-inaugurates-data-centre-extension-budapest

238 Ministry for Innovation and Technology, Hungary's Artificial Intelligence Strategy 2020 – 2030, May 2020, pp. 15-16

239 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

240 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

241 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

242 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

| Top 5 EU collaborating Countries | Bilateral Score |
|---|---|
| France | 1.2 |
| Germany | 1.1 |
| Slovakia | 0.8 |
| Italy | 0.6 |
| Austria | 0.5 |

Figure 48: Volume of cross-border collaboration in research

In February 2020, a Memorandum of Understanding was signed by Estonian and Hungarian public and private entities, e.g. the Estonian cybersecurity company Guardtime, TalTech, the Estonian Ministry of Social Affairs, as well as the Hungarian Ministry of Innovation and Technology, the Semmelweiss University and the Hungarian company E-Group ICT Software ZRT.[243] This memorandum promotes the collaboration between the two countries, aiming to jointly undertake data-driven and trustworthy AI Training range projects.

Hungary is already recognized as a leading country in using big health datasets to guide the healthcare decision making process.[244] Through this collaboration between Hungarian and Estonian research institutions and companies, Hungary will be able to demonstrate the reliable use of AI and further promote the reliability testing of AI algorithms before their use in medicine.

## 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

In July 2020, the National Research Development and Innovation Office of Hungary has announced the HUF 2 billion funding programme (up to HUF 300 million of funding per incubator) with the aim of supporting the expert and mentoring activity of business incubators. This will lead the growth and development of innovative Hungarian businesses. The motivation for this programme has come from the parliamentary and strategic state secretary of the Ministry of Innovation and Technology. The priority for the Hungarian government is to increase the innovation performance of domestic small and medium-sized enterprises[245].

243 Cf. Guardtime: "Estonian and Hungarian Governments partner with Guardtime to develop an AI Training Range for Health-Care Assured AI". Retrieved from: https://guardtime.com/blog/estonian-and-hungarian-governments-partner-with-guardtime-to-develop-an-ai-training-range-for-health-care-assured-ai (accessed in December 2020).

244 Cf. ibid.

245 National Research, development and innovation office Hungary, HUF 2 billion funding programme for incubators to boost the Hungarian startup ecosystem, July 2020. Retrieved from: https://nkfih.gov.hu/english/news-of-the-office/huf-2-billion-funding (accessed in December 2020)

Another relevant initiative was the adoption of the "Digital Start-up Strategy of Hungary" through the Digital Success Programme of Hungary in 2016. The strategy set out to strengthen entrepreneurship and entrepreneurial competencies, foster a culture of cooperation, and develop a supportive business environment with available sources of financing, by the end of 2020[246].

There are at least two start-ups in Hungary whose work is focused mainly on AI-enabled tools in the healthcare sector and they are mainly supported by private angel investors and EU grants, such as Horizon 2020[247].

# 4. Awareness and use of AI technologies and applications in healthcare

Overall, Hungarian online news activities in this field are relatively low (totalling 291 mentions between June 2019 and July 2020). The news mentions trend nevertheless displayed three peaks of AI awareness.

As seen in the graph below, news mentions are pretty evenly distributed throughout the 13-month period, with slight peaks at three separate points. The first peak, arriving in the fall of 2019, amassed 14 mentions and was centred around Hungary's second annual Health and Technology conference titled HUNGAROMED. A wide range of topics were discussed, with specific insights shared on the implementation of AI in mammography and pathology.

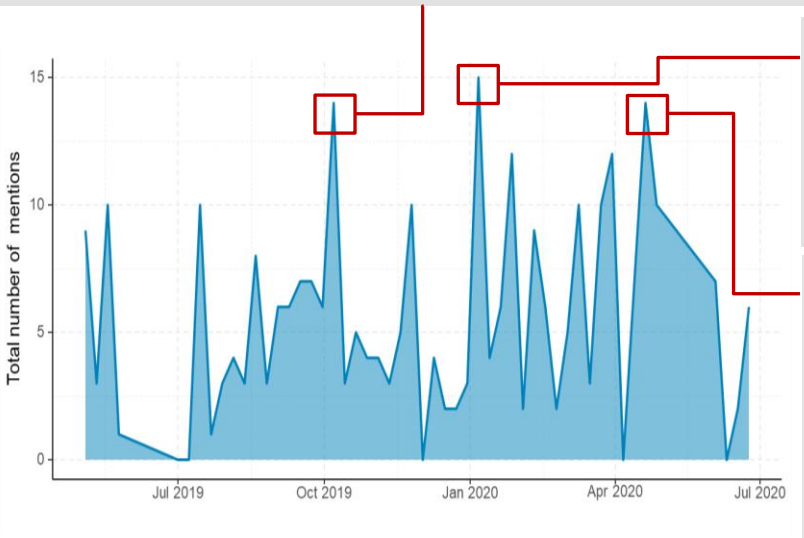
The second peak, occurring at the start of 2020, receiving 15 mentions, focused on the Hungarian Hospital Association's announcement on the use of calling systems, telemedicine and patient monitoring in order to ease the workload of the hospital labour force. The third and final peak, with 15 mentions, coincided with the height of the Covid-19 crisis, therefore all discussions surrounded the applications of AI in health with the view of managing the pandemic.

Some activities from Hungarian Twitter accounts correlate with the approval of AI-based algorithms in medicine and healthcare by the Hungary National Institute of Pharmacy and Nutrition. Another stream of awareness is linked to the invention of the Canadian AI-driven health monitoring platform, BlueDot, that was able to predict the Covid-19 outbreak.

246 Digital Success Programme. Retrieved from: https://digitalisjoletprogram.hu/en/about (accessed in December 2020)

247 A EU financial instrument aimed at securing Europe's global competitiveness: https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020

**October 2019:** Media attention around the second Health and Technology conference, HUNGAROMED, where insights on implementation of **AI in mammography and pathology** were presented and discussed. Moreover, breakthroughs in AI directed towards the understanding and treatment of digestion diseases were reported on during the period.

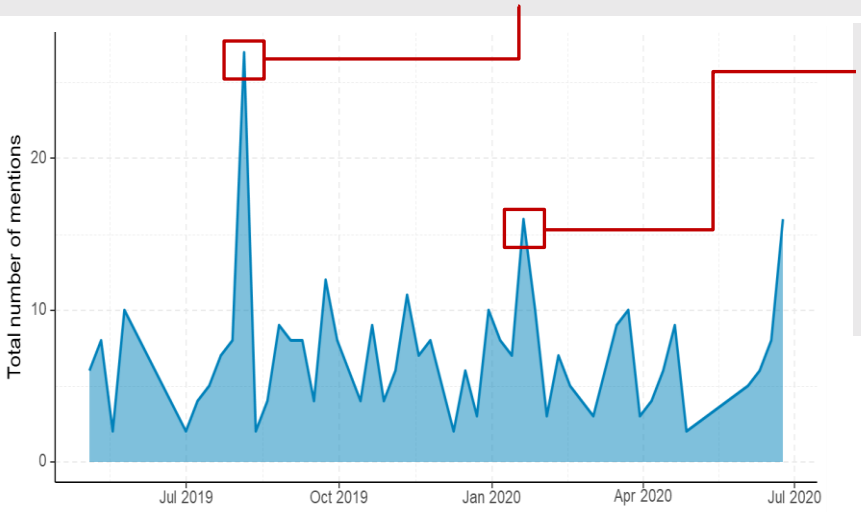



**January 2020:** Main focus was on the use of AI for diagnosis, with the **Hungarian Hospital Association** claiming that calling systems, telemedicine and patient monitoring could all ease the workload of the nursing staff, while other forms AI would help the diagnosis decision making process.

**April 2020:** The highlighted period coincided with the peak of Covid-19 crisis. Therefore, the use of AI for forecasting case numbers and for the search of vaccines were mentioned. Moreover, researchers in MIT have used an AI system to translate the Covid-19 virus protein structure into music, in turn, providing more information **on the nature of the virus.**

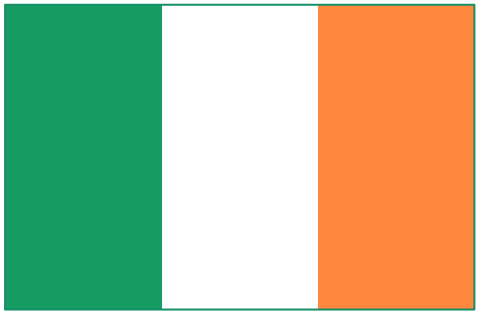
Figure 49: Trend of total mentions in the news

**August 2019:** Hungarian influencer brought strong awareness towards global trends regarding the use of AI in health. Retweets on his post regarding the **FDA approved AI-based algorithms** in medicine and healthcare was at center of the Twitter activity. Other mentions related to **Healthcare AI funding significantly increasing** as the sector matures.




**January 2020:** Similar to the previous peak, sector influencers directed the twitter activity. Awareness surrounding Canadian **AI-driven health monitoring platform** being the first to **predict the Covid-19 outbreak** by using airline ticketing data. The period also included some negative sentiment toward the quality of medicine which AI is able to produce.

Figure 50: Trend of total mentions in social media



**5.0 Mio**[248]
**Total population**

**61.8**[249]
**DESI 2020** Index

**88%**
% of **internet users**

**1.1%**[250]
**Population as a % of** EU27

**6**
**DESI 2020 ranking amongst** EU27

**53%**
% of population with at **least basic digital skills**

**91%**
% of **Open Data**

# IRELAND

## 1. Relevant legislation and policy framework

Ireland has yet to publish its AI strategy,[251] known as "AI – Here for Good", which the government aimed to develop and publish by the first quarter of 2020. The country is ranked in a cluster of EU countries that are performing strongly in their digitalisation.[252] Ireland's AI ecosystem is characterised by 25 years of AI research, a strong mix of multinational and domestic companies, a variety of research centres that focus on different aspects of AI, and strong industry-academic collaboration.[253]

The Department of enterprise, trade and employment of the Irish government has listed health and wellbeing as one of their "Research Priority Areas 2018 to 2023" in the report by the same name[254]. They recognised the importance of technology-enabled solutions for improving research areas like Connected Health and Independent living, medical devices, diagnostics and therapeutics through the impact of Information and Communication Technology, Internet of Things, Artificial Intelligence, Digital Media, In-Vitro Diagnostics, Personalised Medicine, etc. Furthermore, AI-technology can also support other markets that span a wide range of sectors, including Pharma, Biopharma, Digital Health and Analytics.

A report on "Irish business priorities for a national AI strategy"[255] issued by Ireland's biggest lobby group, Ibec, points out that Ireland has been ranked as a European leader in access to open data. Ibec is campaigning the government for a national AI strategy for the period 2020-2024 aligned with EU initiatives and globally relevant standards for interoperable and trustworthy AI. In relation to healthcare, Ibec recommends strengthening public trust in AI by demonstrating benefits in health service delivery.

248 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

249 Digital Economy and Society Index 2020, Country Report: Ireland, Shaping Europe's digital future. Retrieved from: https://ec.europa.eu/digital-single-market/en/scoreboard/ireland (accessed in December 2020)

250 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

251 International Trade Administration, Ireland Artificial Intelligence, June 2020. Retrieved from: https://www.trade.gov/market-intelligence/ireland-artificial-intelligence (accessed in December 2020)

252 European Commission, The Digital Economy and Society Index (DESI), December2020. Retrieved from: https://ec.europa.eu/digital-single-market/en/desi (accessed in December 2020)

253 European Commission, The European AI Landscape – Workshop Report, April 2018, p.13

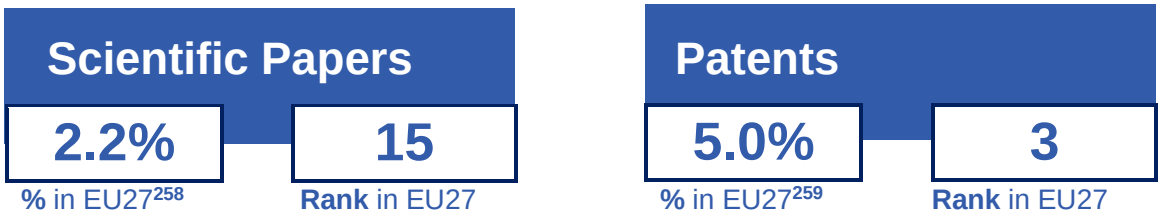
254 Irish Government – Department of enterprise, trade and employment, Research Priority Areas 2018 to 2023, March 2018, pp.13-16

255 Ibec – Irish Business and Employers Confederation, Smarter technology for a better future - Irish business priorities for a national AI strategy, February 2020, pp. 2-8

The main objective of the future national AI strategy will be to provide a high-level direction to the design, development and adoption of AI in Ireland. This cross-government strategy is expected to include healthcare-related matters in its main topic areas.

National authorities that participated in the survey conducted as part of this study, indicated that there is already national legislation in place regarding the storage and sharing of health data.[256] Participants of the survey further stated that the main barriers to the adoption of AI technologies in healthcare refer to the availability of expert skills and resources, the lack of technological understanding and access to high quality data, an insufficient funding and uncertainty of potential returns on investment, the absence of a supportive digital infrastructure and strategic directions for translating R&D into wide scale deployment.[257]

## 2. Research and innovation around AI technologies and applications in healthcare




Ireland contributes approximately 2.2% of scientific output in the area of AI in healthcare which appears relatively high with respect of its population. Irish universities and research centres are the main contributors, with notable examples including University College Dublin, Dublin City University, Trinity College and St. James' Hospital.

In 2018, Ireland developed an industry-driven nationwide Postgraduate master's programme in AI; currently there are four nationwide postgraduate degree programs in AI.[255] With the objective of training more than 120 PhDs, Ireland has established a national Centre for Research Training in AI with funding of over EUR 14 million from Science Foundation Ireland (SFI) and an additional EUR 3.3 million from industry and the academic partners. SFI, the national foundation for investment in research in STEM[260] topics, supports the development of AI for the improvement of human health and mainly funds AI research in the fields of Computer Science[261].

In 2017, SFI announced plans to invest EUR 87 million in five new SFI Research Centres in Ireland over the next six years[262]. Among other research areas, they will address diagnosis, monitoring and treatment of chronic and rare neurological diseases. One of the projects that FutureNeuro, an SFI Research Centre for Chronic and Rare Neurological Diseases, is working on is a Blockchain & AI-Enabled Stratified Trial System (BESTS) project. This solution aims to leverage the power of multi-omics big data[263] to connect a patient to clinical trials and other research projects by means of Blockchain and AI-technology.

256 See survey results.

257 See survey results.

258 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

259 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

260 science, technology, engineering and mathematics

261 Science Foundation Ireland, Artificial Intelligence (AI) Research in Ireland. Retrieved from: https://www.sfi.ie/research-news/stories/ai/ (accessed in December 2020)

262 OECD, SFI Research Centres and Spokes Programme, November 2020. Retrieved from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-3191 (accessed in December 2020)

263 Multi-omics is a biological analysis approach in which the data sets are multiple "omes", such as the genome, proteome, transcriptome, etc.

Ireland's outstanding position with respect to patents applied (3rd rank among the EU-27) is made up of patents for various purposes. Notable patents include, machine learning concepts for detecting healthcare fraud risk, medical recommendation platforms, as well as methods and systems for health monitoring and disease detection. Research activities focus around preventive medicine using IoT and AI.

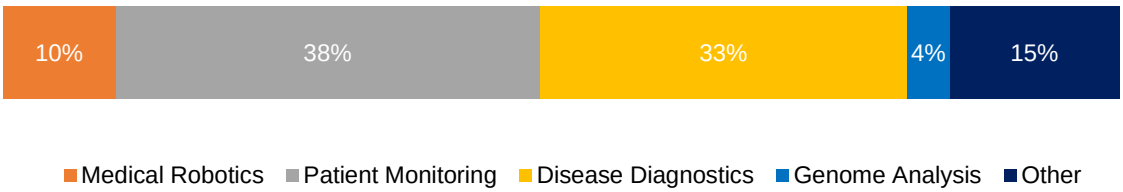



Figure 51: Areas of application in scientific papers

Researchers from Ireland mainly contribute to the fields of patient monitoring and diagnostics, and valuable contributions result in scientific publications around health monitoring systems for smart-homes, decision support for clinical interpretation, design of Ambient and Active Assisted Living systems or the evaluation of the efficiency of machine learning. Overall, there appears to be clear interest in emerging AI technologies for clinical and private use.

## Cross-border collaboration in research

**6.5**
**Multilateral score**[264]

**10**
**EU Collaborating countries**[265]

Ireland has a moderate volume of cross-border collaboration in research, ranking 15th among the EU-27. In particular, Ireland has published papers with researchers from Germany, France, Spain, the Netherlands and Italy.

There is extensive research conducted at the University College Cork (UCC) within the School of Computer Science and Information Technology. UCC is heavily involved in the research of AI, Data Analytics and Algorithmics, and contributes to national research projects under broader themes like machine learning or decision support.[266]
The University College Dublin (UCD) is likewise highly involved, particularly through means of research conducted on AI, machine learning and data analytics in healthcare at the UCD's dedicated "CeADAR, a national centre for applied AI". It is a market-focused technology centre for innovation and research in these fields.[267]

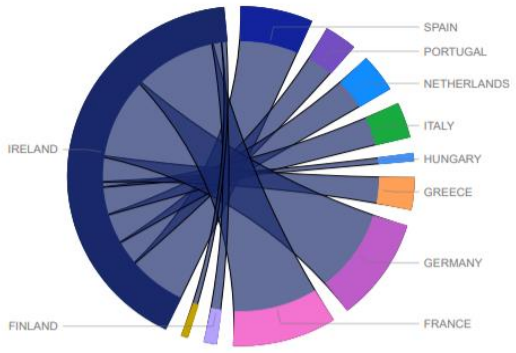
264 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

265 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

266 University College Cork, Ireland, Artificial Intelligence, Data Analytics, & Algorithmics. Retrieved from: https://www.ucc.ie/en/compsci/research/aitheme/ (accessed in December 2020)

267 University College Dublin School of Computer Science, CeADAR: National Centre for Applied AI, Retrieved from: https://www.ucd.ie/cs/researchcentres/ceadar-centreforappliedataanalytics/ (accessed in December 2020)

A considerable share of scientific papers in this area is also published by healthcare institutions mainly by the Sacred Heart Hospital and the Beaumont Hospital.


| Top 5 EU Collaborating Countries | Bilateral Score |
|---|---|
| Germany | 5.7 |
| France | 5.6 |
| Spain | 3.9 |
| Netherlands | 2.1 |
| Italy | 1.9 |

Figure 52: Volume of cross-border collaboration in research

## 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Local Enterprise Offices (LEO) are the initial points of information and support for entrepreneurs within the Irish start-up ecosystem. The governmental organisation "Enterprise Ireland" offers a comprehensive range of support to high-potential startups[268]. This support includes financing, practical help to enter overseas markets, tax incentives, mentoring and networking. The level of support is related to a project's potential. The organisation is the largest seed capital investor in Ireland, with over 1300 investments in its client company portfolio.

Moreover, the National Digital Research Centre, a publicly funded early investor in digital technology start-ups, offers advice and a modest amount of capital by acting as an accelerator[269]. Startup Ireland is a company which is also a valuable member of this ecosystem and provides its expertise through the visa and company support programme to international entrepreneurs wishing to relocate and develop their start-up ideas in Ireland[270].

There are at least six startups in Ireland whose work is focused mainly on AI-enabled tools in the healthcare sector. The field of application of AI in healthcare varies a lot among start-ups. Machine learning methods are used for different identification purposes such as new uses for molecules or AI technology is combined with peptidomics[271] to discover bioactive peptides, amongst others, in order to look for extraordinary health benefits.

268 Dublin's official Site for News, Information and Events, Startup Ecosystem. Retrieved from: https://dublin.ie/invest/starting-a-business/startup-ecosystem/ (accessed in December 2020)

269 OECD, The National Digital Research Centre, March 2020. Retrieved from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24179

270 Startup Ireland. Retrieved from: https://www.startupireland.ie/ (accessed in December 2020)

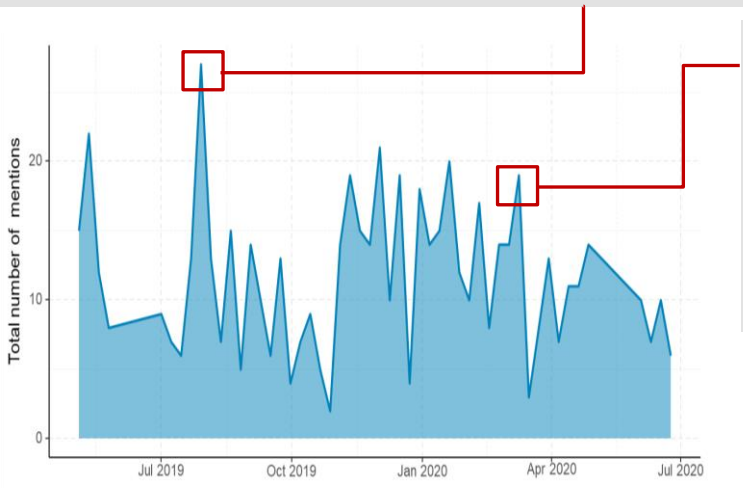
271 Peptidomics is an emerging field that targets endogenously produced protein fragments.

# 4. Awareness and use of AI technologies and applications in healthcare

Irish news sources mentioned the intersection of AI and Health 616 times between June 2019 and July 2020. Google's breakthrough in their AI-driven DeepMind platform that is able to detect kidney injuries significantly earlier than doctors, was one of the dominating topics of the 27-mention spike in the summer of 2019. The use of Chatbot technology to diagnose patients based on their responses to a series of questions attracted additional attention from national news source.

Towards the end of 2019, Ireland experienced a subtle second peak in news mentions, reaching 21 mentions. They were about the announcement from a government minister regarding a sizeable increase in investments towards an innovative technology fund. The fund includes investments into several AI technology projects aimed at healthcare. The period also made reference to telehealth providers using AR and VR technologies to provide continuous, remote monitoring of vital patient data.

**July/ August 2019:** News outlets brought awareness towards **Google's AI DeepMind** breakthrough in kidney injury detection, able to identify injuries 48 hours in advance of doctors. Other mentions related to the general disruptions AI causes in healthcare systems, while **Chatbot technology** received attention from different media sources with **Babylon health** leveraging on AI technology to diagnose patients based on their responses to certain questions.




**December 2019:** News sources reported on the announcement from Minister Humphreys regarding **€ 65 Million investments** in 16 projects under the **Disruptive Technology Innovation Fund,** which included many health themed AI projects.

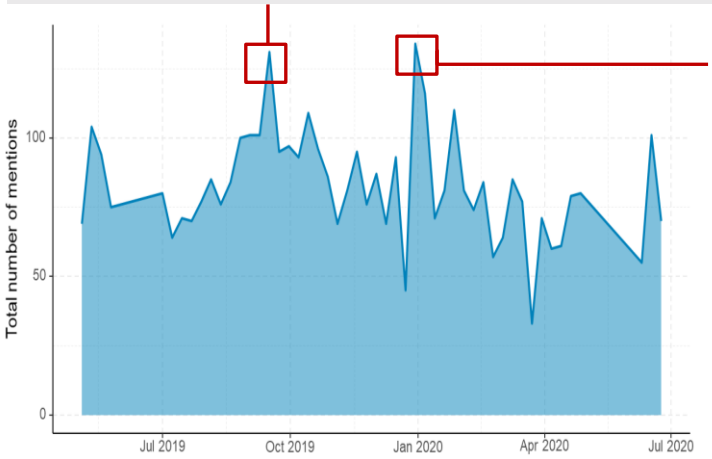
Telehealth providers also received media attention with **XRHealth** using AR and VR technologies to provide a medical platform for doctors to continuously monitor vital data for better informed health decisions.

Figure 53: Trend of total mentions in the news

Social media has clearly been the main catalyst to raise awareness of AI's intervention in health in Ireland. Reaching 4,300 mentions in the 13-month period, the country demonstrates extremely strong activity especially considering the size of the nation.

There was consistently a high number of mentions a day, however the social media platform still experienced two peaks, one in September and the end of December2019/start of January 2020, accumulating 127 and 132 mentions respectively. The first coincided with the Digital Summit Dublin, which included discussions around the intersection of AI and health, and therefore was the subject to a plethora of tweets and retweets applauding the insights provided and highlighting the next steps. The sharp rise in mentions occurring during the transition into 2020, was predominantly caused by Google Health's AI system able to identify cancers from mammograms with great accuracy.

**September 2019:** The majority of twitter activity surrounded the **Digital Summit Dublin**, where healthcare & AI was a key area discussed. The conference received many plaudits on twitter for its insights on the future of healthcare sector in light of AIs intervention. Other social media mentions related to different breakthroughs in AI technology, including the use of **deep learning to diagnose diabetic retinopathy**. Additionally, industry specialist gave a talk on using AI to monitor the **brain health of newborn infants** which was the subject of many retweets on twitter. Concerns over data protection were expressed after Google's intervention in an AI for healthcare-oriented startup in UK.




**December 2019/ January 2020:** National news source, RTE News, tweeted on AI system developed by **Google Health able to identify cancer** in mammograms with greater degree of accuracy than radiologist. **Genomics** was the topic of much of the twitter activity, with questions asked on how much innate knowledge the genome can encode.

Figure 54: Trend of total mentions in social media

# ITALY

**60.2 Mio**[272]
**Total population**

**43.6**[273]
**DESI 2020** Index

**74%**
% of **internet users**

**13.5%**[274]
**Population as a % of** EU27

**24**
**DESI 2020 ranking amongst** EU27

**42%**
% of population with at **least basic digital skills**

**77%**
% of **Open Data**

## 1. Relevant legislation and policy framework

In the context of the European Digital Agenda, Italy has developed its national strategy focussing on addressing the digital transformation of public administration.[275] The three-year plan for information technology in the public administration was approved in 2017 and contained operational indications for the development of digital ecosystems or policy areas in health.[276]

A dedicated task force on AI of the Agency for Digital Italy has released a strategic report on AI in March 2018. This white paper[277] acknowledges the relevance of AI to reduce social inequalities in health and disability and stresses the positive impact on health and well-being. Following the task force's work, Italy's Ministry of Economic Development (MISE) published the first draft of the National Strategy on AI in 2019[278]. It was drafted by a group of 30 experts in the field of AI. MISE considers the definition of an "AI National Strategy" a crucial priority for Italy, especially after the outbreak of Covid-19 and the subsequent crisis. Healthcare has been identified as one of the key priority areas for focus around AI.

An initiative of the MISE is the Blockchain, AI and Internet of Things fund[279], which aims to finance experimentation and testing activities of the respective emerging technologies. The objective of this fund is to foster companies that deal with emerging technologies and which adapt to the digital transformation.

Along 82 recommendations to build the foundations for Italy, including recommendations around policy and legislation, it is worth noting that a large proportion of the budget dedicated to the promotion of AI has been funnelled towards supporting 1,600 projects among PhDs, researchers and professors. The Italian government will reinforce the available public funding

272 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

273 Digital Economy and Society Index 2020, Country Report: Italy, Shaping Europe's digital future. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/italy (accessed in December 2020)

274 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

275 Task Force on Artificial Intelligence of the Agency for Digital Italy ai.italia.it, Whitepaper on Artificial Intelligence at the service of citizens, March 2018, p.6

276 Examples are diagnostic tools to assist in the analysis of reports, data merging, epidemiological analysis to identify public health risks early, precision medicine, Task Force on Artificial Intelligence of the Agency for Digital Italy ai.italia.it, Whitepaper on Artificial Intelligence at the service of citizens, March 2018, p.40

277 Examples are diagnostic tools to assist in the analysis of reports, data merging, epidemiological analysis to identify public health risks early, precision medicine, Task Force on Artificial Intelligence of the Agency for Digital Italy ai.italia.it, Whitepaper on Artificial Intelligence at the service of citizens, March 2018, pp.48-61

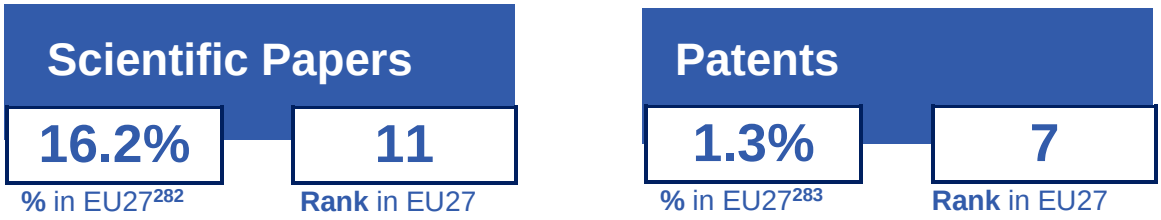
278 Italy's Ministry of Economic Development, National Strategy for Artificial Intelligence, July 2019, pp.4-7

279 OECD, Blockchain, AI and Internet of Things Fund. Received from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-23975 (accessed in December 2020)

and will encourage public-private venture capital support of national centres of excellence such as the Laboratory for AI and Learning Systems[280].
To strengthen the implementation of AI-related initiatives in Italy, founders of AI start-ups operating in the healthcare sector indicated in the survey that they would like to see the following areas of legislation/policy in place:[281]

- Policies around the ethical use of AI;
- Policies aimed at the encouraging the deployment of AI technologies in healthcare;
- Policies aimed at supporting research and innovation in the area of AI in healthcare.

## 2. Research and innovation around AI technologies and applications in healthcare




Italy shows very significant research output in scientific papers published around AI in healthcare. The country ranks as the number one contributing country among the EU-27 (if considering the share of authorship on most relevant papers published).

Areas of application investigated in scientific papers are mostly linked to disease diagnostics, ranging from medical diagnosis with AI technologies and disease assessment and detection, to data driven approaches for predictive medicine and clinical record management. A further focus lies on patient monitoring with publications around the efficiency of machine learning approaches for neuromonitoring systems, intelligent systems for treatment assistance, real-time and behavioural monitoring for home-based therapies, or reviews of assisting systems for patients and platforms for the self-management of chronic conditions.

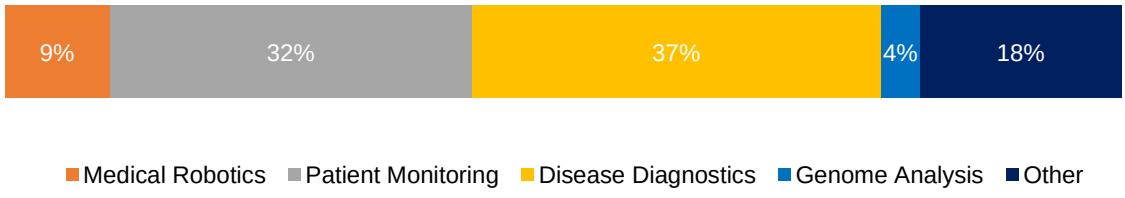



Figure 55: Areas of application in scientific papers

A considerable number of publications are produced by the Institute for High Performance Computing and Networking departments at the National Research Council (CNR). It is worth

280 CINI – National Interuniversity Consortium for Informatics, Laboratory of Artificial Intelligence and Intelligent System. Received from: https://www.consorzio-cini.it/index.php/en/labaiis-home (accessed in December 2020)

281 See survey results.

282 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

283 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

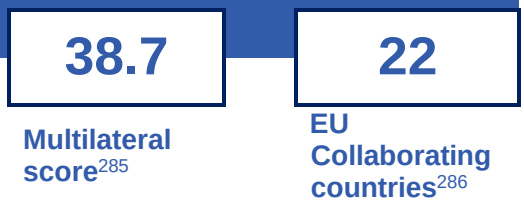
noting that the CNR worked on proposals for the Italian strategy for AI and is considered one of the most important national excellence centres. The CNR regularly proposes research projects in digital health and care to facilitate collaboration between EU Member States.

Other faculties that have issued papers on topics around AI for health are comprised of Engineering and Information Technology departments, such as at the University of Naples "Parthenope" or the University of Naples "Federico II".

Research is also being done in the field of Covid-19: The consortium Cineca[284], which is composed of 92 universities and public institutions, uses the supercomputer Marconi in the frame of the project "Excscalate4CoV". The objective is to identify the safest and most promising drugs for the immediate treatment of the COVID-19 infected population, followed by the identification of molecules capable of inhibiting pathogenesis of COVID-19 to counteract future contagions.

Italy also ranks high in patents. It is 7th among EU Member States. From 2017 to 2020, the country has applied for patents in the fields of monitoring systems, medical imaging of skin lesions or scalable biometric alarm systems for pattern recognition, thus promoting innovation in patient monitoring and disease diagnostics. Additionally, funding schemes have been dedicated to experimentation and testing AI activities.

## Cross-border collaboration in research

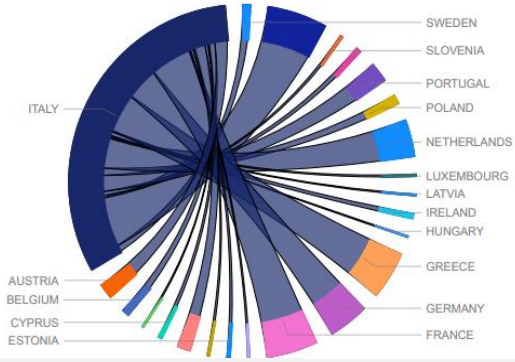



Italy ranks 2nd in cross-border collaboration for scientific publications. We identified at least 22 EU Member States with which Italian researchers collaborated in the area of AI in healthcare. Some of the most frequent collaborators are Spain, France, Greece, Germany and the Netherlands.

284 Cf. Cineca website. Retrieved online: https://www.cineca.it/en (accessed in December 2020).

285 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

286 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.


| Top 5 EU Collaborating Countries | Bilateral Score[287] |
|---|---|
| Spain | 22.7 |
| France | 19.3 |
| Greece | 17.9 |
| Germany | 15.2 |
| Netherlands | 13.8 |

Figure 56: Volume of cross-border collaboration in research

# 3. Start-up and ecosystem relevant to AI technologies and applications in healthcare

Italy hosts a strong start-up network around the area of AI in healthcare with innovative companies working on a range of applications including genome analysis, wearable sensors for home and hospital monitoring and brain monitoring applications.

At least 12 start-ups working on AI in healthcare have been identified as having their headquarters in Italy. Most start-ups are spin-offs from large research universities and are supported by dedicated schemes for start-ups, such as the Italian Startup Act[288]. This is a comprehensive legislative framework aimed at facilitating the creation and the growth of new hi-tech companies in Italy. The close collaboration with research entities for the translation of AI-related research into healthcare applications was likewise reflected in start-ups' responses to the survey conducted as part of this study.

Thanks to the Italian Start-up Act developed by the Ministry of Economic Development, once a start-up qualifies as such, it has access to a range of benefits including tax exemptions and access to financing.

According to the survey, start-ups use either data from their own collection via clinical trials or from hospital EHR systems. The type of collected data was not always specified, but amongst other, vital sign data (biosigns)[289] was indicated. The funding mechanisms of the start-ups are either public funds via national sources or private funds. Public funds invested into the start-

287 Bilateral collaboration score (BCS), based on the Nature Index, is calculated bilaterally between any two countries co-authoring at least one article. It is derived by summing the fractional contributions from articles with authors from both countries. The bilateral collaboration score between two countries is the sum of each of their fractional contributions on the papers to which both have contributed.

288 Italy's Ministry of Economic Development, The Italian Startup Act – Italy's national strategy to support innovative startups and innovative SMEs, July 2019, p.3-4

289 Data recorded from the devices used to monitor a patient's vital signs

up ecosystem adds up to below EUR 100,000, whereas private funds investment ranges from EUR 100,000 to EUR 500,000.
Amongst the surveyed start-ups, there is wide-ranging agreement on the following barriers related to the implementation and utilisation of AI systems by health professionals in health sector:

- Lack of financial resources;
- Lack of understanding of the technology;
- Lack of IT knowledge and competencies.

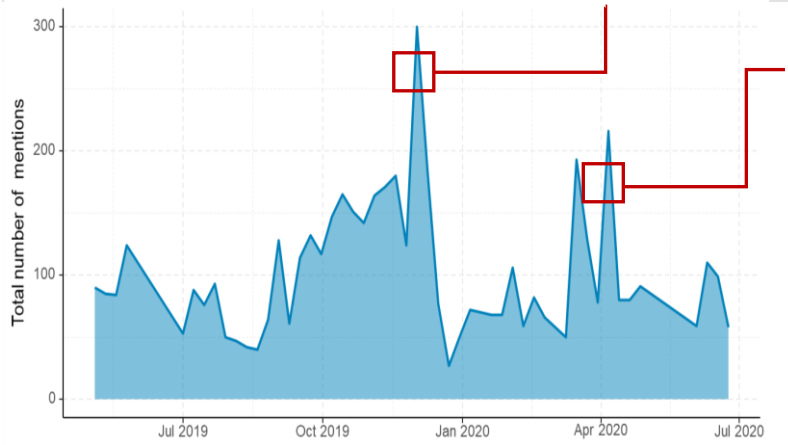
# 4. Awareness and use of AI technologies and applications in healthcare

Despite a moderate percentage of the population with at least basic digital skills (42%)[290], Italy displays relatively strong awareness throughout online news sources. This correlates with Italy's dominant position in the EU with regards to scientific publications. Between June 2019 and July 2020 news mentions totalled 5,500. At the start of 2020, most of the mentions were in the context of the spread of the coronavirus in Europe.

A noticeable peak occurred in late 2019 when particular attention was paid at the Italian leading research institute's (Foundation Bruno Kessler) research agenda with a focus on the impact of AI in healthcare. Trending topics refer to progress in AI technologies, such as for disease prevention and diagnosis. A second peak in April 2020 (223 results) consists of news that underline the positive impact of AI on the diagnosis time of the coronavirus and their potential to predict and consequently limit the spread of the pandemic.

**December 2019: Foundation Bruno Kessler** (FBK), the leading research institute in Italy, announces **AI and health being a priority field for 2020**, to explore predictive medicine amongst other topics.

News outlets in Italy strongly report on the application of varying breakthroughs in AI and machine learning technology. These include developments in AI algorithms used in pathology, which are able to **diagnose patients from changes in their voices**. Other mentions surround progress in machine learning for the purpose of **predicting and detecting heart disease**.




**April 2020:** This peak was dominated by news sources reporting on different applications of AI to be implemented in the battle against Covid-19. The use of AI technologies to scan the lung CT has **reduced the diagnosis time of the virus to 20 seconds**. Additional mentions included the use of AI for the medical research towards Covid-19, while **big data can be used to predict the spread of the pandemic.**

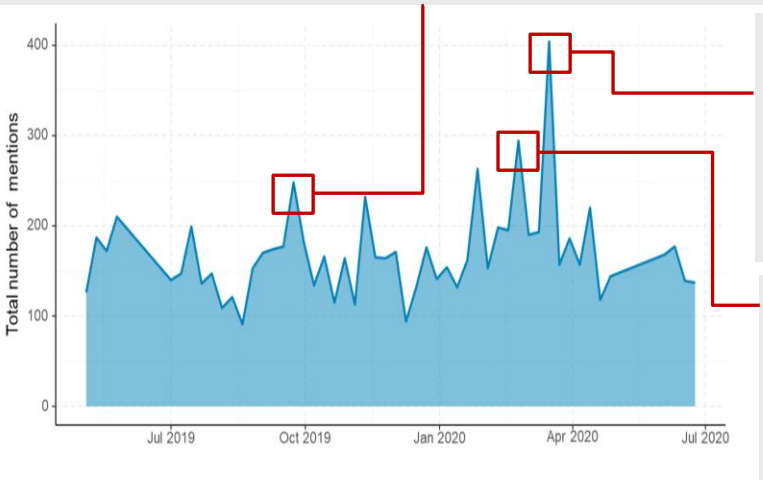
Figure 57: Trend of total mentions in the news

290 Digital Economy and Society Index 2020, Country Report: Italy, Shaping Europe's digital future. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/italy (accessed in December 2020)

Italy further demonstrates a constantly high number of mentions in social media over the same period, reaching a total of 8,500. Social media users in Italy bring the disruptive potential of AI technologies, 5G and blockchain forward.

Similar to results from the news, Tweets related to Covid-19 and the role of AI. Users' attention was drawn to the potential to speed up diagnosis and fight against the spread of the virus. Italian users highlight the relevance of health-tech start-ups in this field. This appears to be a characteristic for big and digitally advanced Member States.

**September 2019:** According to twitter influencers **AI is rivalling human expert regarding the accuracy of medical diagnoses**, with higher success rates both in detecting disease and giving "all-clears". Mentions regarding the use of **blockchain for healthcare** to bring transparency and flexibility to the flow. Other popular twitter users highlighted the ways **AI and 5G will disrupt the current healthcare** system and the directions it is trending in.




**March 2020:** Majority of social media activity, in this peak, related to the Covid-19. Influencers tweeted that China's huge investment in **AI better prepared them in the battle against the virus**. Additionally, a tweet stating that the polyclinic **Campus Bio-Medico of Rome** was the first hospital in Europe to acquire the AI system which diagnoses Covid-19 patients in 20 seconds, went viral with many retweets.

**February/March 2020:** This peak includes tweets regarding the use of **AI for pinpointing disease-linked genes**. Moreover, the use of AI for diagnosis, especially in light of Covid-19, was another popular theme on social media. Other tweets presented benefits **and warning flags** of AI's immediate intervention in healthcare with mentions of **startups as key catalysts in the transformation**.

Figure 58: Trend of total mentions in social media

**1.9 Mio**[291]
**Total population**

**50.7**[292]
**DESI 2020** Index

**84%**
% of **internet users**

**0.4%**[293]
**Population as a % of** EU27

**17**
**DESI 2020 ranking amongst** EU27

**43%**
% of population with at **least basic digital skills**

**75%**
% of **Open Data**

# LATVIA

## 1. Relevant legislation and policy framework

Based on the State Secretaries' meeting in July 2019 that was followed by the Latvian AI informative report,[294] the government issued its national "AI strategy on Developing Artificial Intelligence Solutions"[295] in February 2020. The strategy is based on the original report from 2019 that identified potential uses of AI in healthcare, for example early warning signs of epidemics, detection of drug misuse, drug price monitoring, cost control, diagnosis and preparation of treatment plans, amongst others.

The Latvian AI strategy includes the following objectives:[296]

- Raising awareness of and competences in AI;
- Promoting the adoption and development of AI in the public and private sector and engaging in cross-border collaborations;
- Developing a legal and ethical framework for AI;
- Investing in digital and telecommunications infrastructure to support AI developments.

The strategy further highlights investment projections that are in line with the recommendations of the Coordinated Plan: These estimations amount to a total investment (public and private sectors combined) of EUR 74 million per year.[297]

The Latvian government is also preparing "Digital Transformation Guidelines" to be ready by the second quarter of 2021, which will include policy measures to be implemented to assist the digital transformation. AI is mentioned as an asset to improve the healthcare information system and the government will make financing and support programmes available for research and development projects in AI.[294]

291 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

292 Digital Economy and Society Index 2020, Country Report: Latvia. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/latvia

293 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

294 Cf. Latvijas Republikas Ministru kabineta : "Par mākslīgā intelekta risinājumu attīstību", 2019. Received from: http://tap.mk.gov.lv/lv/mk/tap/?pid=40475479

295 Cf. Latvijas Republikas Ministru kabineta: „Informatīvais ziņojums "Par mākslīgā intelekta risinājumu attīstību", 2019.

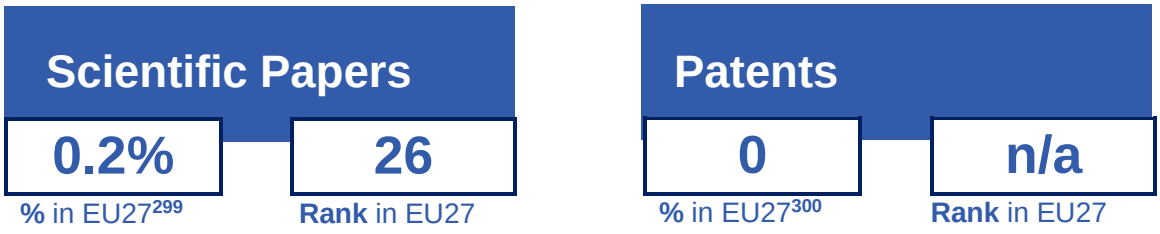
296 Cf. OECD.AI Observatory: "Latvia's National AI Strategy", 2020. Received from: https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-26933

297 Cf. Latvijas Republikas Ministru kabineta: "Tiesību aktu projekti", 2019. Received from: http://tap.mk.gov.lv/lv/mk/tap/?pid=40475479

In the meantime, different uses of AI are being explored in order to improve citizens' quality of life and health services. Public administrations are looking into a tool to create a virtual assistant platform.

Another AI project that is underway is the advancement of Emergency Medical Service (EMS) processes for workload planning and task distribution, information systems control, collection of user feedback. Machine learning technologies can vastly improve the staff's workload planning and task distribution, control of information input accuracy in information systems and the collection of customer feedback. The report furthermore stresses the relevance of standardised safety labels for AI solutions. Currently, according to results from the survey, there is no specific legislation in place to support AI innovation and implementation, with the exception of storing and sharing healthcare data at the regional level.[298]

## 2. Research and innovation around AI technologies and applications in healthcare




Latvia shows very limited scientific contribution in the area of AI in healthcare with a share of 0.2% of scientific papers, thus ranking 26th amongst the EU-27 countries. Nevertheless, Latvia's performance in the European Innovation Scoreboard 2020 belongs to the group of countries that have shown the greatest increases in performance.[301]

The Riga Technical University and University of Latvia are among the institutions which contribute most to the scientific output. As highlighted in the Latvian AI strategy, several universities and research centres are conducting research in the field of AI; the Riga Technical university is a dedicated entity to carry out research in autonomous systems and robots or rather smart sensor systems.[295]

In general, Latvia's ongoing research projects in the field of AI are supported by the European Regional Development Fund and Horizon 2020 programme[302].

Researchers from Latvia show interest in the use of AI for disease diagnostic purposes, such as Artificial Neural Network based approaches and neural network design[303].

298 See survey results.

299 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

300 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

301 European Commission: "Internal Market, Industry, Entrepreneurship and SMEs. European Innovation Scoreboard.", 2020. Received from: https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en

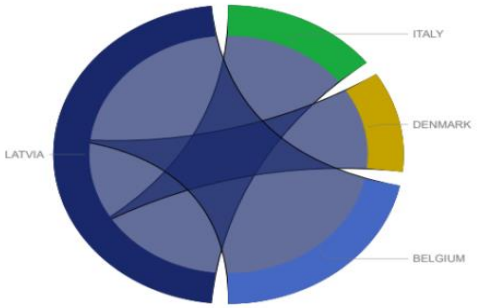
302 Cf. OECD.AI Observatory: "Latvia's National AI Strategy", 2020. Received from: https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-26933

303 Artificial Neural networks or neural networks are computational algorithms. They are intended to mimic the behavior of biological systems composed of "neurons".

## Cross-border collaboration in research

| 0.8 | 3 |
|---|---|
| Multilateral score[304] | EU Collaborating countries[305] |

We identified a number of cross-border collaborations with other EU Member States. The Riga Technical University collaborates with Belgium (e.g. KU Leuven). Other outputs result from collaboration between the Institute of Electronics and Computer Science in Latvia and Denmark (i.e. the Technical University) as well as Italy (i.e. INFN-Laboratori Nazionali di Frascati).


| Top Collaborating EU Countries | Bilateral Score |
|---|---|
| Belgium | 1 |
| Italy | 0.7 |
| Denmark | 0.5 |

Figure 59: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Latvian government is providing support to start-ups at any stage through Magnetic Latvia Startup (StartupLatvia). Moreover, to support Latvia-based early-stage start-ups, in 2017, a EUR 15 million acceleration fund was available through ALTUM ("State Development Bank")[306]. The plan is to provide more funds to start-ups for their growth stage, once the acceleration funds are absorbed, so they can scale up and go global.

Overall, the Latvian start-up infrastructure consists of more than 400 start-ups, a pool of investors, business angels, modern co-working spaces and various business incubators[307].

304 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

305 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

306 Elena Dimoska: "Latvia's start-up system at a glance", 2020. Received from: https://www.eu-startups.com/2020/07/latvias-startup-ecosystem-at-a-glance/

307 Investment and Development Agency of Latvia: "Start-up Ecosystem", 2020. Received from: https://www.liaa.gov.lv/en/invest-latvia/start- ecosystem

However, we identified only one start-up in Latvia in the field of AI for healthcare. Their work is mainly focused on digital assistance for people taking care of relatives with dementia.

According to responses from start-ups that participated in the survey of this study, the main impediment to the adoption of AI technologies in the health sector is funding, especially for innovative solutions in the private sector. Other concerns include a shortage of skilled workers with an expertise in AI and resource capacity, a long certification process, and an inflexible legal framework that hinders innovation.[308]

# 4. Start-up ecosystem relevant to AI technologies and applications in healthcare

Considering the perception of AI technologies and the level of trust in them, users in Latvia show a generally positive attitude. There is solid trust in medical robots, disease diagnostics, patient monitoring, genome analysis in combination with expert judgement for each respective application area.[308]

Similar to its Baltic neighbour Estonia, Latvian news sources were not yet able to raise awareness to their viewership surrounding the disruptive force of AI in the healthcare sector. With a mere 18 mentions between June 2019 and July 2020[309], the AI technology was reported on in the context of the Baltic assembly, at which the general field of AI was discussed and how cooperation between selected member states would be needed, for its appropriate enhancement.

Negligible awareness around the topic through news sources. Only noteworthy mention was of the Baltic assembly, where AI was discussed as area where cooperation between the Baltic countries is needed to further enhance the field.

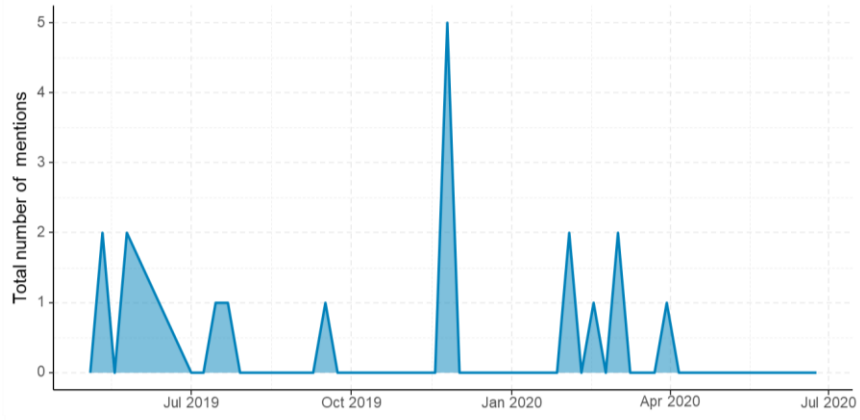



Figure 60: Trend of total mentions in the news

Latvia displayed a much-improved performance regarding social media, producing 103 mentions throughout the 13-month period, providing Latvian citizens with over five times more visibility surrounding AI than traditional news sources.

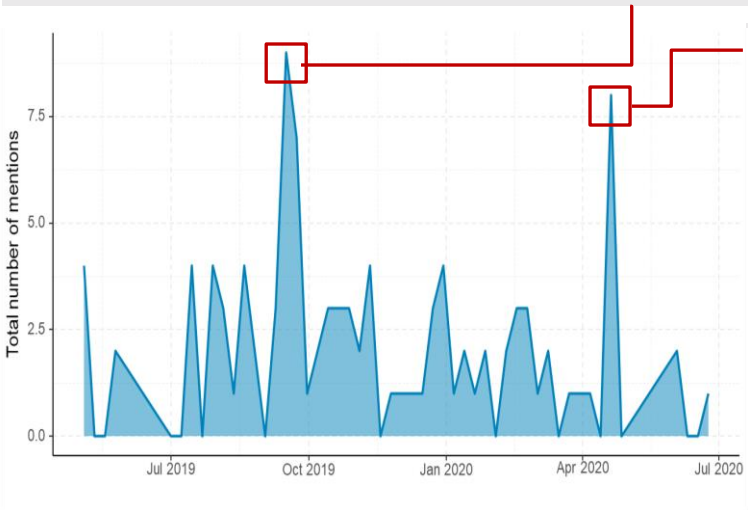
Social media activity noticeably peaked at two points, namely September 2019 and April 2020 (see below graph). The first spike in mentions consisted of influencers elaborating on the implementation of AI in practice, explaining that it would help doctors make more informed

308 See survey results.

309 June 2019 – July 2020

medical decisions rather than replace them. At the same time a health-tech conference also received attention from tweets. Towards the end of the period, awareness peaked again with an anti-AI tweet by a popular user, suggesting that AI will be used as a tool for the powerful to dictate the masses. Covid-19 related posts were also present during the period.

**September 2019:** Influencers enlightened platform user that AI would not replace doctors but rather provide new metrics that can help doctors identify diseases at earlier stages. Other activity related to **NB8UK Health-Tech Innovation Leadership Exchange Conference**, where Latvia were one of 9 countries involved.




**April 2020: Extreme anti-AI sentiment was expressed by a popular user,** claiming that AI is being used in health, among other industries, to dictate the lives of the masses. Remainder of the posts related to machine learning model showing how relaxing lockdown restrictions would lead to spikes in Covid-19 cases and the potential use and benefits of AI-powered neurobots in the public health system.

Figure 61: Trend of total mentions in social media

# LITHUANIA

**2.8 Mio**[310]
**Total population**

**53.9**[311]
**DESI 2020** Index

**81%**
% of **internet users**

**0.6%**[312]
**Population as a % of** EU27

**13**
**DESI 2020 ranking amongst** EU27

**56%**
% of population with at **least basic digital skills**

**53%**
% of **Open Data**

## 1. Relevant legislation and policy framework

The Ministry of Economy and Innovation of Lithuania published the 'Lithuanian Artificial Intelligence Strategy: a vision for the future'[313] in 2019. This strategy emphasises healthcare as a key economic sector which is important to Lithuania's economy and where AI can have a significant impact. The sector has recently adopted a national Electronic Health Record system, which has helped modernizing the healthcare system in Lithuania.

Moreover, an aging population ensures care providers have a growing number of patients assigned to them, causing an increase in the amount of paperwork they need to do and a decrease in the amount of time they can spend with their patient. Hence, AI systems can be used to optimize visits and shorten the time needed to spend on documentation, allowing providers to have more face-to-face time with their patients. Both the adoption of currently available AI systems into healthcare processes and the creation of new ones should be promoted if Lithuania seeks to improve the wellbeing of its citizens. [4]

When it comes to further regulation of AI, the government intends to establish the AI Ethics Committee to develop a proposal for AI ethical and legal regulatory framework based on best practices as well as existing regulations at European level. The focus of new rules and regulations should be on explicability, transparency, fairness, trust, verifiability, safety and security against attacks, which is currently an ethical and legal vacuum.[4] Indeed, even definition of the main AI concepts is still an issue due to lack of appropriate equivalent in Lithuanian language.[314]

The AI start-ups working in the area of healthcare that were surveyed during this study identified the following additional areas of legislation/policy with regards to the development and usage of AI-enabled healthcare tools they would like to see in place:

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Policies around algorithmic transparency;
- Safety and liability rules applicable to AI systems;
- Policies around AI testing and certification in healthcare sector;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Policies aimed at the encouraging the deployment of AI technologies in healthcare.

310 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

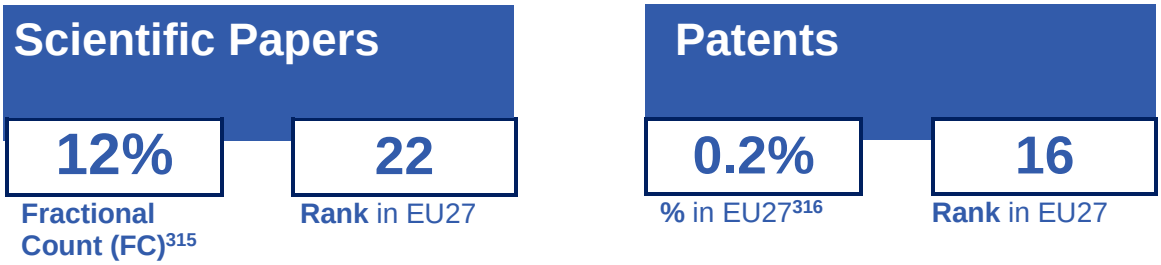
311 Digital Economy and Society Index 2020, Country Report: Lithuania https://ec.europa.eu/digital-single-market/en/scoreboard/lithuania

312 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

313 Ekonomikos Ir Inovaciju Ministerija: Kurk Lietuvai: "Lithuanian Artificial Intelligence Strategy. A Vision of the Future".

314 Dr. Neringa Gaubienė, comment on "Lithuanian Artificial Intelligence Strategy: is Artificial Intelligence understood correctly?", Vilnius University, 2019

# 2. Research and innovation around AI technologies and applications in healthcare




Lithuania has very limited research output in terms of scientific papers and patents in the area of AI in healthcare. It ranks 22nd for scientific papers and 16th for patents amongst EU countries.

Most publications are in the area of process and quality optimization in healthcare and they are outputs from the computer science and engineering departments of major local universities, such as Vilnius University, Kaunas University of Technology and Vytautas Magnus University. There are no bachelor, master or doctorate study programmes specialised in AI and there are no healthcare institutions active in the area of AI research in healthcare[317]. Another challenge resulting in limited research output is the lack of the sophisticated hardware needed for students and scientists to conduct research in AI and insufficient funding[318].

AI academic research projects are mainly funded by the Ministry of Education and Science in Lithuania, but in addition, there are scientific grants for Lithuanian researchers targeting AI research and development. For example, the SMART program managed by the Research Council of Lithuania[319] supports 'Targeted Research in Smart Specialisation Areas', including AI in healthcare, and provides financial support covering the whole spectrum of research implementation, including patent applications and technology transfer activities.

315 Fractional Count (FC), based on the Nature Index, assigns a fractional contribution of each paper to each country based on the ratio of authors from that country compared to the total number of authors. The total FC for a county is calculated by summing the relative contributions over all papers.

316 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

317 OECD dashboard on Top AI research Institutions in Lithuania, filtered by type of institution.

318 Ekonomikos Ir Inovaciju Ministerija: Kurk Lietuvai: "Lithuanian Artificial Intelligence Strategy. A Vision of the Future"

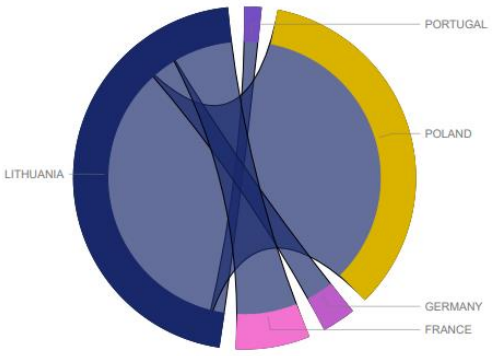
319 The Research Council of Lithuania, R&D Implementation scheme (SMART)

# Cross-border collaboration in research

| 1.5 | 4 |
|---|---|
| Multilateral score[320] | EU Collaborating countries[321] |

Lithuanian Artificial Intelligence Strategy[322] recognises the importance of collaboration and identifies ties with AI experts in Lithuania's diaspora as a priority, then Baltic region, Nordic-Baltic region and only afterwards with other EU countries.

However, when it comes to cross-border collaboration in the area of AI in healthcare, we identified some research activity with the following 4 countries – Poland, France, Germany and Portugal. The volume of collaboration is limited due to overall limited research output in this area in Lithuania.


| Collaborating Countries | Bilateral Score[323] |
|---|---|
| Poland | 3.2 |
| France | 0.6 |
| Germany | 0.3 |
| Portugal | 0.1 |

Figure 62: Volume of cross-border collaboration in research

320 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

321 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

322 Ekonomikos Ir Inovaciju Ministerija: Kurk Lietuvai: "Lithuanian Artificial Intelligence Strategy. A Vision of the Future"

323 Bilateral collaboration score (BCS), based on the Nature Index, is calculated bilaterally between any two countries co-authoring at least one article. It is derived by summing the fractional contributions from articles with authors from both countries. The bilateral collaboration score between two countries is the sum of each of their fractional contributions on the papers to which both have contributed.

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The government of Lithuania is powering 'Startup Lithuania'[324], a national start-up ecosystem facilitator between start-ups, venture capital funds, accelerators, start-up friendly enterprises and the government. This initiative organizes events, publishes start-up ecosystem news, and offers consulting, introducing, networking and education for future entrepreneurs in various areas, including AI in healthcare.

Another key organization of the ecosystem is the Lithuanian Business Angel Network, which was founded in 2018 to further strengthen the local start-up ecosystem and enable new funding opportunities[325]. Moreover, Lithuania has streamlined the entry process for non-EU citizens to enable more talent to come into the country through initiatives such as the talent attraction scheme 'Startup Visa Lithuania'[326].

The ecosystem seems to work, with Vilnius ranking high in recent technical reports in terms[327] of cost-effectiveness and foreign direct investment (FDI) performance for technology start-ups and innovation organisations. However, the Lithuanian Artificial Intelligence Strategy indicates that public sector investment in AI is much more significant than private sector[328] in Lithuania.

There are at least 4 start-ups in Lithuania working on AI technologies and applications in healthcare. According to the survey results of this study, they received mixed private and public funding via national sources or via the European Commission. They all collaborate with other research institutes/ companies/ healthcare delivery centres for the translation of AI-related research into healthcare applications and one of them specifically indicated cross-border collaboration in 3 other countries.

When it comes to the use of data, which is the foundation for AI and ML technologies, all of the start-ups indicated own collection via clinical trials, as well as the use of Open Data from Open databases, however none of them share their own data that they collect such as imaging data, Vital Sign data (biosigns) or unstructured data (e.g., doctor's notes). The Lithuanian government has initiatives like Opendata.gov.lt portal aimed at creating an open data ecosystem, however National Audit Office of Lithuania concluded that uploaded data has limited usability, as data is uploaded in a closed format, and data sets are single purpose and not regularly updated[329].

# 4. Awareness and use of AI technologies and applications in healthcare

With an overall moderate representation of citizens with basic digital skills, Lithuania shows low awareness of the potential, development and use of AI technologies in healthcare. Notably, only 1 out of 4 surveyed start-ups indicated that their technology is actively used by more than 1 healthcare entity.

Following the trend of their Baltic counterparts, Lithuanian media sources had very few news about the developments of AI and other technologies in healthcare sector. With the 13-month period producing 46 total mentions and peaking at only five between February and March. The

324 https://www.startuplithuania.com/about-us/

325 www.litban.lt

326 https://startupvisalithuania.com/

327 https://investinpomerania.pl/wp-content/uploads/2020/06/Tech-Cities-of-the-Future-report.pdf

328 Ekonomikos Ir Inovaciju Ministerija: Kurk Lietuvai: "Lithuanian Artificial Intelligence Strategy. A Vision of the Future", p. 8.

329LR Valstybės Kontrolė, Valstybinio audito ataskaita, "Ar užtikrinamas viešojo sektoriaus turimų duomenų atvėrimas", p. 34.

short increase of mentions consisted exhaustively of news around Toyota's plans to use AI to constantly monitor the health of the population in their newly proposed high-tech cities.

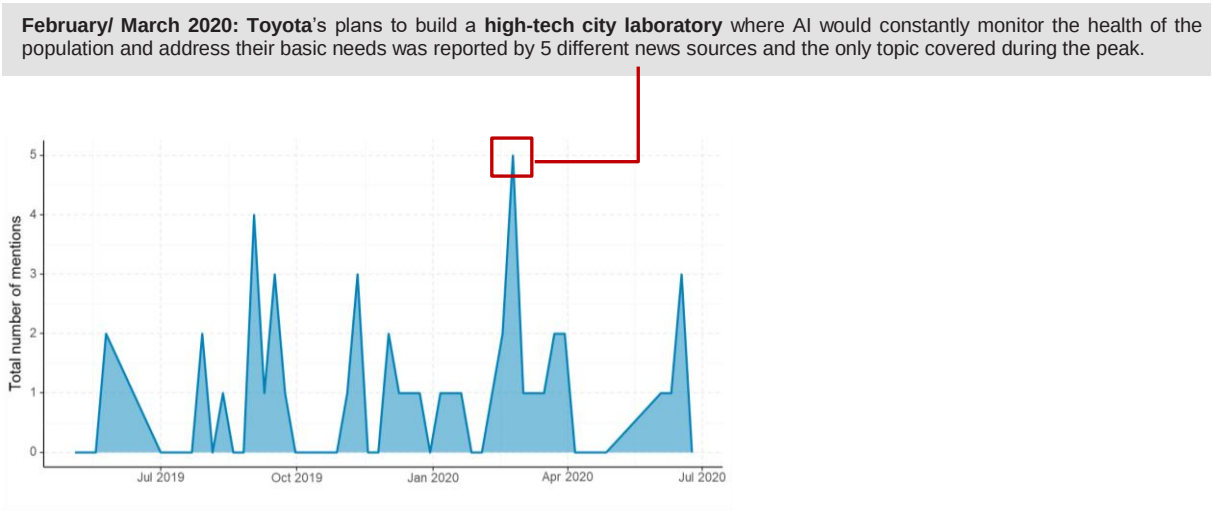



Figure 63: Trend of total mentions in the news

Evidently, the interference of AI and health is much more popular on social media than on news platforms with Lithuanian twitter users mentioning the topic 149 times in total.

Popular tweets of the first peak in July (16 mentions) included insights regarding a local medical imaging company planning to introduce and invest into AI technologies for clinical radiology. The second spike, occurring in quick succession of the first, accumulates 9 results and covers a wide range of relevant news, such as a breakthrough in AI technology enabling the detection of heart failure with extreme accuracy. However, ethical and legal concerns over AI's intervention in medicine were also expressed.

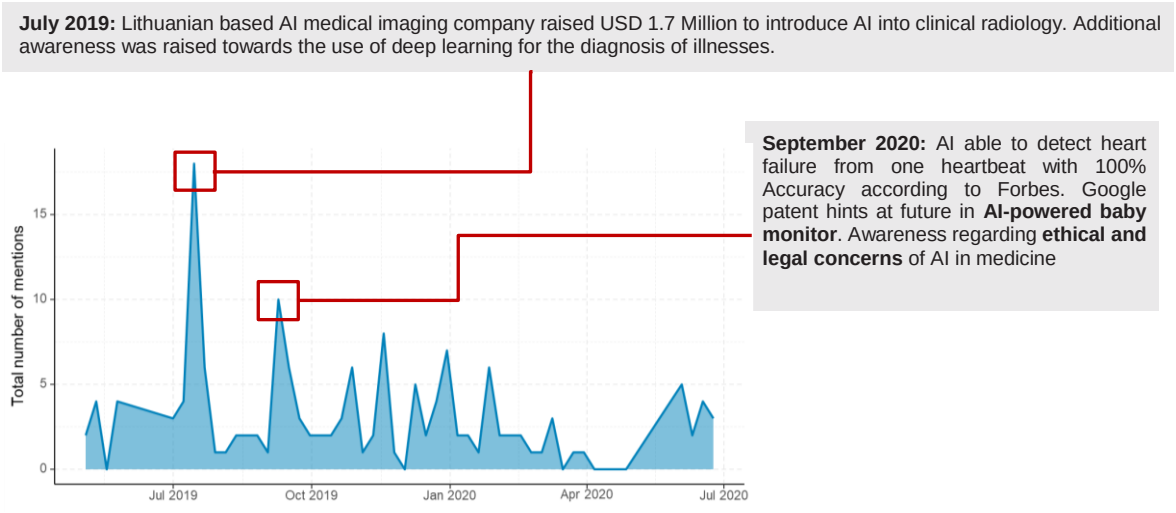



Figure 64: Trend of total mentions in social media

**626,000**[330]
**Total population**

**57.9**[331]
**DESI 2020** Index

**93%**
% of **internet users**

**0.1%**[332]
**Population as a % of** EU27

**10**
**DESI 2020 ranking amongst** EU27

**65%**
% of population with at **least basic digital skills**

**63%**
% of **Open Data**

# LUXEMBOURG

## 1. Relevant legislation and policy framework

In May 2019, the government of Luxembourg published its national AI strategy, entitled "Artificial Intelligence: A Strategic Vision for Luxembourg"[333]. The strategy includes ambitions related to the role of AI in healthcare and foresees progress in the implementation of AI-based solutions, advanced diagnosis and treatment procedures, real-time analysis and quality care.[334] The Ministry of the Economy is therefore setting out a series of actions aimed at supporting new data-driven business models across priority economic sectors such as health technologies innovation.

With close proximity to some of the most advanced AI research centers in France (e.g. INRIA in Nancy) and Germany (i.e. DFKI in Saarbrücken), Luxembourg is able to respond to the Greater Region's respective AI strategies, thus showing potential to become part of a cutting-edge, cross-border hub for applied AI research of the highest level of excellence. With a strategic focus on applied AI, Luxembourg is already today a living AI lab with global influence. With the objective of reinforcing collaborations between Luxembourg, France and Germany, the country aims at establishing a health data hub in biomedicine and personalized medicine.

As part of the living laboratory for AI, Luxembourg supports several initiatives: In the context of its aging and growing population, one key action aims at prioritizing preventive and personalized medicine. It heavily relies on AI-related technologies, as integrated in the new e-Health strategy which is under preparation by the Ministry of Health.

Regarding the European context, Luxembourg has a long-standing tradition of actively participating in new EU initiatives and reiterates its commitment to investing in EU AI-related collaborations. Given the increasing importance of the Greater Region, key cross-regional initiatives will be launched to solve regional issues in health through AI collaborations. To ensure international and regional cooperation on AI-related initiatives and activities, Luxembourg will focus on taking part in cross-border initiatives, e.g. the development of a common database of health images initially dedicated to the most common forms of cancer.

330 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

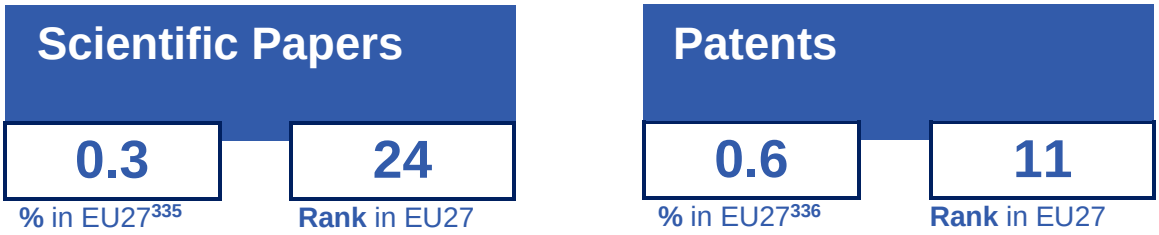
331 Digital Economy and Society Index 2020, Country Report: Luxembourg https://ec.europa.eu/digital-single-market/en/scoreboard/luxembourg

332 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

333 Cf. The Government of the Grand Duchy of Luxembourg: "Artificial Intelligence: A Strategic Vision for Luxembourg", Luxembourg, 2019. Retrieved online: https://digital-luxembourg.public.lu/sites/default/files/2020-09/AI_EN_0.pdf

334 Ibid.

# 2. Research and innovation around AI technologies and applications in healthcare




Luxembourg has contributed 0.3% of scientific output in the area of AI in healthcare which counts for a significant contribution compared to the country's population (626,000).

The patents granted by Luxembourg organisations are 0.6% of the EU-27, ranking Luxembourg 11 in the EU-27 which is significant given the country's size and it comes mostly from start-ups working in methodologies around sensors.

Luxembourg's strategic AI vision is based on a strong financial commitment. The Ministry of Economy has allocated approximately EUR 62 million in 2018 for AI-related projects through R&D grants.[337] The Luxembourg National Research Fund (FNR) has increasingly invested in research projects that cover big data and AI-related topics in fields ranging from Parkinson's disease to autonomous and intelligent systems – approximately EUR 200 million over the past five years. At the request of the Government, the FNR is currently revising the national research priorities for Luxembourg. The data-driven economy and AI-induced innovations in health will be part of the updated research priorities.

To ensure inclusion and enough resources with investment into skills and lifelong learning, Luxembourg will focus on mapping the national education offer, ensuring that AI is integrated into disciplines such as health.

Research areas which scientific publications focus on are disease and imaging diagnostics, with most research coming from the University of Luxembourg and teams including the Life Sciences Research Unit and the Centre for Systems Biomedicine, as well as research on the use of AI for the interpretation of clinical systems and medical imaging from the Luxembourg Institute of Science and Technology (LIST) and the Luxembourg Institute of Health (LIH).

335 Fractional Count (FC) calculated based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

336 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/ , the European Patent Organisation's online patent library.

337 Ibid.

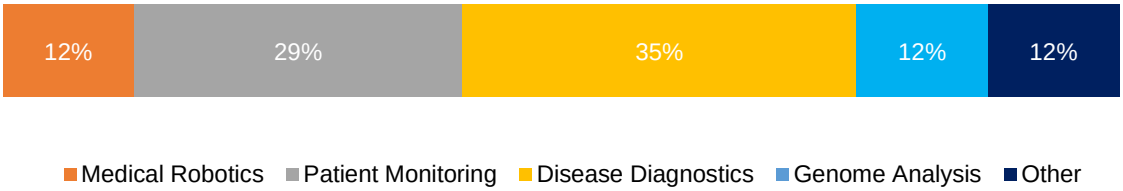



Figure 65: Areas of application in scientific papers

Research entities in Luxembourg obtain data they are using for the development of AI applications through either openly available research databases or own collection via clinical trials.[338] The University of Luxembourg actively uses Open Data from Open databases and shares data to Open Databases.

There is clear accordance amongst the research institutions regarding future legislation aspects and policies to be considered: These include data protection rules regarding the use and exchange of health data, cybersecurity policies, policies around AI testing and certification in the healthcare sector, among others.[339]

## Cross-border collaboration in research

| 2.2 | 5 |
|---|---|
| **Multilateral score**[340] | **EU Collaborating countries**[341] |

In terms of cross-border collaborations for scientific publications, in 2020, Luxembourg has collaborated with a total of 5 countries, especially with its neighboring countries Netherlands, Germany and France.

Suggested elements for the dedicated political health round-table discussions ("Gesondheetsdësch")[342] regarding the future eHealth strategy refer to secure sharing of health data, with the long-term objective of setting up a national health data platform based on cross-border collaboration. Research entities and start-ups will be granted financial support for further progress in innovation.

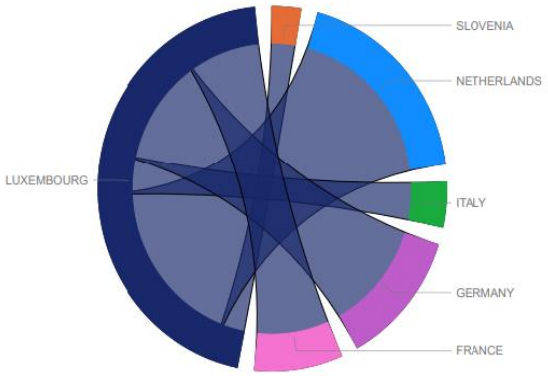
338 See survey results.

339 Ibid.

340 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

341 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

342 Cf. Les partis de la coalition DP, LSAP and Déi Gréng: "Accord de Coalition 2018-2023", 2018.


| Top 5 Collaborating Countries | Bilateral Score |
|---|---|
| Netherlands | 4.2 |
| Germany | 2.7 |
| France | 1.8 |
| Italy | 0.9 |
| Slovenia | 0.6 |

Figure 66: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Start-ups in Luxembourg around the use of AI in healthcare are limited and the ones active have been established as spin-offs from the University of Luxembourg and other local research and innovation centers. There is 1 start-up whose work is focused mainly on AI-enabled tools in the healthcare sector and more specifically, it has developed a humanoid social robot used for special needs education and research[343].

The startup culture in Luxembourg has experienced a huge leap in the recent years, mostly encouraged by an the presence of several incubator and accelerator programs all over the country, often supported by the government, the favorable tax regime and, in particular, an interesting IP tax regime as well as the lowest VAT in Europe.

Additionally, public or para-public grants, such as Luxinnovation[344], currently holding calls for start-ups in health-tech creates a fertile ground for the further development of innovation around AI in healthcare.

# 4. Awareness and use of AI technologies and applications in healthcare

A noticeable percentage of internet users with 93% of the population[345] presents an influential role of web activities on the Luxembourgish population.

During one-year period between May 2019 and June 2020, there were a total of 183 news mentions which is still a considerable result regarding the low population as a percentage of EU27. Overall, mentions in news articles constantly fluctuated throughout the period, with two major peaks in January and April 2020. One peak in January shows predominantly a result of publications by the University of Luxembourg revolving around patient-centered medical approaches, by showing the impact of responsible innovations, such as AI and machine learning, in healthcare, with further focus on the elderly people care and mental health treatment.

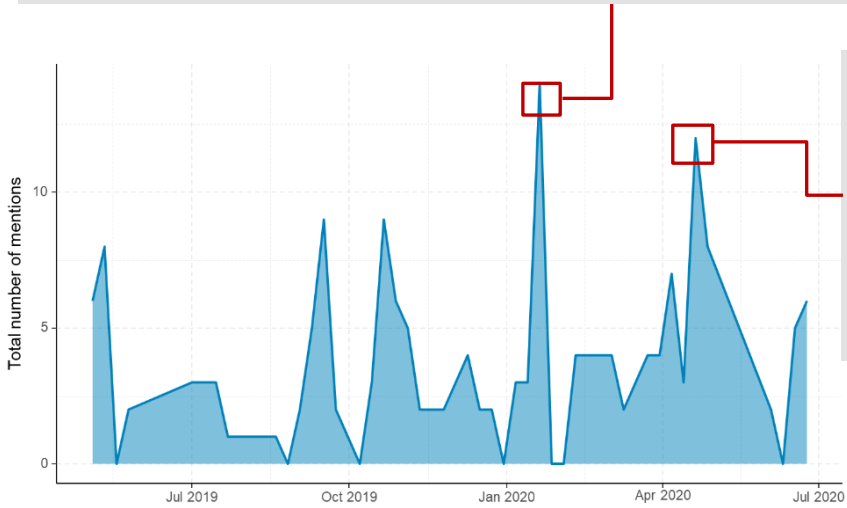
Additional attention was raised by the local banks identifying innovation of AI in healthcare as a priority investment area. The peak in April relates to the heightened awareness surrounding Covid-19, calling for AI-related research in the field for better understanding of the symptoms. News around the use of novel AI methods to address the fragile Tunisian public health system also occurred during the month.

343 https://luxai.com/

344 https://www.luxinnovation.lu/

345 Digital Economy and Society Index 2020, Country Report: Germany https://ec.europa.eu/digital-single-market/en/scoreboard/germany

**January 2020: Patient-centered** medical approaches with a focus on publications by the University of Luxembourg that show an impact on responsible innovation in healthcare through means of AI, Machine Learning for Clinical Decision Support Systems, but also for **elder people care and mental health treatment.**



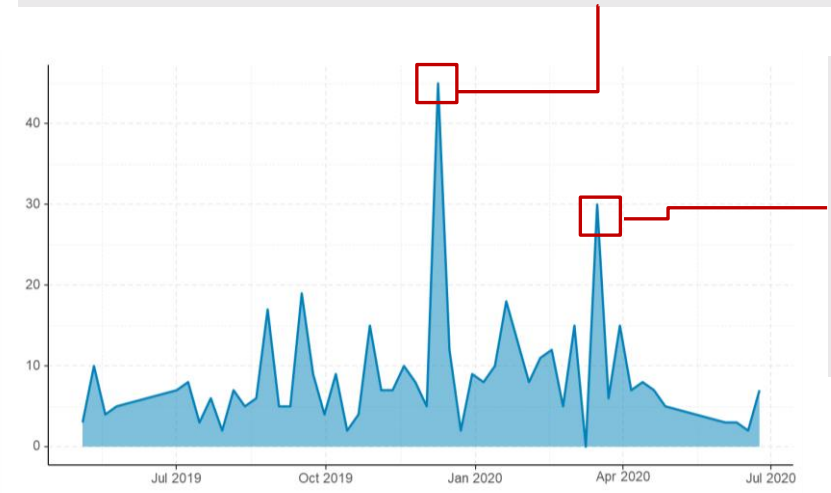

**April 2020:** Awareness raised about a call for **Covid-19 related research** to study differences in **coronavirus symptoms** and addressing experts in digital health and AI. Accelerated and non-profit research related to Covid-19, e.g. signs of pneumonia with advanced lung tests, is further linked to Machine Learning. Discussion about fragile Tunisian public health system that will harness potential of novel AI methods.

Figure 67: Trend of total mentions in the news

With 456 total mentions on social media over the one-year span, the trend shows two relatively high spikes, in December 2019 and in March of 2020 respectively, with rest of the period displaying a tame number of mentions. Tweets, Retweets and Twitter likes being the main indicator, reflect strong results regarding the Horizon2020 fund in the first peak, with further mentions regarding discussions by key influencers on a plethora of uses for novel AI and machine learning, including its impact on personalized medical treatment.

Tweeters in Luxembourg further discuss the use of AI for forecasting and diagnosis of the coronavirus.

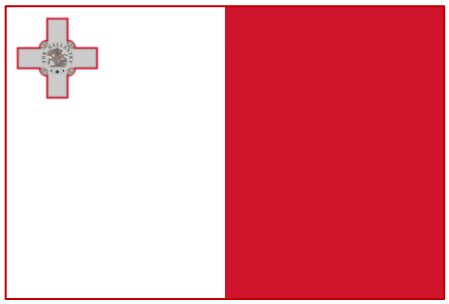
**December 2020:** Top results (Tweets, Retweets, Twitter Likes) reflect information shared about the **Horizon2020 fund** that affects 300 projects across **MSCActions** with AI in health fields. Thematic updates presented during dedicated panel discussions are shared by main influencer on this topic, e.g. novel artificial pancreas technology, Rapid Biomechanics Simulation for **Personalized Clinical Design** or Personalized machine learning for robot perception of engagement in **autism therapy**.




**November 2020:** Leem, the French professional organization for pharmaceutical firms, tweeted about the release of their study on key figures and applications of AI in healthcare.

The French Secretary of State for the Digital Sector tweeted about the importance of AI in healthcare applications as part of the **national strategy** to face the duopolistic situation with the USA and China.

Figure 68: Trend of total mentions in social media



# MALTA

| | | |
|---|---|---|
| **0.5 Mio**[346] **Total population** | **62.7**[347] **DESI 2020** Index | **85%** % of **internet users** |
| **0.1%**[348] **Population as a % of** EU27 | **5** **DESI 2020 ranking amongst** EU27 | **56%** % of population with at **least basic digital skills** |
| | | **42%** % of **Open Data** |

## 1. Relevant legislation and policy framework

Malta has developed "A Strategy and Vision for Artificial Intelligence in Malta 2030", which is a national strategy that aims to place Malta in a leading position in the field of AI[349]. With a favourable and strategic location, a fast-growing economy, continued efforts for diversification and its recognition as the "Blockchain Island", Malta's adoption of AI will enhance its competitive advantage and its innovative edge. There is a taskforce dedicated to policies that consider ethically aligned, transparent and socially responsible AI. They identify policy and regulatory measures to strengthen Malta's position as a digital hub for foreign investment, while identifying the necessary skills base and infrastructure needed to support AI.

There are general fears about how to make AI ethical. To address these concerns, the government developed the Malta Ethical AI Framework which has the following objectives: i) building a human-centric approach ii) respect for laws, regulations and human rights iii) maximising benefits and reducing risks and iv) aligning with international standards and norms[350]. This is especially important when dealing with sensitive personal data, such as medical records. "AI for Good", a phrase coined by professionals in the field, aims to use AI applications to improve human well-being by enhancing healthcare[351].

Under the pillar of "Public Sector Adoption", the Maltese government is committed to promoting and investing in AI pilot projects in healthcare throughout their lifecycle[352]. Malta envisions AI technologies being used for disease prevention, precision medicine, optimised chronic patient care and accelerated biomedical research. The government has made meaningful investments towards becoming "a leader in the digital health space and one of the best countries to undertake health-related AI pilot projects"[353]. One such project will explore how to best utilise data collected over the last ten years from "The Pharmacy of Your Choice (POYC)" platform. By applying AI to POYC, researchers hope to improve patient safety, drive cost savings and create preventative care models for better health outcomes.

Digital Health Malta is an NGO, which aims to bring the public sector, charities, industry and academia together in an effort to transform the Maltese healthcare sector through the use of digital health. To date, they held over six conferences, launched two digital health projects and started their own original research[354].

346 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

347 Digital Economy and Society Index 2020, Country Report: Malta https://ec.europa.eu/digital-single-market/en/scoreboard/malta

348 Eurostat, 2020 data, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en

349 https://malta.ai/

350 https://malta.ai/wp-content/uploads/2019/10/Malta_Towards_Ethical_and_Trustworthy_AI_vFINAL.pdf

351 Ibid,. p.8

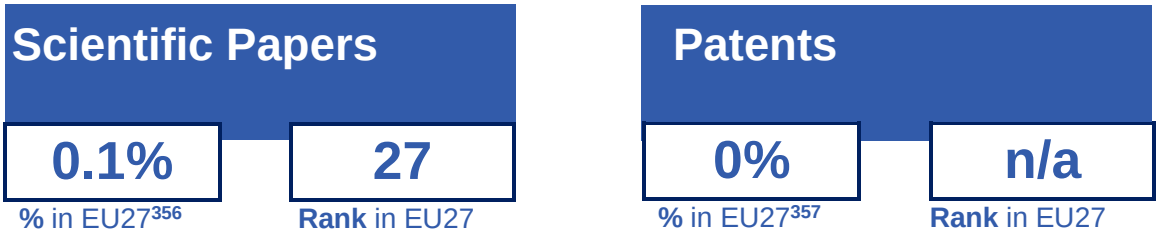
352 https://malta.ai/wp-content/uploads/2019/11/Malta_The_Ultimate_AI_Launchpad_vFinal.pdf

353 Ibid., p.29

354 https://digitalhealthmalta.com/

Notwithstanding, the implementation of AI into health policies currently face some challenges, namely the dissemination of relevant information, awareness-raising about the subject, training staff in the use of AI technologies and financial investment [355].

## 2. Research and innovation around AI technologies and applications in healthcare




Malta contributes approximately 0.1% of scientific output in the area of AI in healthcare and ranks 27th among the EU Member States. Out of the many papers published in the area of Blockchain, a very limited number are focused on its possible uses in healthcare. This follows the nation's recognition as the "Blockchain Island". The University of Malta with its Faculty of ICT is the main contributing research entity and it is worth noting that the dedicated Department of Artificial Intelligence is involved in several European, national and departmental projects.[358] Some of these projects relate to Creative Computing for Virtual Reality in Mental Health and Pain Management.

Some research is also being conducted by the Mater Dei Hospital, a teaching hospital that recently invested in a € 4 million robot for prostatectomy therapies.[359]

Malta did not apply for patents and there are no cross-border collaborations on publications in this field.

## 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Malta Enterprise is the country's economic development agency and its main task is the attraction of new foreign investments and the facilitation of growth of existing operations. Malta Enterprise published the start-up finance for 2020 with the aim to support small Start-up undertakings that demonstrate a viable business concept, they provide support of maximum EUR 400,000 (or EUR 800,000 if the start-up is an Innovative Enterprise)[360]. The support, with the exception of a one-time Accelerator Grant, is awarded as a repayable advance.

Further, despite its strong public healthcare system, Malta has been experiencing very limited activity regarding start-ups focusing on AI-enabled tools in the healthcare sector. Only one start-up could be identified, which has revolutionised the monitoring of vital signs in healthcare.

355 See survey results

356 Using Fractional Count (FC) method based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

357 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

358 https://www.um.edu.mt/ict/ai/ourresearch

359 https://timesofmalta.com/articles/view/robot-to-assist-in-surgeries-at-mater-dei-hospital.748158

360 http://maltaenterprise.com/support/start-finance-2020

# 4. Awareness and use of AI technologies and applications in healthcare

Unsurprisingly, given Malta's limited research activities and number of news outlets one can suspect the low awareness raised and accordingly represented in new activities. With 22 total mentions, awareness around the topic is centred around two events. The first relates to a new hospital implementing an automatic robotic system to store and deliver medicine, while the other is on the Prime Minister announcing that Malta will be the first country to launch a national AI certification program, with health as one of the pilot areas.

Very low awareness by news outlets in Malta. Of the few relevant articles, one related to the use of AI and robotics for automatic robotic system to store and deliver medicine to patients at new Mater Dei Hospital through a pneumatic tube. Additional media attention surrounded the Prime Minister of Malta, Joseph Muscat, announcing that Malta will be the first country in the world to launch a **national AI certification program at the Delta Summit**. The healthcare sector will be the subject of one of 6 AI pilot projects.

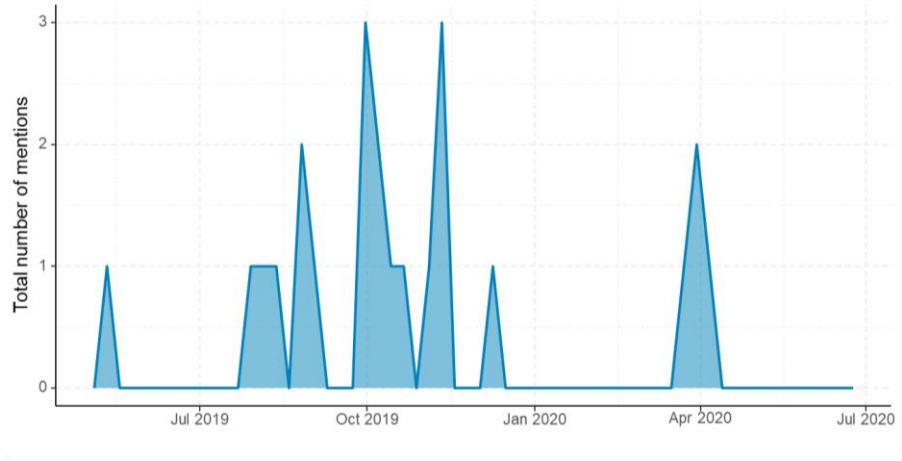



Figure 69: Trend of total mentions in the news

Despite a relatively low performance compared to the rest of the EU Member states in terms of news mentions, Malta's social media activity around the selected topic was relatively strong. Out of the 282 total mentions, 42 of them occurred during the huge spike in the fall of 2019. This spike coincided with Malta becoming the first country to launch an AI Certification Program, as previously stated in the section above. Other popular tweets came from a Maltese MEP, expressing concerns over the lack of control and regulation over the development of AI in healthcare.

**September/ October 2019:** The strong spike in mentions was primarily caused by the Prime Minister of Malta, Joseph Muscat, launching the **world's first AI Certification Program**, with the healthcare sector identified as one of the pilot areas for AI intervention. Maltese MEP brought awareness to the lack of control and regulation over the development and use of AI in healthcare. Other tweets related to breakthroughs in AI technologies such as the MIT designed snake robot used to clear blood clots inside the brain of stroke victims.

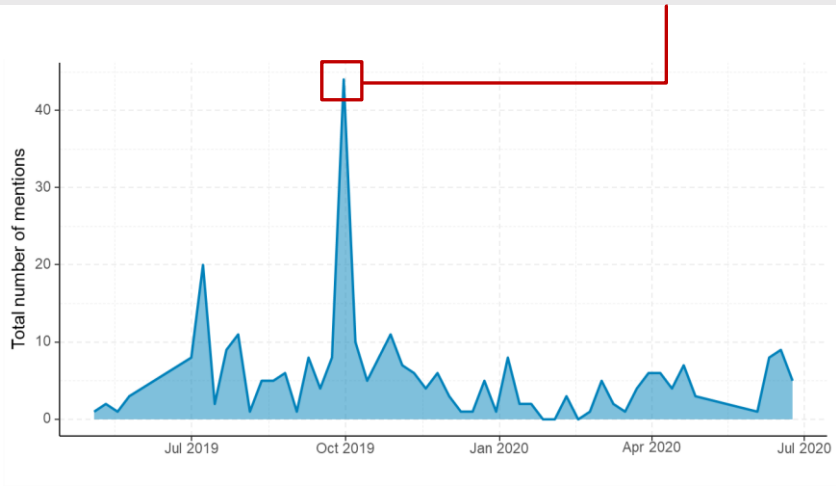



Figure 70: Trend of total mentions in social media

**17.4 Mio**[361]
**Total population**

**67.7**[362]
**DESI 2020** Index

**95%**
% of **internet users**

**3.9%**[363]
**Population as a % of** EU27

**4**
**DESI 2020 ranking amongst** EU27

**79%**
% of population with at **least basic digital skills**

**78%**
% of **Open Data**

# NETHERLANDS

## 1. Relevant legislation and policy framework

The AI strategy of the Netherlands covers the healthcare sector and has a wide scope, ranging from disease prevention, diagnosis and treatment to logistics.[364] Extensive research has been done by the Ministry of Health, Welfare and Sport to explore the risks and opportunities of applying algorithms and AI in healthcare – including legal and ethical issues, as well as the associated instruments. Based on the outcome of these sessions, the Ministry is examining how the application of AI can be facilitated.

However, basic principles for the use of health data, such as privacy and citizens' control over their own data, need to be continuously observed. Furthermore, The Ministry of Health, Welfare and Sport has chosen to invest in Prevention and Big Data and this investment has been doubled from the National Science Agenda.

There is a great deal of focus on data standardisation in the healthcare sector, as evidenced by various initiatives around the Basic Data Set for Care (Basisgegevensset Zorg, BGZ[365]) by Nictiz, or the Registration at the Source (Registratie aan de Bron[366]) programme of the university medical centres.

The Personal Health Train (PHT)[367] is a metaphor for the set of agreements, the architecture and implementation for the responsible use of health data in, among other things, AI applications. Under the Medmij framework agreement for patient data, patients are in control of their own healthcare data. Regarding supervision of AI, the Health Care and Youth Inspectorate supervises software or AI that is used as a medical device and therefore falls under the new European Medical Device Regulation (MDR)[368], which lays down requirements for software.

361 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

362 Digital Economy and Society Index 2020, Country Report: Netherlands, Shaping Europe's digital future, https://ec.europa.eu/digital-single-market/en/scoreboard/netherlands (accessed in December 2020)

363 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

364 Ministry of Economic Affairs and Climate, Strategic Action Plan For Artificial Intelligence, October 2019, p.16

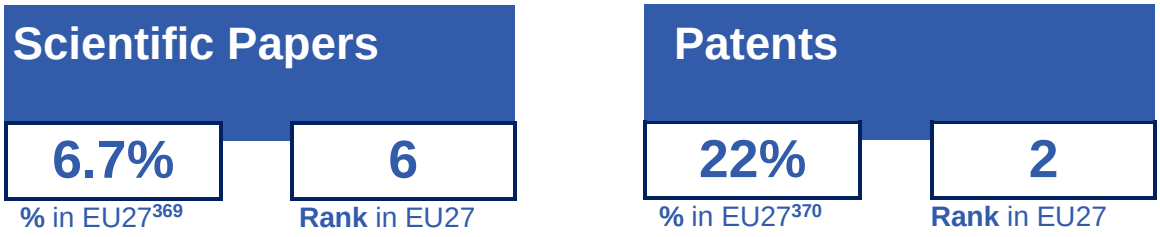
365 Nictiz, Basisgegevensset Zorg (BgZ), https://www.nictiz.nl/standaardisatie/informatiestandaarden/basisgegevensset-zorg-bgz/ (accessed in December 2020)

366 Registratie aan de bron, https://www.registratieaandebron.nl/ (accessed in December 2020)

367 Health-RI, Personal Health Train, https://www.health-ri.nl/initiatives/personal-health-train#:~:text=The%20PHT%20concept,of%20individual%20patients%20and%20citizens. (accessed in December 2020)

368 Business.gov.nl, Medical devices, https://business.gov.nl/regulation/medical-devices/ (accessed in December 2020)

# 2. Research and innovation around AI technologies and applications in healthcare




The Netherlands contribute around 6.7% of scientific output in the area of AI in healthcare. The scientific contribution of the Netherlands is relatively high as it ranks 6th amongst EU countries.

The main contributors tend to be research groups from universities such as Leiden University, Utrecht University, Radbound University and Eindhoven University. Other centers and institutes include the Spinoza Centre for Neuroimaging and the Netherlands Cancer Institute.

Since the institutions, mentioned above, show a high level of scientific contribution in the area of AI, they are involved in diverse fields of where AI can be applied. For instance, deep learning is used for various kinds of MRI analyses like diagnosis on Multi-Parametric MR images, techniques for automatic MRI Cardiac Multi-Structures Segmentation or the assessment of MRI in neuro-oncology. Furthermore, machine learning methods are deployed in the field of big data classifications, disease detections and automated predictions. In addition, artificial neural network, and in particular convolutional neural network, are used for detection and classification purposes.

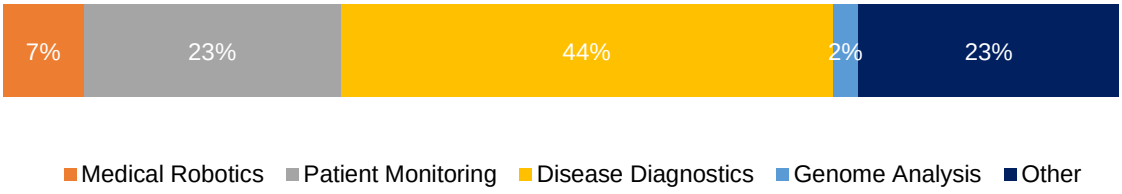



Figure 71: Areas of application in scientific papers

Moreover, despite accounting for 22.9% of patent contribution in the EU, most patents in the Netherlands are not coming from start-up companies but from the Dutch multinational conglomerate Philips.
The recent creation of the first AI Research Agenda for the Netherlands (AIREA-NL) presented by the Dutch Research Council (NWO) aims to strengthen the AI research in the country and is crucial for the development of a broader and more solid knowledge base of AI[371].

369 Using Fractional Count (FC) method based on Nature Index's FC score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of most relevant papers published between January 2015-August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

370 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/, the European Patent Organisation's online patent library.

371 Dutch Research Council, AI research agenda for the Netherlands area, https://www.nwo.nl/binaries/content/documents/nwo/algemeen/documentation/application/nwo/beleid/open-science/ai-research-agenda-for-the-netherlands-airea-nl/9 (accessed in December 2020)

PwC Netherlands identified two major challenges in the adoption of AI for healthcare: a lack of systems and processes that enables adoption and a “mindset- and knowledge gap”, that prevents decision makers from making AI and emerging technologies a key priority. Regarding the first challenge, there are many sources of healthcare data, each coming in a different environment and format. In order to solve this problem, differences, in how electronic health record (EHR) systems are designed and implemented, will need to be eliminated. Regarding the second challenge, understanding and trust in new applications remains remarkably low, not just for patients but also for doctors and other healthcare professionals.

The proportion of medical professionals who have the skills needed to fully understand the tools remains small, hindering the adoption of AI for healthcare[372].

## Cross-border collaboration in research

| 28.1 | 18 |
|---|---|
| Multilateral score[373] | EU Collaborating countries[374] |

The Netherlands can be considered as a country with high volume of cross-border collaboration in Europe, regarding AI technology. The countries with which they collaborate most frequently are – Germany, Italy, Spain, Denmark and Belgium.

In their Strategic Action Plan for Artificial Intelligence from 2019, the Netherlands emphasize the increase in the coming years of the share of Dutch knowledge centres and companies in major AI-related European programmes, as will cooperation with other member states on AI research and programmes.

The aim is to increase the visibility of Dutch AI knowledge and expertise and thus to promote opportunities for Dutch industry and knowledge centres in research, innovation, trade, acquisition and security. To achieve this goal, the Netherlands is strengthening its cooperation with other Member States and European initiatives, including through the Holland Innovation Network and economic missions[375]. The Netherlands is actively seeking collaboration on AI with other countries within and outside Europe, such as Germany, France, Singapore, the US and Belgium. For example, an innovation mission to Singapore was organised at the end of 2019 for collaboration in the field of AI, and in 2020 opportunities were explored for effective bilateral collaboration between the US and the Netherlands in specific AI areas.

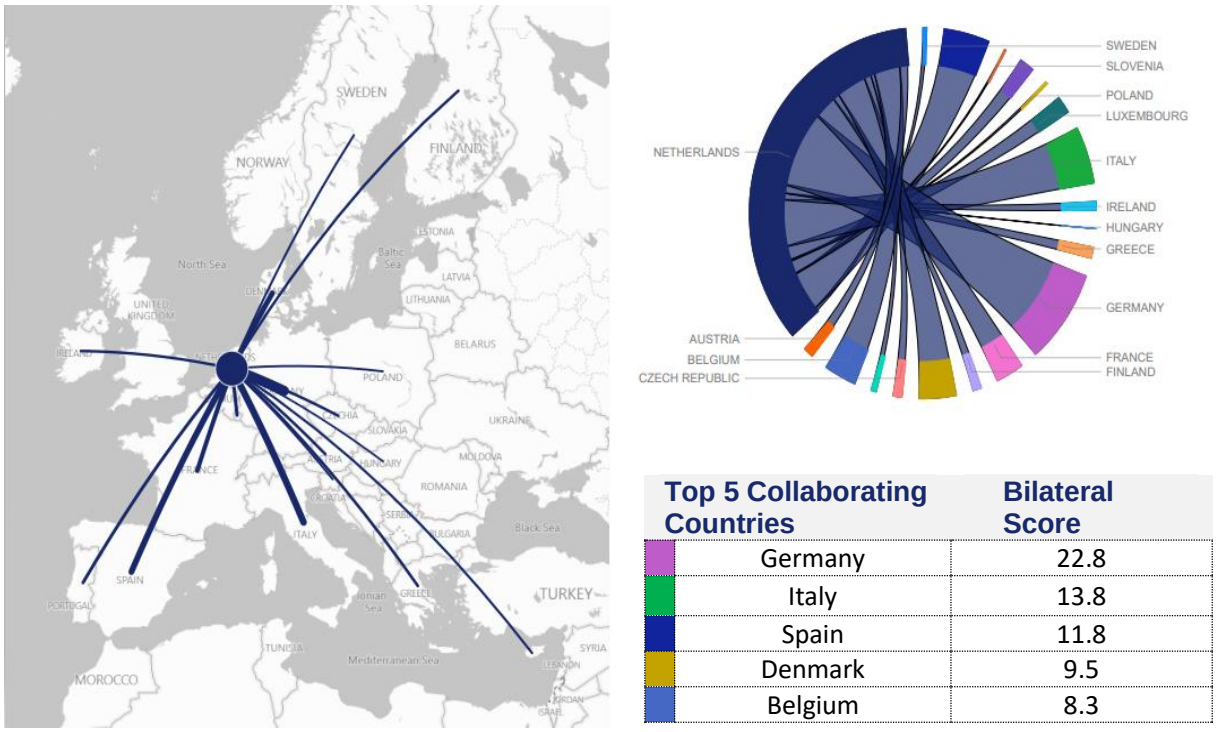
Within the European Horizon 2020 programme, EUR 986 million was allocated to 580 AI related projects from 2014 to 2017. From this budget, Dutch parties received EUR 61 million (6.1%).

372 PwC Netherland, AI adoption challenges for healthcare in the Netherlands, January 2020, https://www.pwc.nl/nl/actueel-publicaties/assets/pdfs/pwc-from-potential-to-performance.pdf (accessed in 2020)

373 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

374 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

375 Strategic Action Plan for Artificial Intelligence, Ministry of Economic Affairs and Climate,October 2019




| Top 5 Collaborating Countries | Bilateral Score |
|---|---|
| Germany | 22.8 |
| Italy | 13.8 |
| Spain | 11.8 |
| Denmark | 9.5 |
| Belgium | 8.3 |

Figure 72: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Techleap.nl is a non-profit publicly funded organization which aims to enhance the Dutch tech ecosystem by providing access to data, producing reports, building partnerships and by enabling access to capital, talent and technology. Interestingly, the Netherlands is still one of the fastest-growing start-up hubs in Europe, with more than 7500 start-ups[376].

The Government of the Netherlands has a budget of EUR 75 million for their "Ambitious Entrepreneurship Action Plan"[377]. The funding will be spent helping entrepreneurs by helping them research their ideas (initial stages), by helping on European projects such as "Eurostars projects" and "Horizon 2020" and even by bringing non-EU entrepreneurs to the country. Moreover, the Dutch government offers "Startup Box", an online tool that helps entrepreneurs to identify whether the Dutch government has a funding instrument suitable for their startups[378].

The strong startup ecosystem in the Netherlands is further supported by the presence of at least 15 startups related to AI technologies and applications in healthcare. The datatype they are using, according to the survey, is very often imaging data or unstructured data.

There is also a consensus among the start-ups regarding the collaboration with other research institutes, companies or healthcare delivery centres for the translation of AI-related research into healthcare applications. They actively collaborate with universities for clinical research or support AI companies in their innovation network.

376 Techleap, https://www.techleap.nl/dutch-ecosystem/ (accessed in December 2020)

377 Government of the Netherlands, Supporting ambitious entrepreneurs and startups, https://www.government.nl/topics/enterprise-and-innovation/supporting-ambitious-entrepreneurs-and-startups (accessed in December 2020)

378 Business.gov.nl, Startup funding from the government, https://business.gov.nl/starting-your-business/launching-an-innovative-startup/startup-funding-from-the-government/?gclid=EAIaIQobChMIuMfGh4_w6wIVEentCh2iYAbgEAAYASAAEgKrtvD_BwE (accessed in December 2020)

Regarding the desired policy framework, there is a demand for policies around AI testing and certification in healthcare sector and around the ethical use of AI. Furthermore, policies should be introduced, aimed at supporting research and innovation in the area of AI in healthcare.

The startups expect that due to their AI healthcare development and applications, an earlier detection of cancer as well as higher quality of dental care will be possible, as a result of higher accuracy of diagnosis and operation planning.

# 4. Awareness and use of AI technologies and applications in healthcare

The high percentage of internet users refers to a high online activity. Indeed, news publications in the Netherlands are quite active on AI and more particularly on AI applied to health, as shown by the number of mentions going beyond 2,000 over the past year.

The awareness on AI technologies and applications seems continuous, even if some events, like the Covid-19 outbreak and the related scientific developments for epidemic simulation or patient treatment, triggered a hype around the topics of personalized treatment, epidemiological simulation models and diagnostic methods.

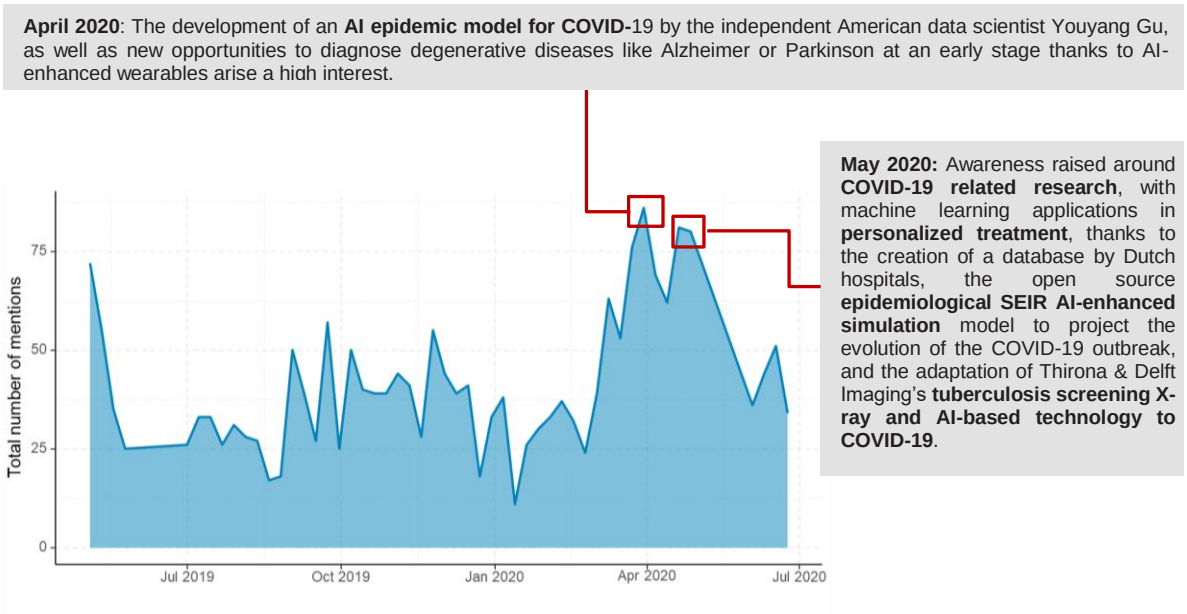
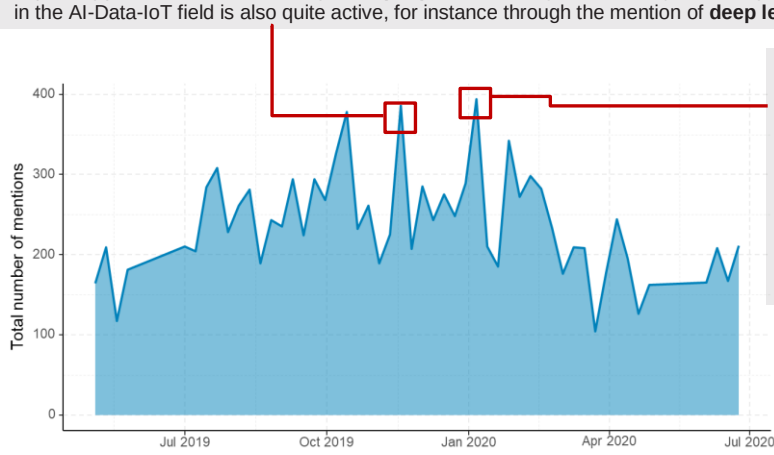



Figure 73: Trend of total mentions in the news

Consistently, social media in Netherlands are continuously mentioning AI technology and application, with 12,700 mentions throughout the past year and various peaks led by corporate communication like Philips' announcement on the major stakes of AI applications in the healthcare sector and by the notorious influencer Ronald Van Loon, CEO of the Intelligent World.

**November 2019:** A high number of mentions is triggered by **Philips** communication on AI applications in Healthcare to manage **growing amounts of data**, identify risk both in **population health management** or in individual **genomics and epigenetics**, improving prediction of **falls among elder people** and making health a subject of **daily action**. **Ronald van Loon**, a famous influencer in the AI-Data-IoT field is also quite active, for instance through the mention of **deep learning solutions to fight heart diseases**.




**January 2020:** This local peak in number of mentions is mainly caused by a few tweets from **Ronald van Loon**, CEO of the Intelligent World and renowned AI-Data-IoT-Influencer, about the top-10 innovative technologies that will change our world, including in the healthcare sector, about a new **brain-controlled exoskeleton** and **AI-based diagnostic methods** that detect diseases through breath and smell analysis.

Figure 74: Trend of total mentions in social media

**38 Mio**[379]
**Total population**

**45**[380]
**DESI 2020** Index

**78%**
% of **internet users**

**8.5%**[381]
**Population as a % of** EU27

**22**
**DESI 2020 ranking amongst** EU27

**44%**
% of population with at **least basic digital skills**

**78%**
% of **Open Data**

# POLAND

## 1. Relevant legislation and policy framework

The Polish Ministry of Digitisation has published a draft of its national AI strategy, entitled "Artificial Intelligence Development Policy in Poland 2019-2027"[382], suggesting strategic guidance and policy initiatives to build a holistic AI ecosystem.

Some of the objectives of this strategy are to reform the educational system and provide lifelong learning opportunities in AI-related fields, to support AI research and encourage partnerships in the field, to build a trust-worthy data ecosystem and upgrade existing infrastructures and frameworks to boost AI innovations.

In 2019, under the direction of the Ministry of Digital Affairs, the bedrock for the "Artificial Intelligence Development Policy" (AI Policy) project was established.

In particular, the Artificial Intelligence Development Policy identifies healthcare as one of the priority sectors, where AI applications could help elevate the healthcare industry.

One of the objectives in the field of e-health is to support activities aimed at the interoperability of existing systems, with a particular focus on projects aimed at the care of the elderly and projects aimed at preventing epidemics and combating their effects[383].

Actions and goals with regards to the policy for the development of AI are defined for Poland in the short term (until 2023), medium term (until 2027) and long term (after 2027)[384]. They are all divided into six areas:

- AI and society
- AI and innovative companies
- AI and science
- AI and education

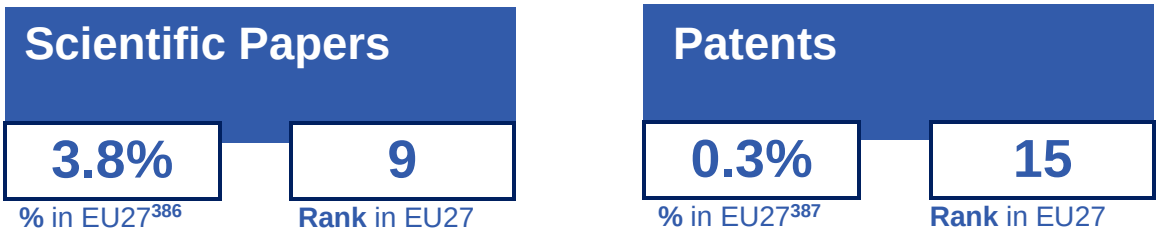
379 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en
380 Digital Economy and Society Index 2020 - Country Report: Poland, Shaping Europe's digital future, https://ec.europa.eu/digital-single-market/en/scoreboard/poland
381 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en
382 Ministry of Digitisation – Poland, Artificial Intelligence Development Policy in Poland for 2019-2027, National AI Strategy, August 2019
383 OECD, Poland's national AI Strategy, November 2020, https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24268 (accessed in December 2020)
384 OECD, Poland's national AI Strategy, November 2020, https://oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24268 (accessed in December 2020)

- AI and international cooperation
- AI and public sector

where most of the areas fit perfectly into the healthcare domain.

Digital Poland, a foundation which places Poland as a leading innovation hub, encourages cross-industry nationwide initiatives and connects various stakeholders to create opportunities for the polish economy[385]. Some of their notable indicatives include the AI Challenge, the Digital Economy Hub, E-Health and the Startup Ecosystem.

## 2. Research and innovation around AI technologies and applications in healthcare




Poland contributes approximately 3.8% of scientific output in the area of AI in healthcare. The scientific contribution of Poland is relatively small with respect to its population, nevertheless, it is ranked 9th amongst EU countries.

There is a wide range of focus application areas, the AGH University of Science and Technology, Silesian University of Technology and Warsaw University of Technology are some of the main drivers of such scientific output.

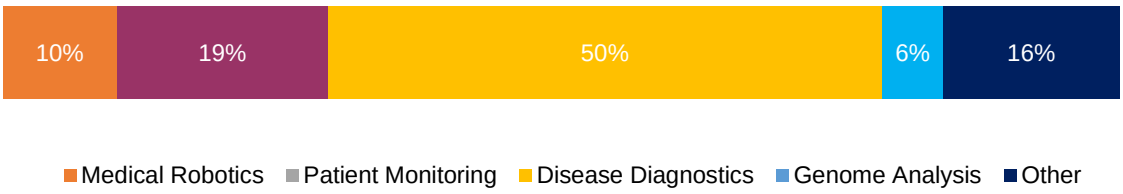



Figure 75: Areas of application in scientific papers

The main research activities are performed in the domain of Disease Diagnostics, notably by means of deep learning or machine learning methods. These methods are amongst others used for early disease detections or image classification. Furthermore, neural networks are also used for image classification, disease detection or e.g. for improving radiologists' performances in breast cancer screening.

385 Digital Poland, https://www.digitalpoland.org/en/ (accessed in December 2020)

386 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

387 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

## Cross-border collaboration in research

| 10.1 | 15 |
|---|---|
| Multilateral score[388] | EU Collaborating countries[389] |

Regarding cross-border collaboration in the domain of AI healthcare domain, Poland cooperates most frequently with Germany, Spain Italy Lithuania and France.

The participants of the 2020 Round Table Series in September 2020 emphasised the fact that a good cooperation is required between research centres, universities and healthcare units at a national and international level when working on data-driven technologies like AI[390]. One example is the The Centre for Preventive Healthcare and Epidemiology of Cancers (OPEN) in Poznan, which performs screening for the early detection of breast cancer. OPEN cooperates with Merantix Labs from Germany, a technology lab and incubation platform for AI.

EIT (European Institute of Innovation and Technology) Health considered regulation and policy making considered as the most challenging part of AI implementation, which has to be thoroughly planned, not only at the national level but also more broadly at the regional and European level. Furthermore, financing, reimbursement and the need to create new models of financing are critical points which should not be neglected. Another key topic is the ethical dilemma related to the AI implementation in healthcare.

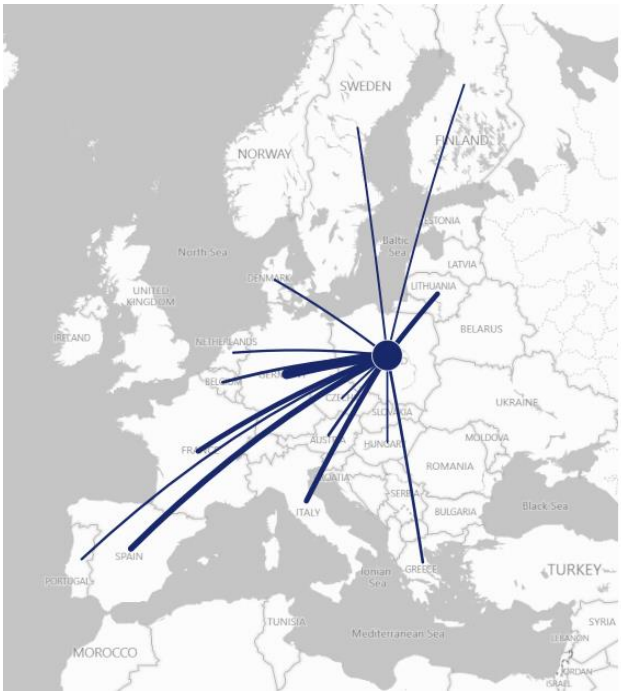
The ethics of AI is closely linked to the safety process of the AI implementation, which is a critical factor. Awareness of transparency, liability and explainability in the context of sensitive data-driven technology is crucial.[391]

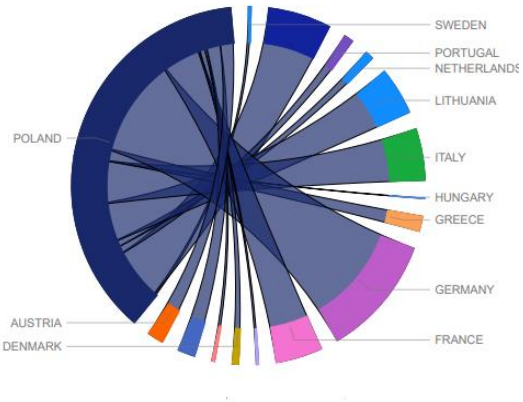
388 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

389 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

390 EIT Health,2020 Round Table Series, Healthcare Workforce and Organizational Transformation with AI, 15.09.2020, https://eithealth.eu/wp-content/uploads/2020/11/Think-Tank-Round-Table-Proceedings_Poland_fin.pdf

391 EIT Health,2020 Round Table Series, Healthcare Workforce and Organizational Transformation with AI, 15.09.2020, https://eithealth.eu/wp-content/uploads/2020/11/Think-Tank-Round-Table-Proceedings_Poland_fin.pdf




| Top 5 Collaborating Countries | Bilateral Score |
|---|---|
| Germany | 8.1 |
| Spain | 4.2 |
| Italy | 3.4 |
| Lithuania | 3.2 |
| France | 3.1 |

Figure 76: Volume of cross-border collaboration in research

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Polish government has multiple plans to help people start their own businesses, with priority given to the unemployed and recent graduates. A lot of attention is given in the development of new businesses in the caring and agriculture sector. Specific initiatives include the creation of the "Polish Development Fund S.A.", Poland's strategic company offering instruments for the development of enterprises, local governments and private individuals. The "Operational Programme Development of Eastern Poland" is another such initiative which launched in order to provide mentoring and guidance to young people who want to start their businesses in eastern Poland[392].

Poland and in particular, Warsaw, have numerous active venture capitalists, business angels, important accelerators, incubators and events which enhance its start-up ecosystem. Examples include the Wolves Summit, Google Campus and MIT Enterprise Forum Poland[393].

Recently, the Polish start-up Infermedica has raised $10.25 million in a Series A funding, which was led by the European Bank for Reconstruction and Development (EBRD) and digital health fund capital, and with participation of other venture capital funds[394]. The start-up is a creator of an AI-based platform for preliminary diagnosis and triage.
There are at least 12 start-ups in Poland whose work is focused mainly on AI-enabled tools in the healthcare sector.

392 Biznes Poland, https://www.biznes.gov.pl/en/firma/doing-business-in-poland/types-of-economic-activity-in-poland/before-you-decide-to-start-your-own-business/financing-for-start-up-business (accessed in December 2020)

393 EU-startups, Warsaw's startup ecosystem at a glance, January 2019, https://www.eu-startups.com/2019/01/warsaws-startup-ecosystem-at-a-glance/ (accessed in December 2020)

394 Tech.eu, Polish health tech startup Infermedica raises $10 million Series A, August 2020, https://tech.eu/brief/infermedica-series-a/#:~:text=Facebook-,Polish%20health%20tech%20startup%20Infermedica%20raises%20%2410%20million%20Series%20A,million%20in%20Series%20A%20funding.&text=The%20new%20capital%20brings%20total%20funding%20to%20%2415%20million. (accessed in December 2020)

# 4. Awareness and use of AI technologies and applications in healthcare

Poland's early state in regulation and AI strategy is reflected in the current state of poor awareness of AI technologies and applications throughout news and social media.

A single peak in October 2019 refers to the repeated online publication of the same article about new development opportunities in the field of medical imaging thanks to Polish AI scientists updated several times.

**October 2019:** This single peak was caused by the repeated release of an article on the development **of AI-based imaging technique** by Polish scientists on the local news website twoje-miasto.pl after several updates in the article.

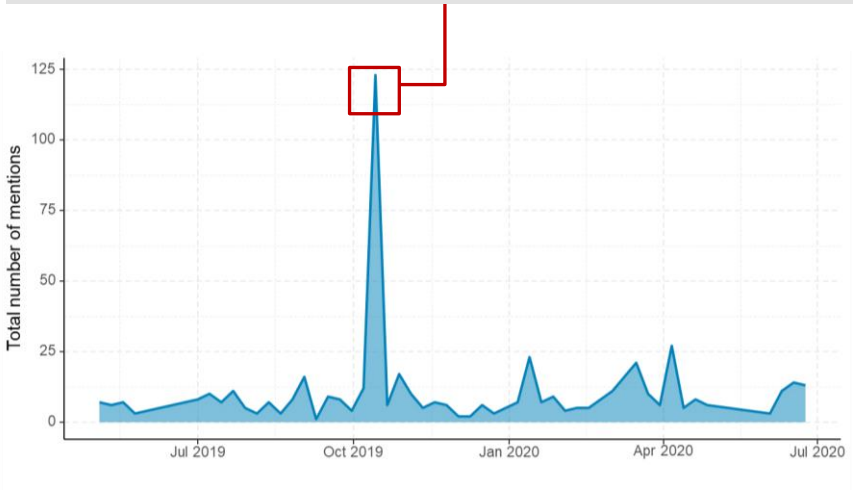



Figure 77: Trend of total mentions in the news

Similarly to news, the overall number of mentions on social media is rather low, with 980 mentions over the past year and a weekly number of mentions that barely goes beyond 25. The only noticeable peak is a consequence of the wake of the Covid-19 outbreak and the announcement of Pragmasoft about new AI solutions for thermal cameras.

**March 2020:** In the wake of the COVID-19 outbreak, Pragmasoft, a software firm, communicated about the development of **infrared thermal vision cameras and AI solutions to fight with COVID**, which triggered several retweets.

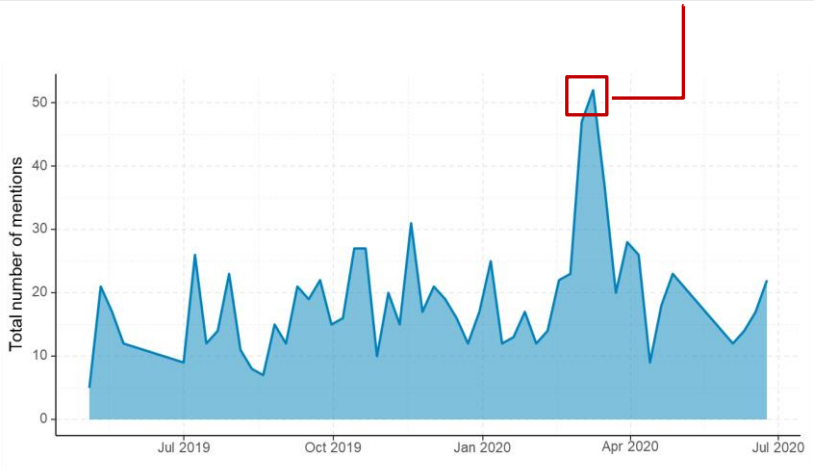



Figure 78: Trend of total mentions in social media

**10.3 Mio**[1]
**Total population**

**49.6**[1]
**DESI 2020** Index

**73%**
% of **internet users**

**2.3%**[1]
**Population as a % of** EU27

**18**
**DESI 2020 ranking amongst** EU27

**52%**
% of population with at **least basic digital skills**

**42%**
% of **Open Data**

# PORTUGAL

## 1. Relevant legislation and policy framework

Portugal's national AI strategy "AI Portugal 2030" [395] includes aspects relating to research and innovation in European networks. This strategy highlights the benefits of AI for the healthcare sector and provides a vision to support and consolidate the use and development of Ambient Assisted Living (AAL) through the use of AI technologies.

Big data and data sharing are essential tools and there is a significant potential for AI to deliver benefits in this sector, such as by discovering new drugs, reducing costs, diagnosing diseases, improving patient care, personal medicine and public health.
The "AI Portugal 2030" strategy emphasizes that the definition of regulatory frameworks, as well as the definition and deployment of ethical guidelines are crucial.[395] Since AI systems will make critical decisions autonomously, transparency and auditability will be demanded by society, to foster safety and ethical principles. Therefore, the legal framework needs to be adjusted to assign responsibility in the event of conflicts with involvement of AI decision-making.

Policies already in place address the fields of cybersecurity and the deployment of AI technologies in healthcare. According to results from the survey, Portugal does yet not have legislation in place regarding the storage and sharing of healthcare data. Open data initiatives exist but these are not specifically developed for use/suitable for AI applications.[396] In general, results of the survey identified the lack of regulations and policies as a general barrier to the further adoption of AI technologies in healthcare, especially with regards to the following matters:

- Regulations on data sharing for health-related research;
- Regulation on AI development and deployment in healthcare;
- Financial incentives and policies for AI development in healthcare.

## 2. Research and innovation around AI technologies and applications in healthcare

395 Cf. INCoDe.2030, FCT, ANI, AMA, AI Portugal 2030: Portuguese National Initiative on Digital Skills - An innovation and growth strategy to foster Artificial Intelligence in Portugal in the European, June 2019, p. 31-37

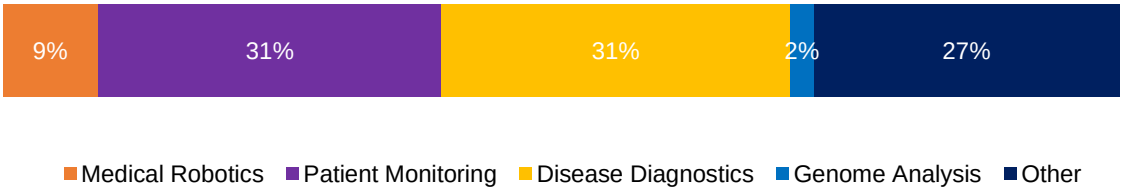
396 See survey results.

| 8% | 5 | 0.6% | 12 |
|---|---|---|---|
| **%** in EU27[397] | **Rank** in EU27 | **%** in EU27[398] | **Rank** in EU27 |

Portugal contributes approximately 8% of scientific output in the area of AI in healthcare, ranking 5th amongst EU countries. The scientific contribution of Portugal is relatively large with respect to its population and it is mainly driven by the technological and medical faculties of universities such as University of Minho, University of Porto and University of Lisbon. Moreover, the Institute for Systems and Computer Engineering, Technology and Science (INESC – TEC), as well as the Centre for Health Technology and Services Research (CINTESIS) are also important contributors for the scientific output in the area of AI in healthcare.

Further, the AAL Alliance is a group of nine Fraunhofer Institutes that work jointly to research, develop and evaluate sustainable technologies and services in the areas of ambient assisted living and personal health.
AAL is one specific area where AI can play an essential role, particularly in the support of ageing. Fraunhofer Portugal currently materializes itself through the Fraunhofer Portugal Research Centre for Assistive Information and Communication Solutions (AICOS), with consolidated competences in Human-Centered Design, AI and Cyber-Physical Systems. By means of deep learning methods, the Fraunhofer AICOS develops cognitive systems inspired in the way the human brain works as well as its capabilities to learn from past experiences.[399]

Figure 79: Areas of application in scientific papers




The main publications refer to the domains of patient monitoring and disease diagnostics. Different lung cancer stages are assessed by means of deep learning techniques, and novel AI platforms are assessed in their efficiency of improving cancer patient's quality of life. Furthermore, there are publications about the predictive power of AI in health, i.e. triage waiting time in maternity emergency care or the use of data mining in cases of postoperative complications with gastric cancer patients.
The development of a national AI strategy supports the development of a strong AI knowledge-intensive research and innovation ecosystem through policy initiative proposals[400]. One example includes the development of a Centre of excellence for AI R&D.

397 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

398 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

399 Cf. Fraunhofer Center for Assistive Information and Communication Solutions – AICOS. Received from: https://www.aicos.fraunhofer.pt/en/scientific_expertise/intelligent-systems.html

400 Portugal AI Strategy Report . Received from: https://ec.europa.eu/knowledge4policy/ai-watch/portugal-ai-strategy-report_en

In 2018, the Portuguese government supported 15 new AI projects for public services with 3.8 million euros, seven of which originated from the health sector, e.g. “Neuroimaging Biomarkers for Diagnosis of Neuropsychiatric Diseases, using AI” or “ICDS4IM – Intelligent Support to Clinical Decision in Intensive Medicine”[401].

The CMU Portugal is a partnership between the US Carnegie Mellon University and the Government of Portugal, which encourages collaboration between academia and industry in Portugal’s innovation economy. Their aim is to foster areas of data science and engineering such as AI and machine learning through research projects and to promote innovation and technology[402]. In June 2018, CMU Portugal announced a new research and development funding of more than € 23 million to promote projects, that cover the domains of data science and engineering.[402]

## Cross-border collaboration in research

| 19.8 | 20 |
|---|---|
| Multilateral score[403] | EU Collaborating countries[404] |

Spain is clearly the most interactive collaborating partner of Portugal in terms of scientific output, working together on prediction or early warning systems or on automatic learning methods.

Furthermore, a coordinated approach at a European level is recommended by the “AI Portugal 2030” strategy, in order to solve the biggest challenges in the health domain, amongst others[405]. One of the main challenges is clearly the strengthening of a societal robustness by building a clear vision of the impacts of AI in democracy, privacy and commercial transparency.

401 João Reis, Paulo Santo & Nuno Melão, Impact of Artificial Intelligence Research on Politics of the European Union Member States: The Case Study of Portugal, August 2020, p.15-17

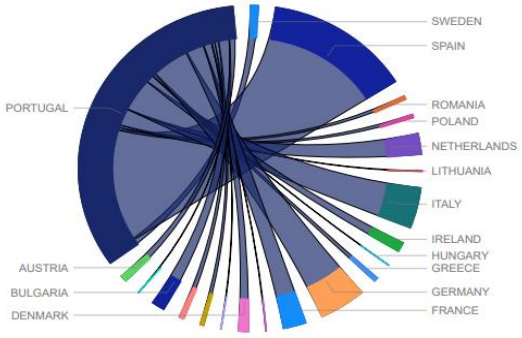
402 Carnegie Mellon University, CMU Portugal Program Announces $23M Funding for R&D Projects, June 2020. Received from: https://www.cmu.edu/news/stories/archives/2020/june/cmu-portugal-funding.html (accessed in December 2020)

403 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

404 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

405 INCoDe.2030, FCT, ANI, AMA, AI Portugal 2030 : Portuguese National Initiative on Digital Skills - An innovation and growth strategy to foster Artificial Intelligence in Portugal in the European, June 2019, p.17

Figure 80: Volume of cross-border collaboration in research


| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Spain | 25 |
| Germany | 8.1 |
| Italy | 7.4 |
| France | 4 |
| Netherlands | 3.8 |

# 3. Research and innovation around AI technologies and applications in healthcare

The Portuguese government has launched “Start-up Portugal” with the aim to create and support the national ecosystem, to accelerate the growth of Portuguese start-ups in foreign markets, and to attract national and foreign investors. “Start-up Portugal” operates as a medium between the government, entrepreneurs, incubators, and accelerators. Its offerings include training, consulting, funding and connections to business angels and venture capital.

There are at least 5 start-ups in Portugal whose work is focused mainly on AI-enabled tools in the healthcare sector, i.e. for biosignals monitoring and disease monitoring and treatment support.

AI-assisted medical robotics, as well as genome analysis were listed as the most common AI tool in public hospitals by respondents to the survey for this study.[406] Furthermore, founders of those start-ups indicated that they are sporadically collaborating with other research institutes and companies etc. due to their limited investment capacities.

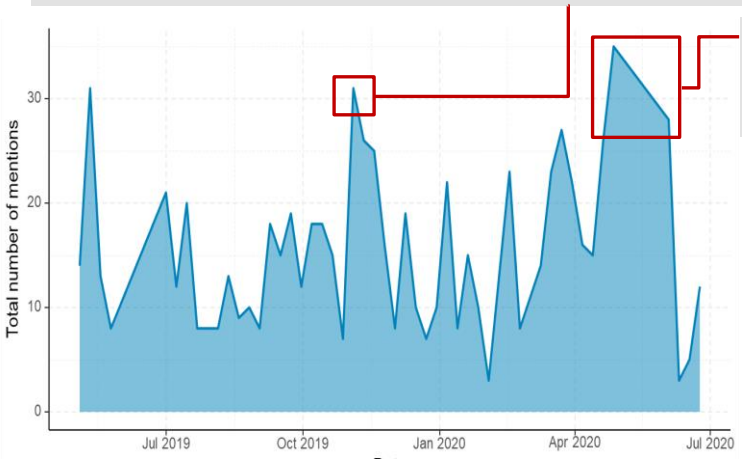
# 4. Awareness and use of AI technologies and applications in healthcare

In terms of online awareness throughout news publications and social media posts, results from news in Portugal demonstrate consistent awareness in this sector, with a total number of mentions of 808 over the past year. Some start-ups, e.g. iLoF, are beginning to step in the field. Consistent with results found for other EU countries, the Covid-19 outbreak triggered thoughts about AI opportunities in the health and care sectors.

406 See survey results.

## Figure 81: Trend of total mentions in the news

**November 2019: iLoF**, a Portuguese start-up, was awarded and ensured € 2 million in a competition organized by **EIT Health's Wild Card program, to fight Alzheimer with AI and photonics**. Also, Google has been facing concerns on **privacy and confidentiality** as a reaction to the disclosure of a secret AI Health project.

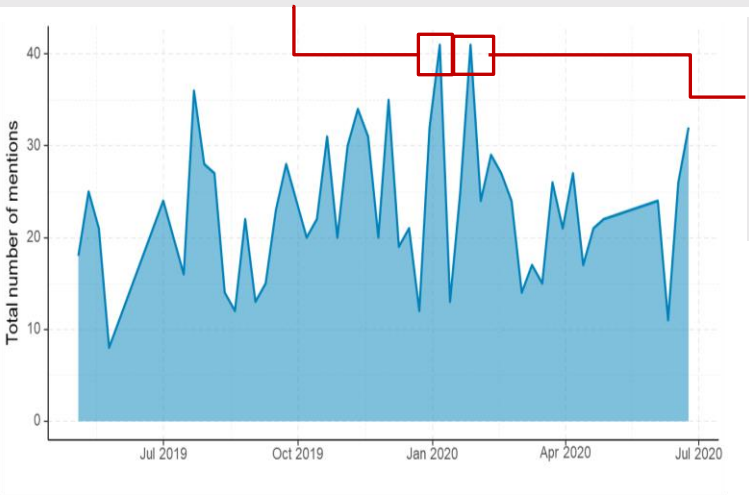



**April – May 2020:** As a consequence of the COVID outbreak, interest rose in AI applications that could help ensuring social distancing and investigate genetic factors.

The number of mentions on social media was anyhow rather low over the past year, totaling 1,100 mentions. It is yet worth mentioning that the Fraunhofer Institute has an office in Lisbon that focuses on Digital Solutions, including AI. Tweets mention the participation of researchers in a global workshop about regulatory frameworks for AI in healthcare.

## Figure 82: Trend of total mentions in social media

**January 2020:** The Portuguese office of the **Fraunhofer Institute's** department on Assistive Information and Communication Solutions sent two researchers to attend the **ITU/WHO focus group on AI and Health** and to participate in a workshop about AI for Health Standardized Assessment Framework.




**January 2020:** The tech-related communication website "pplware" tweeted ironically about the fact that a Canadian Health-monitoring platform has been able to notify its customers of a flu-like outbreak in China (which is now known as the origin of the COVID outbreak) before the WHO even notified the public thanks to AI tools.

# ROMANIA

**19.3 Mio**[407]
**Total population**

**40**[408]
**DESI 2020** Index

**72%**
% of **internet users**

**4.3%**[409]
**Population as a % of** EU27

**25**
**DESI 2020 ranking amongst** EU27

**31%**
% of population with at **least basic digital skills**

**57%**
% of **Open Data**

## 1. Relevant legislation and policy framework

Romania has not yet released its National AI Strategy, although the Ministry of Communications and Information Society announced that a strategy is on its way.[410]

However, the government did release the National Strategy on the Digital Agenda of Romania 2020, which has been modified to achieve the targets set by the Europe 2020 Strategy. One of the objectives is to modernise the public sector and embed ICT in the health sector[411].

Moreover, a new National Strategy for Smart Specialisation 2021-2027 is currently in progress with a budget of €50 million to €100 million. Its objective is to find sectors that would benefit from the entrepreneurial discovery process, such as AI for health[412].

## 2. Research and innovation around AI technologies and applications in healthcare

**Scientific Papers**

| **3.3%** | **10** |
|---|---|
| **%** in EU27[413] | **Rank** in EU27 |

**Patents**

| **0.6%** | **11** |
|---|---|
| **%** in EU27[414] | **Rank** in EU27 |

Romania contributes approximately 3.3% of scientific output in the area of AI in healthcare. There is a substantial scientific output from universities in the country with notable examples

407 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

408 Digital Economy and Society Index 2020, Country Report: Romania. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/romania

409 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

410 Alexandru Petrescu, at the 2019 Ministerial Council meeting of the Organization for Economic Cooperation and Development (OECD) in Paris. Received from: https://ec.europa.eu/knowledge4policy/ai-watch/romania-ai-strategy-report

411 Government of Romania, 2020. Received from: https://www.gov.ro/en/government/cabinet-meeting/national-strategy-on-the-digital-agenda-for-romania-2020

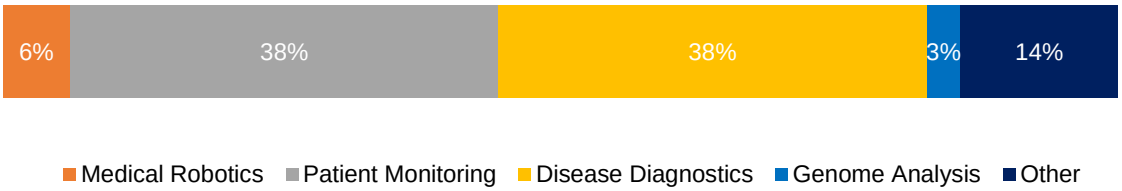
412 Romanian Ministry of Education and Research, 2020. Received from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-26914

413 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

414 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

including Politehnica University Timisoara, University of Pharmacy and Medicine, Transilvania University of Brasov and many more. Some of the main research areas include medical imaging, medical diagnosis and the management of medical data.

Figure 83: Areas of application in scientific papers




AI Romania, a project started by volunteers from the private sector in and around Romania, stresses the importance of education and research in order to be able to develop and adopt AI technologies. They hope to provide support through various projects, course materials and networks[415]. Romania has a challenge to create and retain skilled workers in the field of AI. In response, AI Romania established "AI for high school", a project that introduces AI education to young adults. Part of the project is training teachers to be able to teach the basics of AI to their students[415].

Furthermore, ARIA is a non-profit scientific association which promotes Romanian research and education in the field of AI. They bring major universities, institutes, researchers at the PhD, graduate and undergraduate levels together with economic actors like IT companies[416].

In the draft proposal of "Artificial Intelligence: A strategy for the development and adoption of AI technology at a country level", some of the initiatives address research and innovation specifically.

One initiative is creating an international Master's program in AI at a Romanian university that would attract both skilled and knowledgeable professors and young talent. Another notable initiative is a framework for businesses to provide funding to AI research groups and experts in the field[415].

## Cross-border collaboration in research

| 19.8 | 20 |
|---|---|
| Multilateral score[417] | EU Collaborating countries[418] |

Romania has primarily collaborated with Spain, Portugal, Italy, Germany, France, Finland and Austria on various research papers in the field of AI. There are several collaborative publications that focus on AI technology to help elderly or disabled people.

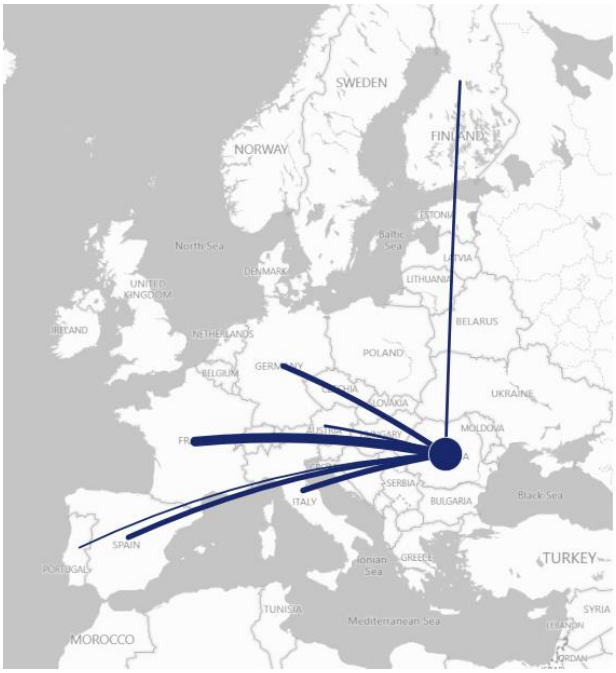
415 AI Romania, Recommendations for the development and adoption of AI technologies in Romania 2019. Received from : https://www.airomania.eu/ai-education-research

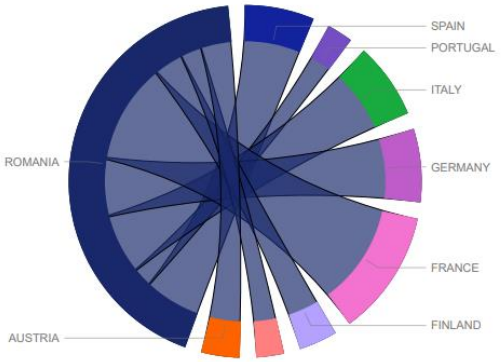
416 ARIA (Asociaţia Română pentru Inteligenţă Artificială), Received from: http://aria-romania.org/

417 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

418 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

Figure 84: Volume of cross-border collaboration in research




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| France | 5.9 |
| Italy | 3.6 |
| Germany | 3.5 |
| Spain | 2.2 |
| Austria | 2.0 |

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Based on the 'Specific Support to Romania – Starts-ups, Scale-ups and Entrepreneurship in Romania' report released by the European Commission, business funding in Romania is the 5th most important problem that Romanian SMEs face, just before finding customers (28 % of SMEs), availability of skilled staff (18%), labour production costs (13%) and regulation (12%) as more problematic than access to finance (11%)[419].

Crowdfunding, angel investments, venture capital and EU funding are amongst the best options for start-ups to be funded. Some examples of networks comprising of angel investors and venture capitalists are TechAngels, AngelConnect and VentureConnect[420].

We identified only one start-up in Romania whose work is primarily focused on AI-enabled tools in the healthcare sector and which aims to improve the quality of oncological care through the use of analytics.

419 Specific Support to Romania Start-ups, Scale-ups and Entrepreneurship in Romania. Received from: https://uefiscdi.gov.ro/resource-87095

420 Which types of investment and funding opportunities are out there? Received from: https://yecommunity.com/en/countries/romania/funding

# 4. Awareness and use of AI technologies and applications in healthcare

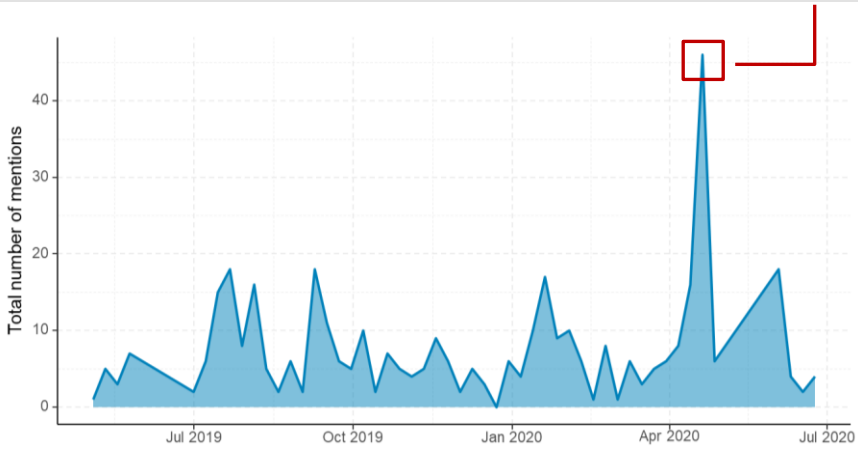
The country's healthcare system has scored lower in performance comparing to other Member States within the European Union[421]. Health spending per capita in Romania is the lowest in the EU. Rural areas do not have the same access to healthcare as urban areas, leading to medical needs being unmet. The low funding combined with the inefficient use of public money obstructs decision-making and information sharing in healthcare. There is a general lack of investment and therefore lack of use of advanced technologies. If realised, the implementation of AI technologies is expected to improve the overall quality of the healthcare system[421].

Online awareness on AI and Health topics is relatively low in Romania, with a total of 388 mentions in the news within the past year (June 2019 – July 2020). The only noticeable peak was caused by the Romanian AI start-up Wello within Google's Startups Accelerator.

Online awareness on AI and Health topics is relatively low in Romania, with a total of 388 mentions in the news within the past year (June 2019 – July 2020). The only noticeable peak was caused by the Romanian AI start-up Wello within Google's Startups Accelerator.

Figure 85: Trend of total mention in the news

**April 2020:** Wello, a Romanian start-up based in Cluj, was selected by Google's Startups Accelerator for their AI-based nutritional health platform for children and parents.

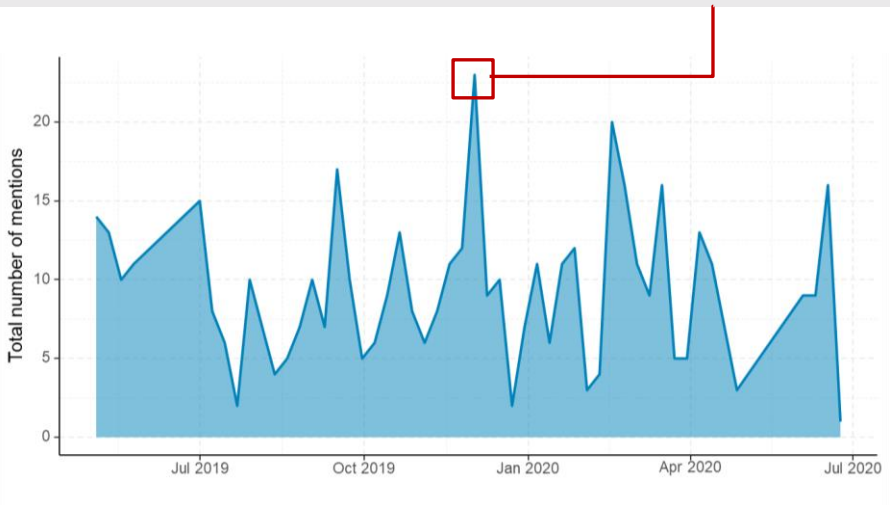



Activity related to AI and health on social media is, on an overall basis, rather low and erratic. In December 2019, a few more mentions than usual were caused by discussions on AI-enabled precision medicine and on Amazon's role in the advance of AI in healthcare.

421 European Commission, 2017. Received from: https://www.euro.who.int/__data/assets/pdf_file/0008/355994/Health-Profile-Romania-Eng.pdf

## Figure 86: Trend of total mention in social media

**December 2019:** Discussions about the **new ways to fight disease thanks to AI**, such as the **identification of molecular patterns of cancer**, and about **Amazon's investments** in the field of AI applied to Healthcare bring a slightly higher number of mentions than usual.



**5.5 Mio**[422]
**Total population**

**45.2**[423]
**DESI 2020** Index

**82%**
% of **internet users**

**1.2%**[424]
**Population as a % of** EU27

**21**
**DESI 2020 ranking amongst** EU27

**54%**
% of population with at **least basic digital skills**

**33%**
% of **Open Data**

# SLOVAKIA

## 1. Relevant legislation and policy framework

The government has developed an "Action plan for the digital transformation of Slovakia for 2019-2022"[425] which is part of the wider strategy report "2030 Digital Transformation Strategy for Slovakia". In addition to the action plan for digital transformation, the "state R&D programs, state R&D infrastructure development programs and the Slovak Research and Development Agency programs" are the national instruments for the distribution of public finances for R&D, covering AI initiatives.

As part of this broader digitalisation strategy and with a view of developing a digital single market, the Slovakian government intends to support the development of AI across two themes. The first focusses on research and education in the field of AI. This entails governmental support in setting up expert groups in order to move the research and application of AI forward. The pillar foresees research institutions strengthening their involvement in projects that provides access to data[426]. The second theme prioritises economic growth in Slovakia using AI. The government sees enormous potential in AI tools and technologies that can in turn increase the country's competitiveness.

The Ministry of Health confirms that there is some national legislation in place in the area of AI in healthcare, particularly regarding the storage and sharing of personal health data[427]. Moreover, the government has implemented data protection rules regarding the use and exchange of health data for the purpose of AI analysis, cybersecurity and algorithmic transparency[426]. An open data platform is also under consideration. The Ministry of Health is responsible for initiating the assessment of impacts on the use of smart systems and digital technologies on health. They have therefore set up a team of experts who deploy humancentric principles into smart systems.

Furthermore, via the Institute for Health Policies, the Ministry of Health is working on a "Roadmap for utilising AI in healthcare" to secure adequate human capital, infrastructure and a legal framework in order to integrate AI in healthcare[428]. To help advance this work, the Slovak government is actively endorsing new business models that support platforms which

422 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

423 Digital Economy and Society Index 2020, Country Report: Slovakia. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/slovakia

424 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

425 Action plan for the digital transformation of Slovakia for 2019 – 2022. Received from: https://www.mirri.gov.sk/wp-content/uploads/2019/10/AP-DT-English-Version-FINAL.pdf

426 Ibid.

427 See survey results.

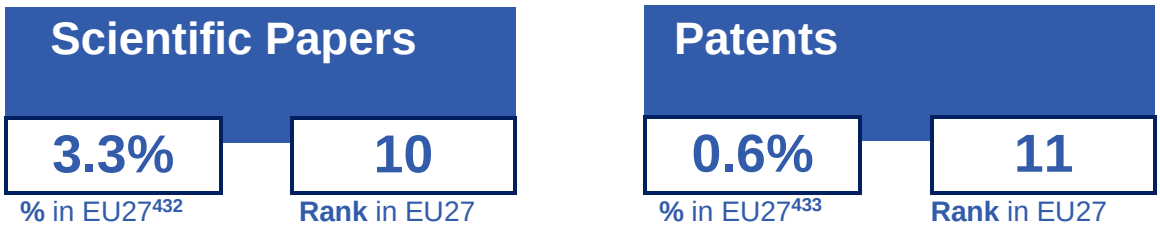
428 How artificial intelligence arrives to health care. Received from: https://spectator.sme.sk/c/22404205/the-arrival-of-artificial-intelligence.html https://spectator.sme.sk/c/22404205/the-arrival-of-artificial-intelligence.html

may transform health care. In other words, Slovakia is setting up regulatory sandboxes[429] and introducing future-proof regulations[430].

In the survey conducted as part of this study, founders of AI start-ups who operate in the healthcare sector indicated that they would like to see the following areas of legislation/policy in place:[431]

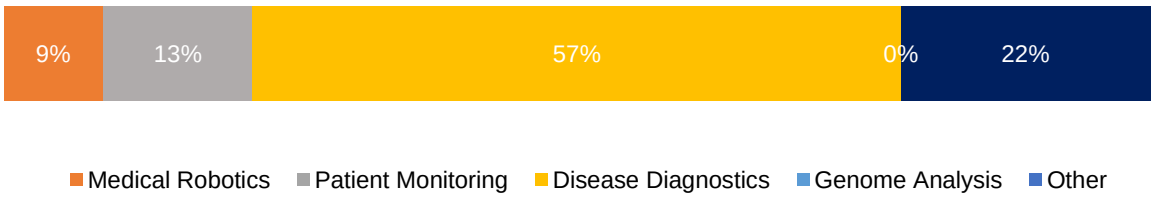
- Policies aimed at the encouraging the deployment of AI technologies in healthcare;
- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Policies around AI testing and certification in the healthcare sector.

## 2. Research and innovation around AI technologies and applications in healthcare




Research on AI for healthcare in Slovakia is rather immature. The country contributes approximately 0.8% of scientific output in this area and ranks 17th amongst EU countries. Despite regulatory efforts such as the action plan for digital transformation, the field of AI remains nascent.

Figure 87: Areas of application in scientific papers




The main area of application in scientific papers cover disease diagnostics. The Technical University of Košice, the Slovak University of Technology in Bratislava and the Slovak Academy of Sciences are some of the main contributors to these scientific papers. These

429 a framework set up by a regulator that allows innovative startups conduct live experiments in a controlled environment under a regulator's supervision.

430 Action plan for the digital transformation of Slovakia for 2019 – 2022. Received from: https://www.mirri.gov.sk/wp-content/uploads/2019/10/AP-DT-English-Version-FINAL.pdf

431 See survey results.

432 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

433 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

institutions are among the six AI research institutions of Slovakia, which boast more than 200 AI researchers all together[434].

The privately founded institute KInIT, dedicated to research of intelligent technologies, i.e. AI, NLP, ML and other areas of data science, is the first independent institute of this kind in Slovakia.[435] KInIT is seeking to collaborate with universities in Europe and private companies with the goal of bringing quality R&D in the areas of intelligent technologies and computing in the private sector. Current research topics that could be applied to healthcare comprise of Neuro-Linguistic Programming (NLP) and software visualisation and testing.

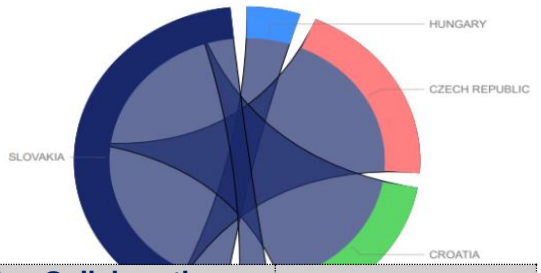
## Cross-border collaboration in research

| 2.9 | 4 |
|---|---|
| Multilateral score[436] | EU Collaborating countries[437] |

Despite efforts to encourage research at the national level (as stated in the action plan for digital transformation), the volume of cross-border collaboration in research is very low. Some publications have been released in collaboration with researchers from the Czech Republic and the technological faculties of the Technical University of Košice, e.g. investigating decision support frameworks for Parkinson's disease and the use of intelligent systems for mental wellbeing.

Slovakia enters further collaborations with neighbouring countries like Croatia, Hungary and Austria.

Figure 88: Volume of cross-border collaboration in research


| Top Collaborating EU Countries | Bilateral score |
|---|---|
| Czech Republic | 3.0 |
| Croatia | 2.8 |
| Hungary | 0.8 |
| Austria | 0.5 |

434 SLOVAK ACADEMIA FOR AI. Received from: https://slovak.ai/wp-content/uploads/2020/02/bro%C5%BE%C3%BAra_SK-Academia-AI.pdf

435 Cf. Website Kempelen Institute of Intelligent Technologies. Received from: https://kinit.sk/index.php/en/site/index

436 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

437 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Slovak Business Agency is offering the “Microloan programme”, a programme intended for small businesses employing up to 50 people, and offers microloans of up to € 50,000, with repayment set from 6 months to 4 years and interest rate ranging from 1.26 % to 9.16%[438]. The aim of the “Microloan programme” is to provide financial support to micro and small entrepreneurs, increase the sustainability of small businesses and create conditions for employment maintenance and creation of new job opportunities. The Slovak Business Agency is also offering venture capital and non-financial assistance to SMEs such as consultation services, formulation of business plans and short-term education[439].

In the Slovak Startups Report of 2016 completed by the Slovak Alliance for Innovation Economy (SAPIE), it is reported that 44% of start-ups did not approach public institutions for support due to overbearing bureaucratic procedures, or simply because they saw no need for such funds[440].

There are at least four start-ups in Slovakia whose work is focused mainly on AI-enabled tools in the healthcare sector. For example, one start-up created a platform to ease cooperative analysis of medical images, or in other words, a decentralised healthcare AI system based on blockchain technology. Most of the start-ups aim to make an impact on the acceleration of the diagnostic processes and the interpretation of medical data.

According to responses from three of those Slovak start-ups, there is no notable collaboration between SMEs and research entities/healthcare delivery centres or public/private organisations regarding the translation of AI-related research into healthcare applications.[427] Survey participants indicated that they obtain data for the development of AI applications in healthcare from openly available research databases, mainly using imaging data and to some extent microbiology data.

Amongst those start-ups who responded to our survey, there is wide-ranging agreement on the following barriers related to the implementation and utilisation of AI systems by health professionals in the health sector:[441]

- Lack of IT knowledge and competencies;
- Lack of legislation;
- Lack of understanding of the technology;
- Lack of trust in AI.

438 Slovak Business Agency. Received from: http://www.sbagency.sk/en/microloan-programme

439 Slovak Business Agency Report. Received from: http://www.sbagency.sk/sites/default/files/sba_shark_eng_000000`02.pdf

440 Slovak Startups Report 2016. Received from: https://www.startitup.sk/wp-content/uploads/2016/11/file-1478174997-581b2915dd7c5.pdf

441 See survey results.

# 4. Awareness and use of AI technologies and applications in healthcare

Results from the survey show that AI-enabled healthcare tools developed by start-ups are used to a limited extent in Slovakia. Yet, according to their national strategy plan, the country shows a high uptake of publicly available AI tools that are directly used by patients.[426]

Despite some of its regulatory and policy initiatives, Slovakia's digitally-literate population (54%) has shown little interest in dedicated AI strategy. Throughout a one-year period (June 2019 – July 2020) there was a relatively low number of mentions in the news and on social media in Slovakian online sources. No contextually significant peaks have been identified (see graphs below).

Figure 89: Trend of total mentions in the news

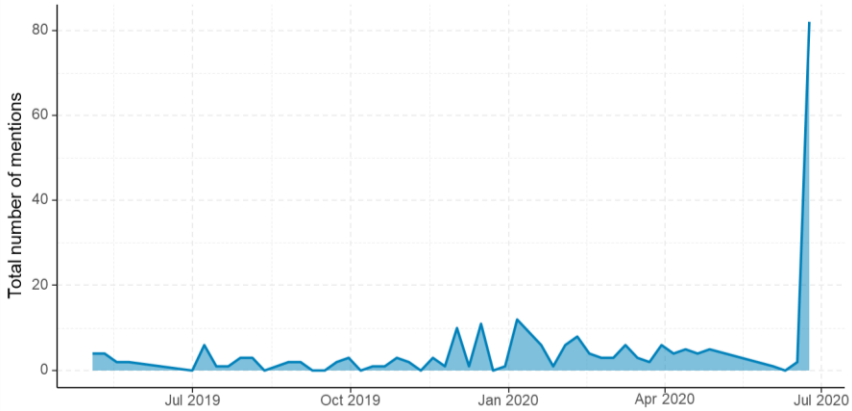
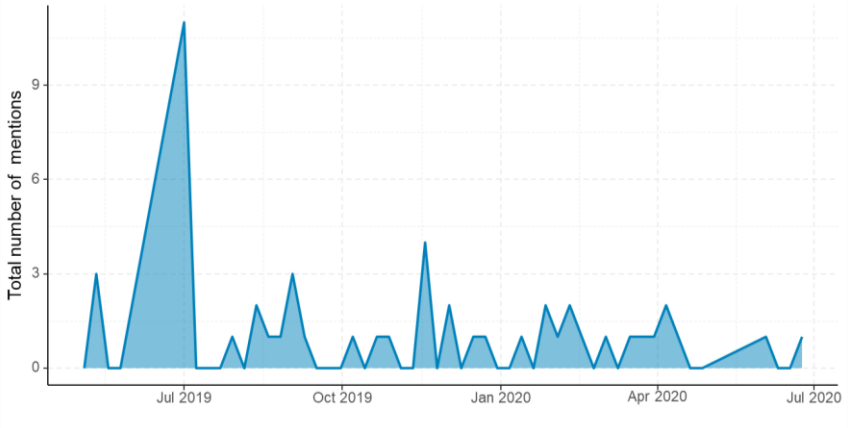



Figure 90: Trend of total mentions in social media



# SLOVENIA

**2.1 Mio**[442] **Total population**

**51.2**[443] **DESI 2020** Index

**81%** % of **internet users**

**0.5%**[444] **Population as a % of** EU27

**15** **DESI 2020 ranking amongst** EU27

**55%** % of population with at **least basic digital skills**

**75%** % of **Open Data**

## 1. Relevant legislation and policy framework

"Digitalna Slovenia" is a digital coalition with an aim to transition the country into an increasingly digital age. The stakeholders include the Government of the Republic of Slovenia, Slovenian Rectors' Conference, Coordination of Independent Research Institutions of Slovenia (KOsRIS), Association of Municipalities and Towns of Slovenia, the National network of NGOs for an inclusive information society, as well as other economic stakeholders. The coalition is focussed on opening opportunities and improving development across sectors in ICT. One of their main objectives is to coordinate policies and measures that help build the digitalisation capacity among the stakeholders.

The recently released "National Program Promoting Development and Use of Artificial Intelligence in Republic of Slovenia by 2025" was developed by a working group that consists of representatives of various ministries, research institutions and government departments. Their work focused on four domains, one of which is health and medicine. This program thus provides strategic guidelines that define objectives and measures in the healthcare sector.[445]

## 2. Research and innovation around AI technologies and applications in healthcare

**Scientific Papers**

| **23 %** | **18** |
|---|---|
| **%** in EU27[446] | **Rank** in EU27 |

**Patents**

| **0** | **n/a** |
|---|---|
| **%** in EU27[447] | **Rank** in EU27 |

442 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

443 Digital Economy and Society Index 2020, Country Report: Slovenia. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/slovenia

444 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

445 Nacionalni program spodbujanja razvoja in uporabe umetne intelligence v Republiki Sloveniji do leta 2025, Republic of Slovenia, 2020. Received from: https://www.gov.si/assets/ministrstva/MJU/DID/NpAI_SI_2020-08-20_draft.pdf

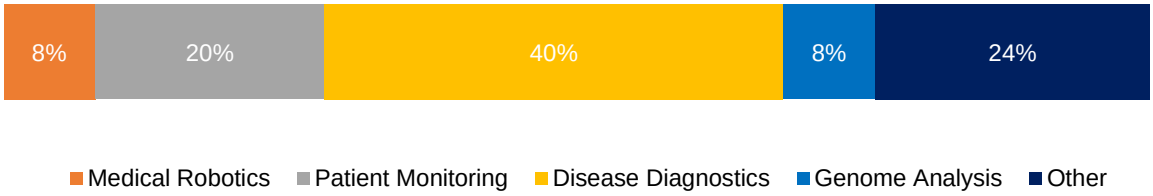
446 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

447 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

Slovenia contributes 0.8% of scientific publications in the area of AI in healthcare, ranking 20th amongst the EU27. Most publications are outputs of the technology and medicine faculties of the major Slovenian Universities, as well as research institutes such as the Josef Stephan Institute[448] in Ljubljana which has a dedicated Artificial Intelligence lab[449] and the National Institute of Public Health[450].

Slovenia has many years of experience in researching the use of AI in the field of health and medicine, particularly in the field of machine learning for diagnostic purposes. There is a strong cooperation between researchers in medicine and AI.

Figure 91: Areas of application in scientific papers




One of the parallel initiatives around AI in Slovenia is the establishment of the International Research Centre in Artificial Intelligence[451], backed by UNESCO, in Slovenia's capital Ljubljana with strategies around research, training, impact and outreach and policy innovation around AI. It is also worth noting that the "Slovenian Artificial Intelligence Society" exists since 1992 and connects researchers and practitioners to promote theoretical and applied research as well as the transfer of AI technology to industrial and commercial environments[452].

Support for research and innovation is outlined in the "National Program Promoting Development and Use of Artificial Intelligence in Republic of Slovenia by 2025". The state will support targeted research to ensure its excellence and capacity in the field of AI, and research, development and innovation projects in the field of AI. The aim is to use AI in innovative products and services (in the private and the public sector), which have the potential to contribute to competitiveness, economic development and the general quality of life of people. Healthcare will be one of the targeted research areas. The Slovenian government will encourage interdisciplinary activities by connecting the research and higher education sphere with the economy and non-governmental sectors both at the national as well as the international level[445].

## Cross-border collaboration in research

| 1 | 8 |
|---|---|
| Multilateral score[453] | EU Collaborating countries[454] |

Slovenia collaborates with at least eight other EU Member States in the research area of AI in healthcare. Institutions like University of Ljubljana, the Jožef Stefan Institute, University of

448 Jožef Stefan Institute, Annual Report, 2018. Received from: https://www.ijs.si/ijsw/JSI

449 Jožef Stefan Institute, Artificial Intelligence Laboratory - E3. Received from: https://www.ijs.si/ijsw/Artificial%20Intelligence%20E3

450 National Institute of Public Health Slovenia. Received from: https://www.nijz.si/en

451 International Research Centre on Artificial Intelligence under the auspices of UNESCO, Jožef Stefan Institute. Received from: https://ircai.org/

452 Slovenian Artificial Intelligence Society. Received from: http://slais.ijs.si/

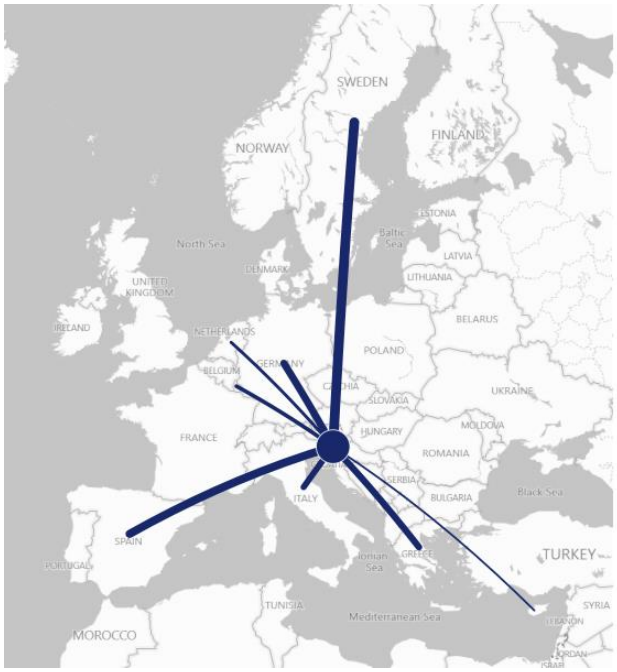
453 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

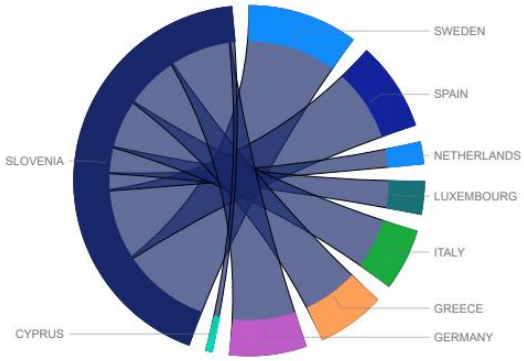
454 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

Maribor, the National Institute of Chemistry, Health Centre Velenje, University Rehabilitation Institute and the National Institute of Public Health all took part in collaborative research papers in various uses of AI in health.

The research ranged from patient monitoring solutions (such as a nutrition tracking application for people with Parkinson's Disease, or glucose measurement machine-learning technology for diabetic patients), to Disease Diagnostics (detection of Multiple Sclerosis progress through MRI scans, detection of Chronic heart failure from heart sounds), to evaluating medicines (Application of advanced supervised and unsupervised machine learning techniques) to retrospective treatment studies (using retrospective data on chronic disease).

Figure 92: Volume of cross-border collaboration in research




| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Sweden | 2.0 |
| Spain | 1.6 |
| Germany | 1.4 |
| Greece | 1.2 |
| Italy | 1.1 |

## 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The start-up ecosystem in Slovenia is supported by schemes such as the "Slovene Enterprise Fund" (SEF)[455] aiming to improve the access to financial resources for micro, small and medium-sized enterprises (SMEs). SEF is offering financial solutions with favourable refundable means (loans, guarantees for loans, subsidised interest rates, venture capital) and in 2019 alone supported 3,820 projects, including projects in AI in healthcare.

Additionally, Slovenia has angel investors clubs such as the "Business Angels of Slovenia"[456], offering smart money seed investments of €50.000 up to €250.000 to help start-ups grow and develop, as well as, open platforms such as "Startup Slovenia"[457] which are contacting, coordinating and promoting the stakeholder network of the Slovene start-up ecosystem in Slovenia and abroad.

455 Slovene Enterprise Fund, 2020. Received from: https://podjetniskisklad.si/en

456 Business angels of Slovenia, 2020. Received from https://www.poslovniangeli.si/en

457 Startup Slovenia. Received from: https://www.startup.si/en-us

We identified at least two start-ups in Slovenia working on AI technologies and applications in healthcare, mainly focusing on preventive medicine and the design, creation and global distribution of medical devices.

# 4. Awareness and use of AI technologies and applications in healthcare

Slovenia ranked high compared to other Member States in the use of e-health services by regular users, indicating the relative interest of the population in such services. The government believes that successful implementation of AI in healthcare will also have a high uptake. The state plans for AI technology to be used to treat patients as well as create potential preventative actions in the health system. Due to demographic changes towards an aging population, the use of AI will be very relevant for Slovenia to support the elderly**Error! Bookmark not defined.**.

Despite a generally decent overall internet activity in Slovenia, the awareness of AI and Health topics in Slovenia is relatively low, both thru the number of mentions in the news and on social media. No significant peaks with an identified cause have been identified over the past year, see images below.

Figure 93: Trend of total mentions in the news

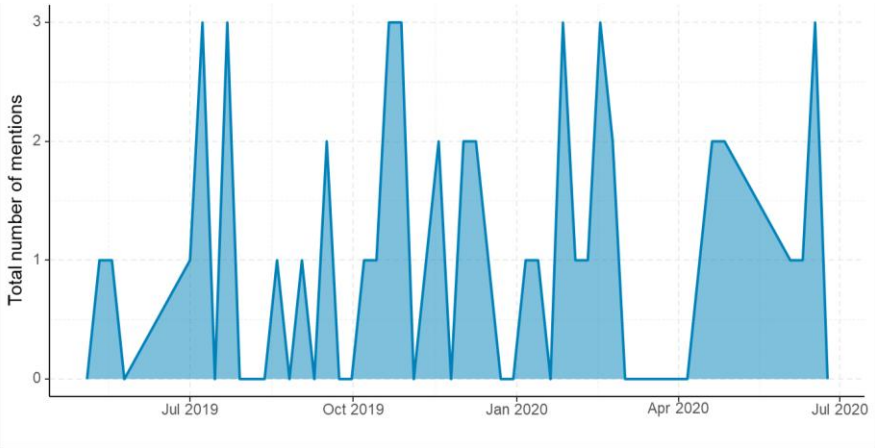
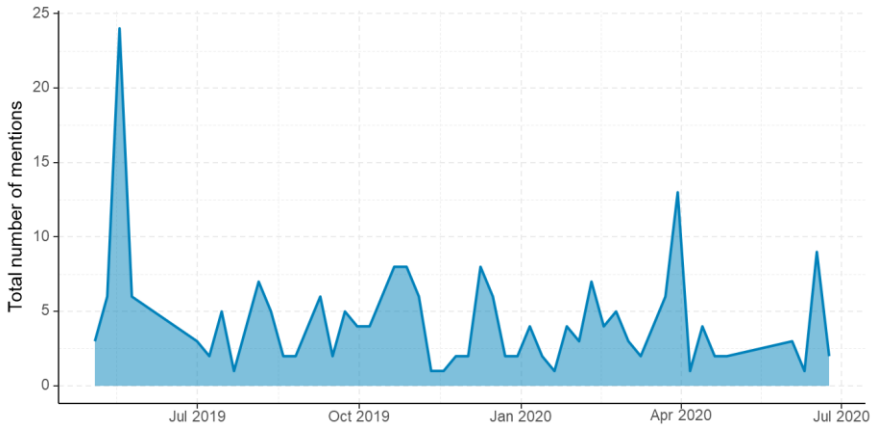



Figure 94: Trend of total mentions in social media



# SPAIN

**47.3 Mio**[458]
**Total population**

**57.2**[459]
**DESI 2020** Index

**88%**
% of **internet users**

**10.6%**[460]
**Population as a % of** EU27

**10**
**DESI 2020 ranking amongst** EU27

**57%**
% of population with at **least basic digital skills**

**90%**
% of **Open Data**

## 1. Relevant legislation and policy framework

Spain published a national "Research, Development and Innovation (RDI) Strategy on AI" in March 2019, which is considered as the required foundation for the development of a national AI strategy.[461] In this report, Spain's Ministry of Science, Innovation and Universities has laid out relevant priorities and policy recommendations for the creation of a solid research, development and innovation ecosystem in the field of AI.

Healthcare is one of the priority areas identified, with an emphasis on the positive impact of AI on prevention, diagnosis and treatment of childhood obesity, cardiovascular diseases as well as various types of cancer.[462]

Considering the increasing life expectancy until 2040[463], the Spanish government aims at an improved person-computer interaction and automatic assistance of health professionals. The concept of "P4 medicine"[464] should be based on automatic learning and computer vision. Moreover, emphasis is given on the creation of a digital data ecosystem with open data access and structuring of health-related data for improved interoperability (i.e. information from Electronic Health Records or medical imaging tools).

Another notable initiative which paves the way toward the progressive use of AI in the healthcare sector is the formation of the AI Advisory Council in 2020[465]. This body is responsible for providing analysis, advice and support to the Spanish Government regarding AI and its safe and ethical use.
In the survey conducted for this study, founders of AI-focused SMEs operating in the healthcare sector indicated that they would like to see in place the following areas of legislation/policy:[466]

458 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

459 Digital Economy and Society Index 2020, Country Report: Spain. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/spain

460 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

461 Ministry of Science, Innovation, Universities: "Spanish RDI Strategy in Artificial Intelligence", 2019. Received from: https://www.ciencia.gob.es/stfls/MICINN/Ciencia/Ficheros/Estrategia_Inteligencia_Artificial_EN.PDF

462 Cf. ibid.

463 Cf. Ministry of Industry, Commerce and Tourism: "Industria Conectada 4.0", 2020. Received from: https://www.industriaconectada40.gob.es/Paginas/index.aspx

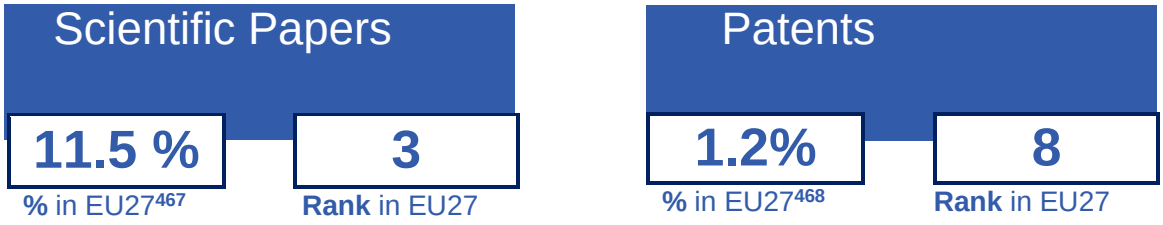
464 "P4 medicine" refers to predictive, personalized, preventive and participatory medicine. (Cf. Flores, Mauricio et al. "P4 medicine: how systems medicine will transform the healthcare sector and society." Personalized medicine vol. 10,6, 2013. doi:10.2217/pme.13.57)

465 Cf. Ministry of Economic Affairs and Digital Transformation: "El Gobierno constituye el Consejo Asesor de Inteligencia Artificial", 2020. Received from: https://www.mineco.gob.es/portal/site/mineco/menuitem.ac30f9268750bd56a0b0240e026041a0/?vgnextoid=51884ba89bc63710VgnVCM1000001d04140aRCRD

466 See survey results.

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis,
- Policies around AI testing and certification in healthcare sector;
- Cybersecurity policies;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Policies around the ethical use of AI.

## 2. Research and innovation around AI technologies and applications in healthcare




Research, development and innovation activities constitute the core of future national AI strategy. The Spanish RDI strategy on AI indeed reveals the health sector as a prioritized strategic area for the development of research, development and innovation activities in AI, e.g. for Intelligent Production Systems, design of cognitive assistants, data analysis and automatic learning.

Spain contributes approximately 11.5% of scientific output in the area of AI in healthcare and ranks 3rd amongst EU countries. Universities as well as independent research groups and institutes are contributing to this output. There is research conducted in this field at different universities in Barcelona, e.g. the University of Barcelona (Mathematics and Computer Science Department) and the University Politècnica de Catalunya.

Other research entities with medical focuses in Barcelona comprise the CETIR Grup Mèdic Barcelona, the MedTech Universitat Pompeu Fabra Barcelona or the Universitat Autònoma de Barcelona (Department of Psychobiology and Methodology of Health Sciences). Considerable scientific publications also originate from the Department of Computer Technology at the University of Alicante or rather the Intelligent Data Analysis Laboratory at the University of Valencia.

Spain's Artificial Intelligence Research Centre (IIIA) was formed in 1994 to carry out research in the field of AI along three main research lines and in various domains, including medicine.[469] In 2019, the Ministry of Science and Innovation created a 'Capabilities Map' to inform the Spanish public on the institutions carrying out research in the field of AI in Spain.[470]

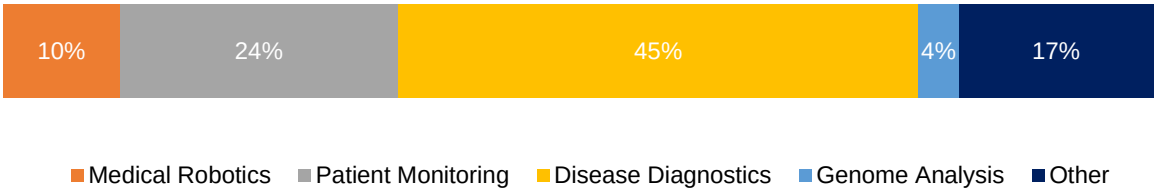
467 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

468 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

469 Cf. IIIA – CSIC: "Research and Development in different areas of Artificial Intelligence", 2020. Received from: https://www.iiia.csic.es/

470 Cf. Ministry of Science and Innovation: "El Ministerio de Ciencia, Innovación y Universidades identifica las fortalezas españolas en IA", 2019. Received from: https://www.ciencia.gob.es/portal/site/MICINN/menuitem.edc7f2029a2be27d7010721001432ea0/?vgnextoid=cd1b8116b1d8d610VgnVCM1000001d04140aRCRD&vgnextchannel=4346846085f90210VgnVCM1000001034e20aRCRD&lang_choosen=en

Figure 95: Areas of application in scientific papers




Generally, there is a high amount of publications in the areas of disease diagnostics and patient monitoring. Amongst all Spanish healthcare institutions, it appears that the Hospital General Universitario Gregorio Marañón, situated in Madrid, is one of the key contributors in the field of high-precision AI for improved diagnosis and disease.[471]

## Cross-border collaboration in research

**41.9**

**Multilateral score**[472]

**18**

**EU Collaborating countries**[473]

Spain's output in terms of scientific publications results in a high multilateral collaboration score. There is a high level of cross-border collaboration with at least 18 EU countries, especially Portugal, Italy, France, Germany and the Netherlands. There are considerable results from cross-border collaborations with University Hospitals in Spain.

Considering that research, development and innovation activities in the healthcare domain are identified as a priority area, Spain aims at developing an organizational structure for a robust research, development and innovation system and increase the opportunities for collaborative partnerships, supported by different policy initiatives.[474]

The creation of a Network of Centres of Excellence in AI and Digital Innovation Hubs will be considered in the context of such a regulatory framework. This network, mainly formed by existing national AI research centres and other research centres, aims to strengthen research, development and innovation activities and promote collaborations. To enhance collaboration, Spain's national RDI strategy suggests an AI Capability Map mapping competences and capabilities.

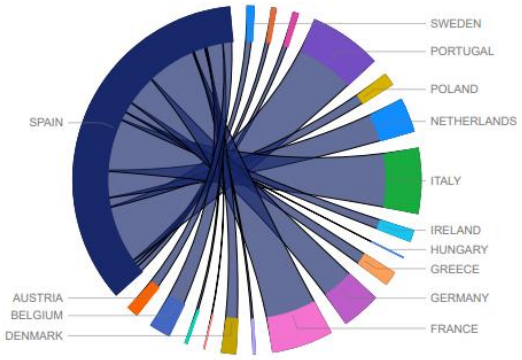
471 Cf. Universidad Carlos III de Madrid: "High Precision AI and Tomosynthesis System for COVID-19", 2020. Received from: https://healthmanagement.org/c/imaging/news/high-precision-ai-and-tomosynthesis-system-for-covid-19

472 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

473 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

474 European Commission: "Spain AI Strategy Report", 2020. Received from: https://knowledge4policy.ec.europa.eu/ai-watch/spain-ai-strategy-report_en

Figure 96: Volume of cross-border collaboration in research


| | Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|---|
| | Portugal | 25 |
| | Italy | 22.7 |
| | France | 21.3 |
| | Germany | 13.5 |
| | Netherlands | 11.8 |

# 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

Falling under the management of the General Directorate of Industry and SMEs, the state-owned organisation ENISA supports the culture of innovative entrepreneurship in Spain.[475] More specifically, ENISA boosts the growth potential of SMEs by providing them with financial support. It offers three distinct financing options: an option for young people with recently established enterprises, an option for recently established enterprises and start-ups regardless of the owner's age and a third option aiming at the growth of a business and its competitive advantage.

Spanish start-ups surveyed in the context of this study indicated that they received more than EUR 500,000 via public funds/European Commission funds in the past three years.[469]

There are at least 14 start-ups in Spain whose work is focused mainly on AI-enabled tools in the healthcare sector. These start-ups specialize in various fields such as diagnosis, evaluation of treatments and human wellbeing. Regarding types of data used for the development of AI applications in healthcare, start-ups that participated in the survey indicated to mainly use imaging data and vital sign data. [469]

The major part of these start-ups use data from open databases but are not willing to share their data. The remaining start-ups responded to neither use open data, nor share their data to open databases. They use unstructured data (e.g. doctor's notes), vital sign and genome data and data extracted from wearables. [469]

In terms of expected impact at the end-user level, founders of AI SMEs indicated improved and earlier diagnosis and an expected objectivity in the evaluation of X-Rays, MRIs and CT images, eventually leading to improved quality of patients' lives.

475 Cf. Ministry of Industry, Commerce and Tourism, Enisa: "We are Enisa", 2020. Received from: https://www.enisa.es/en

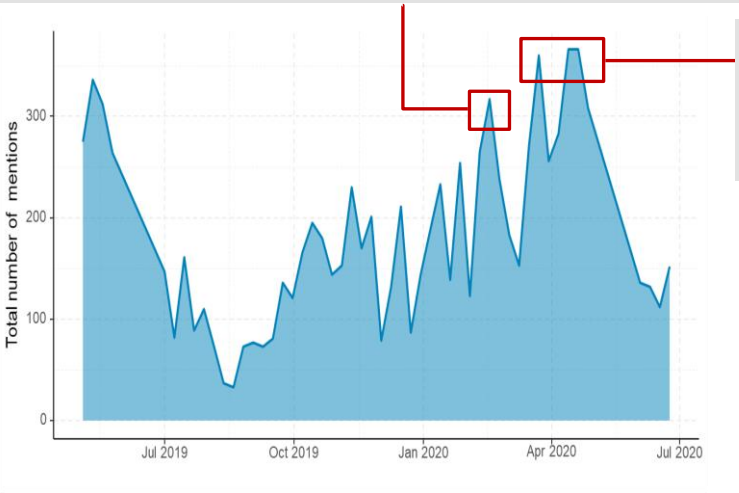
# 4. Start-up ecosystem relevant to AI technologies and applications in healthcare

Regarding awareness raised across online news publications, despite a medium level of digital literacy (e.g. 57% of people with at least basic digital skills), Spain shows a relatively high level of online awareness on AI and health topics. The total number of mentions on this topic totals in 11,200 mentions thru the analysed time frame. The use of new AI-related technology in health, such as surgical robots, as well as the engagement of international key players like Samsung arouses end users' interest (see graph below).

As many other countries, the outbreak of Covid-19 resulted in an even more vivid interest in how AI technologies could help to face the crisis.

Figure 97: Trend of total mentions in the news

**February 2020:** The use of an AI-enhanced **surgical robot in Cordoba's hospital**, as well as the opening of **Samsung's new showroom** in Barcelona and discussions about legal changes to keep up with AI developments in ethically sensitive fields like Health are behind this increase in the number of mentions.

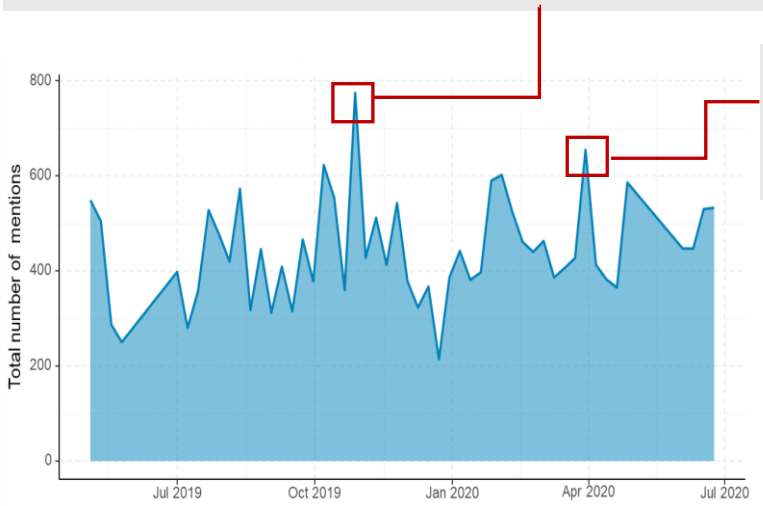



**March to May 2020:** Spain has known a **growing interest in AI** developments related to the fight against COVID-19, ranging from AI-**enhanced X-Ray** imaging to detect COVID, to AI-based **epidemiological models**, and including **genetical sequencing of the virus**.

Mentions about AI and health on social media are stable through time in Spain, with a total of 23,700 mentions over the past year. In particular, hype created around the movie "Blade Runner" or announcements about the Covid-19 outbreak by researchers resulted in relatively noticeable peaks in the number of mentions.

## Figure 98: Trend of total mentions in social media

**November 2019:** Hype on the fact that November 2019 is the month in which the story of the movie **Blade Runner** takes place, which is the occasion to compare today's developments in **AI and genetics** as well as the emergency to address climate issues with this dystopian fiction.




**April 2020:** A group of researchers from the Loyola University arouse people's hope by stating that the **mathematical model they built with AI techniques** infers that Andalusia has exceeded the **peak of the Covid-19 outbreak**.

# SWEDEN

**10.3 Mio**[476]
**Total population**

**69.7**[477]
**DESI 2020** Index

**95%**
% of **internet users**

**2.3%**[478]
**Population as a % of** EU27

**2**
**DESI 2020 ranking amongst** EU27

**72%**
% of population with at **least basic digital skills**

**55%**
% of **Open Data**

## 1. Relevant legislation and policy framework

The Swedish government released the "National Approach for Artificial Intelligence" in 2018, to provide an overall direction for AI-related work and recommendations to help the country improve its welfare and competitiveness through the exploitation of AI[479].

The Swedish government is setting up policies to foster AI collaborations and partnerships by creating networks between players within the country and cross-border collaborations with other Member States or beyond the EU by setting up a framework of nodes and co-location areas across Sweden. As an example, the Örebro node[480], a collaboration between Örebro University and Region Örebro County, will form the foundations of the new node in Örebro, which will work, amongst other things, on health issues.

Furthermore, the Analytic Imaging Diagnostic Arena (AIDA), a Swedish arena for cross-disciplinary and cross-sectoral collaboration in research and innovation on analytic image-based diagnostics, is aiming for large scale impact from AI in healthcare.

Regarding ethical and sustainable AI, the Swedish government has emphasized the importance of developing ethical guidelines to ensure a transparent, explainable, and non-discriminatory development of AI, particularly in systems that may affect the physical world, such as AI applications in healthcare.[481] To this purpose, the Swedish government established a Committee for Technological Innovation and Ethics (KOMET)[482] in August 2018 with initiatives including the establishment of the AI sustainability center, and seminars at universities on the ethical challenges of AI in business, administration and across various sectoral areas.

Sweden has a considerable amount of policy initiatives in place, including strengthening SMEs' ability to use data as a strategic resource, or accelerating research and innovation by

476 Eurostat, Population on 1 January, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00001/default/table?lang=en

477 Digital Economy and Society Index 2020, Country Report: Sweden, Shaping Europe's digital future. Received from: https://ec.europa.eu/digital-single-market/en/scoreboard/sweden (accessed in December 2020)

478 Eurostat, Population as a percentage of EU 27 (from 2020) population, 2020, https://ec.europa.eu/eurostat/databrowser/view/tps00005/default/table?lang=en (accessed in December 2020)

479 OECD, National Approach to Artificial Intelligence, October 2020. Received from: https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24975 (accessed in December 2020)

480 Örebro University, Örebro to be AI node in national innovation initiative for applied AI, October 2019. Received from: https://www.oru.se/english/research/research-news/orebro-to-be-ai-node-in-national-innovation-initiative-for-applied-ai/ (accessed in December 2020)

481 Government Offices of Sweden - Ministry of Enterprise and Innovation, National approach to artificial intelligence, February 2019, p.5

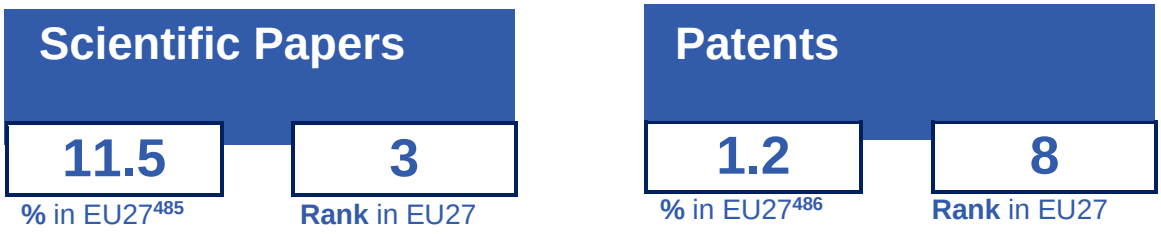
482 The Committee for Technological Innovation and Ethics (Komet). Received from: https://www.kometinfo.se/in-english/about-us/ (accessed in December 2020)

making data available in an enabling way. Yet, these initiatives do not specifically address healthcare which is a sector experiencing a major growth around the use of AI.[483]

This challenge was also articulated by the participants of the survey conducted for the study. The following areas of legislation/policy are considered as relevant in the future:[484]

- Data protection rules regarding the use and exchange of health data for the purpose of AI analysis;
- Cybersecurity policies;
- Policies around AI testing and certification in healthcare sector;
- Policies around algorithmic transparency;
- Policies around the ethical use of AI;
- Policies aimed at supporting research and innovation in the area of AI in healthcare;
- Safety and liability rules applicable to AI systems;
- Policies aimed at the encouraging of the deployment of AI technologies in healthcare.

## 2. Research and innovation around AI technologies and applications in healthcare




Sweden contributes approximately 4.4% of scientific output in the area of AI in healthcare and ranks 7th amongst EU countries. Notable contributors include the KTH Royal Institute of Technology, the Karolinska Institute, the Chalmers University of Technology, Stockholm University, as well as the Lund and Linkoping University.

483 OECD, Policy initiatives for Sweden. Received from: https://oecd.ai/dashboards/policy-initiatives?conceptUris=http:%2F%2Fkim.oecd.org%2FTaxonomy%2FGeographicalAreas%23Sweden (accessed in December 2020)

484 See survey results.

485 Using Fractional Count (FC) method based on Nature Index's score (https://www.nature.com/articles/d41586-018-05559-2) on the basis of the most relevant papers published between January 2015 – August 2020 identified from the following scientific publishers' search engines: IEEExplore, Springer, Sage and Elsevier.

486 Percentage calculated on the basis of most relevant patents granted in the period January 2017-August 2020 identified from espacenet https://worldwide.espacenet.com/patent/)(, the European Patent Organisation's online patent library.

Figure 99: Areas of application in scientific papers


It is also ranked high (3rd) for its patenting activity in this area. It is important to note that Sweden is one of the two countries that has continued to apply the "Professor's privilege" law, whereby researchers are the owners of their discoveries and developments. Maintaining such a system is expected to be more conducive high-quality research and patenting activity[487].

Deep learning methods are used, amongst others, for predicting response to therapy in cancer, for generalization of prostate cancer classification or for segmentation of selected bones in CT scans. Convolutional neural networks have been applied for automatic segmentation of the spinal cord or for Computer-aided detection of ureteral stones. In addition, Machine Learning techniques have furthermore been proposed for the yeast metabolome prediction or for early diagnosis from real-time physiological data.

Regarding the adoption of AI, the Swedish government sees the skills gap as one of the biggest challenges. Therefore, it aims to support lifelong learning and applications within society. Furthermore, the government needs to raise ethics and transparency issues to ensure that AI is used for the benefit of humankind[488].

## Cross-border collaboration in research

**12.3**
**Multilateral score**[489]

**16**
**EU Collaborating countries**[490]

In the research field, we identified 5 main collaboration partners, namely Germany, Finland, Belgium, Denmark and France.

In November 2017, France and Sweden agreed on a bilateral partnership to drive innovation and green solutions. The partnership aims to develop closer ties in the areas of sustainable digital transformation and artificial intelligence, among others. The partnership will also foster cooperation in life sciences and healthcare and promote innovative solutions through small and medium-sized enterprises[491].

487 Viromii, Professor's privilege, does it really impact technology transfer, March 2019. Received from: https://www.viromii.com/2019/03/06/professors-privilege-does-it-really-impact-technology-transfer/ (accessed in December 2020)

488 Government Offices of Sweden, Artificial Intelligence will strengthen Sweden's welfare and competitiveness, March 2018. Received from: https://www.government.se/articles/2018/03/artificial-intelligence-will-strengthen-swedens-welfare-and-competitiveness/ (accessed in December 2020)

489 Multilateral Collaboration Score (MCS), based on the Nature Index, is derived by first dividing the total fractional contribution for each country by one less than the total number of institutions which collaborated on the article. This is done for each collaborating country and the values are summed for each pair of countries to give the total MCS for that pair on an article. The MCS for each country is the sum of the values from each of its pairs of countries over all papers.

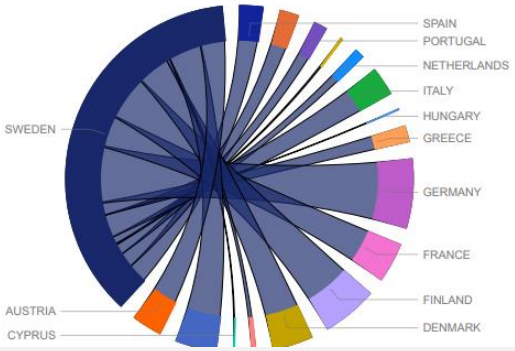
490 Number of other countries with which the country has collaborated in at least one publication on the topic of AI in healthcare.

491 Government Offices of Sweden, Declaration between France and Sweden on cooperation in European affairs and updating the French-Swedish partnership for innovation and green solutions, June 2019, p.1

In May 2018, the Ministry for Digital Development launched an international AI collaboration, called Data Factory & Arena[492].

This "arena" should be a leading international environment for collaboration on AI and thereby developing and accelerating the application of AI in society. Moreover, the arena will be open to individuals and teams from academia, industry and the public sector who are involved with AI-related research and innovation activities. Life sciences, healthcare and medicine are some of the priority areas of the arena[493].

Figure 100: Volume of cross-border collaboration in research


| Top 5 Collaborating EU Countries | Bilateral Score |
|---|---|
| Germany | 7.4 |
| Finland | 5.9 |
| Belgium | 4.4 |
| Denmark | 4.3 |
| France | 4.2 |

## 3. Start-up ecosystem relevant to AI technologies and applications in healthcare

The Swedish state-founded Almi Företagspartner AB is committing to help companies, established or not, and business concepts that have growth potential by offering loans and assisting in their business development. The loan type is dependent on the occasion, with the "Almi Micro Loan" being offered to entrepreneurs with smaller capital requirements. Almi may lend up to 100 per cent of the capital requirement up to SEK 200,000 without security[494].

There are at least 9 start-ups in Sweden whose work is focuses mainly on AI-enabled tools in the healthcare sector, e.g. they are using smart data analysis and predictive analytics or AI to identify data patterns for prediction and identification purposes of health risks.

According to the survey, the start-ups are mainly working with openly available research databases or they are using data which they collect via clinical trials. The used datatype is either Vital Sign data, microbiology data or imaging data. Regarding funding, almost all start-

492 Government Offices of Sweden, Sweden will create a leading international environment for collaboration on AI, May 2018. Received from: https://www.government.se/press-releases/sweden-will-create-a-leading-international-environment-for-collaboration-on-ai/ (accessed in December 2020)

493 Lindholmen Science Park, Sweden will create a leading international environment for collaboration on AI. Received from: https://www.lindholmen.se/en/news/sweden-will-create-leading-international-environment-collaboration-ai-0 (accessed in December 2020)

494 Almi Företagspartner AB. Received from: https://www.almi.se/en/in-english/ (accessed in December 2020)

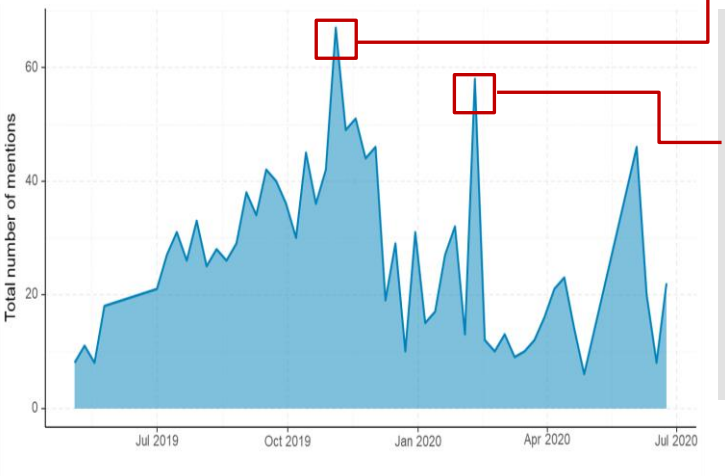
ups indicated that they receive public funds for the development of AI-enabled healthcare tools.[495]

# 4. Awareness and use of AI technologies and applications in healthcare

Sweden displayed strong mentioning regarding the cross section between AI and healthcare through their national news sources.
Awareness was particularly high in 2019, with the highest peak of 67 mentions in November. During the first peak, the use of AI for pathology and diagnostic was a theme shared throughout the multiple articles, with its further development to be used for predictive analysis. More specifically, an article was shared on the first automatic assistance system in gastroenterology, managing to detect abnormal tissue patterns that could be cancerous. The second peak, in March 2020, revolved around the use of AI for detection of different diseases or conditions. However, an app that supposedly detects skin cancer received strong criticism on its accuracy. Finally, an article relating to the use of artificial neural networks for the detection of diseased genes also gained national attention.

Figure 101: Trend of total mentions in the news

**November 2019:** The use of AI for pathology and diagnostics, and its further use in predictive analytics were strongly featured in articles during the peak. More specifically, an article on the first **automatic polyp assistance system** with an AI algorithm able to **detect abnormal tissue patterns** from a colonoscope video feed. Finally, additional awareness was raised around the use of AI and machine learning to reduce the contact services in the healthcare sector.




**March 2020:** There was a high frequency of articles concerning the use of AI **for detection of various medical conditions**, including: cardiac arrests, colorectal and skin cancer. However, applications relating to the detection of skin cancer have been criticized for their accuracy.

Further awareness was brought to advanced machine learning and bioinformatic technologies finding **biomarkers to detect certain diseases**.

Moreover, Linköping University published an article on the use of **artificial neural networks** to find patterns in large samples of gene expression for subsequent disease detection.

Similarly with news mentions, Sweden also displayed strong social media mentions (3,100). The first peak, accumulating 110 mentions, included tweets regarding a new application to be launched in Uganda, which uses AI to increase the access to health check- ups. This peak also included several tweets with sceptical sentiments directed to the infiltration of AI in the healthcare sector.

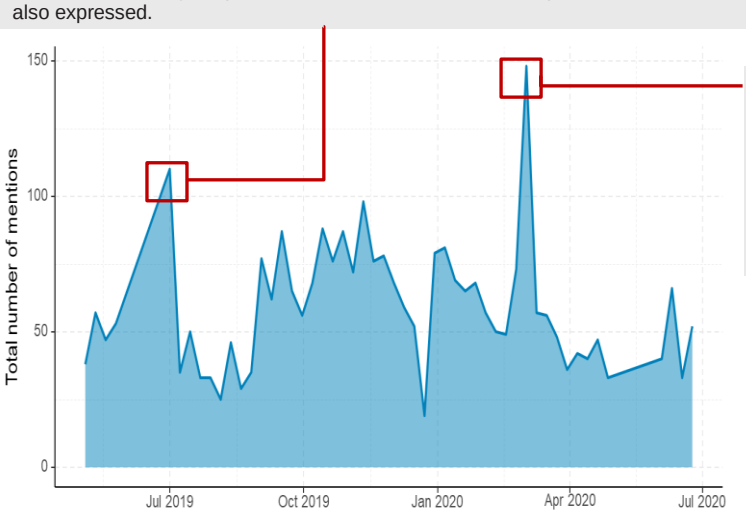
The second peak in March 2020, amassing 147 mentions, included tweets regarding the detection of an antibiotic that managed to kill antibiotic resilient bacterial strains using AI algorithms. Finally, the spike included tweets relating to doctors resisting the use of AI despite the alleged millions it could save the healthcare sector.

495 See survey results.

## Figure 102: Trend of total mentions in social media

**July 2019:** The new app called **AITOPYA** using **AI to help sick people easily access health check-ups**, to be launched in Uganda, was topic of several tweets.

Other tweets during the peak related to the use of AI to treat patients with heart failure, while some **skepticism over AI in health** was also expressed.




**March 2020:** Tweets mentioning a new machine learning algorithm that identifies a new **antibiotic compound killing previously antibiotic resistant bacteria**, gained traction.

Additional posts regarding **doctors' reluctance to adopt AI technologies**, were prevalent during the period.

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