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# Happiness, a New Measure of Progress

Reading the insight on Denmark's healthcare system, where the country consistently ranks among the happiest in the world, caught my attention. Many would wonder how could they be so happy, if they pay some of the highest taxes in the world? By investing in quality of life. Yes, because, probably, the key to understanding the high levels of happiness in Denmark is the welfare model's ability to reduce risks, uncertainties, and anxieties among its citizens, and prevent extreme unhappiness. The Danish welfare model provides opportunities for its citizens to pursue their happiness from advanced starting positions disregarding economic, social, gendered, or cultural backgrounds. For example, education is free, and even at university level, there is no tuition fee. Meanwhile, every Danish student receives a sum of money, per month, from the state. This means I won't have to worry about how to finance my kid's education. It will be their talents and dreams that shape the path of their careers, not my wallet. There is free quality healthcare for everyone, and the welfare model works as a risk-reducing mechanism, and that forms a sound basis for high levels of happiness. The Danish labor market is based on flexibility and provides a safety net for workers and the unemployed. Employers can easily make changes in staff, and the unemployed can look for new jobs without the same level of financial anxiety. This is mainly because Denmark does well in terms of preventing extreme unhappiness. The poorest Danes generally are quite happier than the poorest in many other nations. Since the poorest people in Denmark enjoy a wide range of public social benefits that the poorest in many nations do not – while the difference between the wealthiest people in each country is very little.



A country with high rates of happiness, does not mean that it does not struggle with the myriad of global conditions arising out of modern lifestyles and societies. Stress, isolation, depression. Loneliness, often misunderstood and undiagnosed, is a major cause of suicide and its manifestations have become increasingly complex in an interconnected world. Unresolved problems with addiction to drugs, pharmaceuticals, and alcohol remain as well. All of these factors, and many others, including generational poverty and the impact of climate change upon traditional industries and customs, also account on the rates of depression or suicide. But these causes are universal, and another topic, to discuss separately.

**While, if happiness is defined by an individual's freedom to choose, and lead, a life he or she has reason to value, it is worth tracking it as a sign of national progress.**

There was a time when most economists believed that income was a fair measure of personal well-being, and GDP per capita could adequately reflect a country's progress. Today, few would disagree that quality of life assessments should be multidimensional.

In recent years, there is growing awareness among people, politicians, and scientists that economic progress is no longer a satisfactory indicator for the progress of a society. Happiness, well-being, and quality of life have made a powerful imprint on policy making. The Organization for Economic Cooperation and Development now includes life satisfaction as a parameter for the development of the member countries. The United Nations Development Program, for example, ranks countries by an annual human development index that aggregates income, life expectancy and education. But are even these factors fully adequate for measuring social well-being? Quality of life assessments that account for happiness and life satisfaction go beyond what GDP can show. There are several factors, in addition to income and wealth, which determine quality of life, including health, education, environmental conditions, social connections, political voice and security. Yet these are still objective indicators. They tell us little about a person's own assessment of his or her well-being.

Subjective indicators, like happiness and life satisfaction, capture an important dimension of well-being that is missed by objective measures. Self-reporting also shows the importance people place on having dignity and a voice, as well as access to democratic institutions. We need both objective and subjective measures to accurately reflect quality of life on a global scale. And especially when it comes to framing policy, measurement, and quantification, even when it comes to happiness, is important.

By no means, there is no perfection, and each country faces challenges and issues. But I do believe that some countries can be a source of inspiration in how to increase quality of life. What's more, if enough people feel that their happiness depends on living in an environmentally sustainable and equal world, the pursuit of happiness could even be good for the planet!

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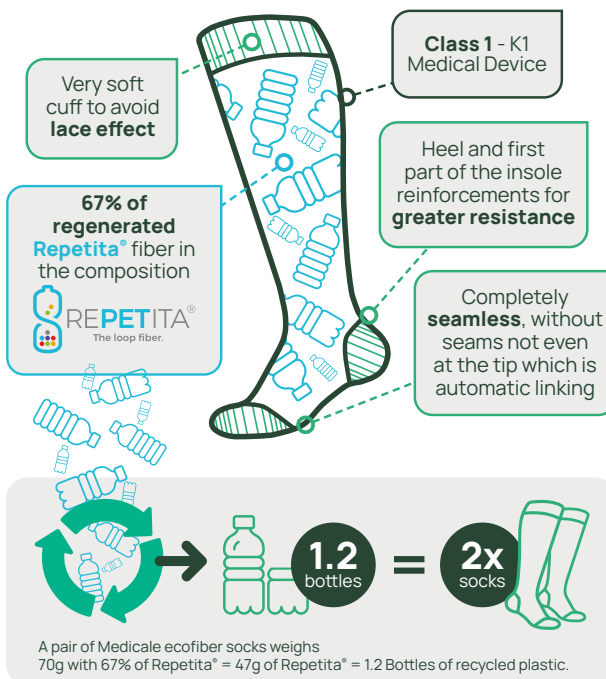
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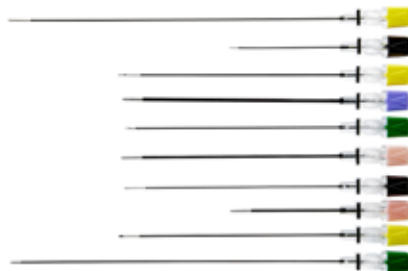
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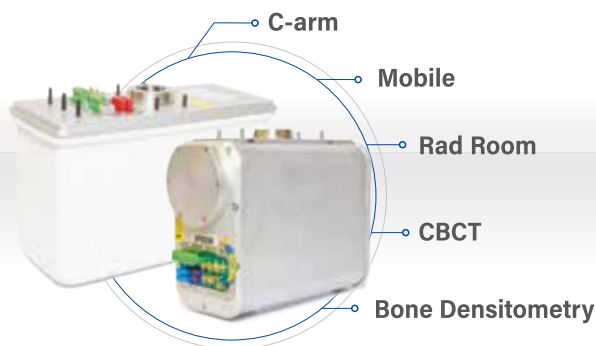
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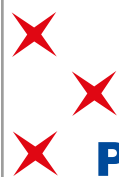
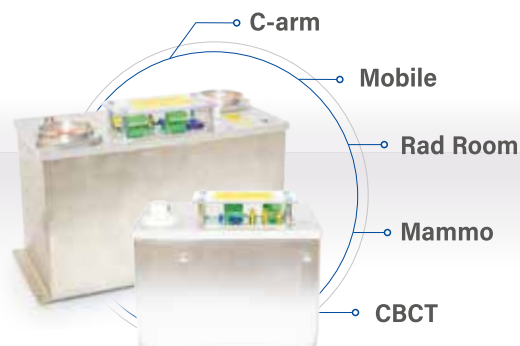
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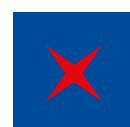
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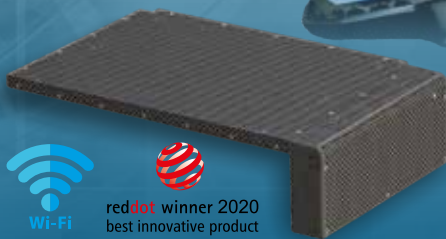
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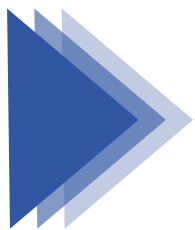
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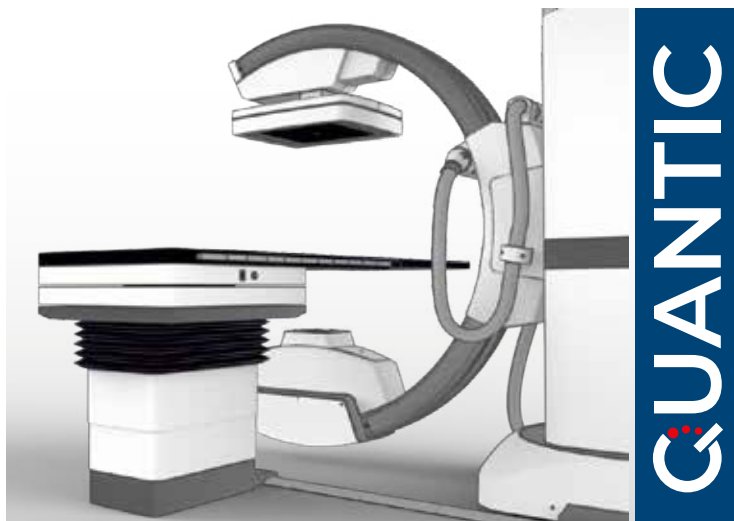
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# Raymond V. Damadian, MD, Recognized as “The Father of MRI” Dies at 86

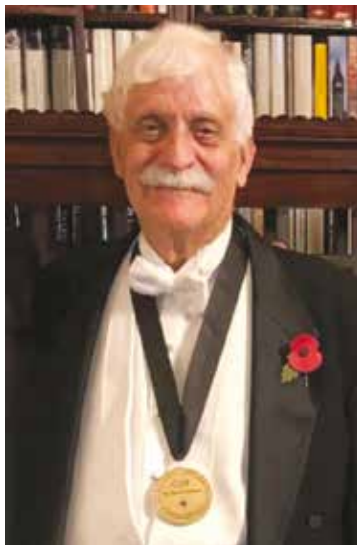
*The imaging community has lost a legend, recognized for having revolutionized the field of diagnostic medicine. Raymond Vahan Damadian, MD, “the father of MRI,” died on August 3, 2022, at the age of 86. A true pioneer, committed to medicine and research, Damadian was one of the first to propose the use of nuclear magnetic resonance (NMR) to produce medical images. He was widely recognized throughout his lifetime for his development and commercialization of the world's first commercial MRI machine, now widely used in clinical applications globally, which has transformed the diagnosis and treatment of disease.*

## Milestone Research

In 1971, Damadian's findings were published in the journal *Science*. “Tumor Detection by Nuclear Resonance Imaging” (March 19, 1971) documented that cancerous and healthy tissue can be differentiated in laboratory rats using NMR. The Abstract offered the following: “Spin echo nuclear magnetic resonance measurements may be used as a method for discriminating between malignant tumors and normal tissue. Measurements of spin-lattice (T1) and spin-spin (T2) magnetic relaxation times were made in six normal tissues in the rat (muscle, kidney, stomach, intestine, brain, and liver) and in two malignant solid tumors, Walker sarcoma and Novikoff hepatoma. Relaxation times for the two malignant tumors were distinctly outside the range of values for the normal tissues studied, an indication that the malignant tissues were characterized by an increase in the motional freedom of tissue water molecules. The possibility of using magnetic relaxation methods for rapid discrimination between benign and malignant surgical specimens has also been considered. Spin-lattice relaxation times for two benign fibroadenomas were distinct from those for both malignant tissues and were the same as those of muscle.”

Shortly after, on March 17, 1972, US Patent 3789832 was filed by Damadian. A patent was issued by the US Patent and Trademark Office for “Apparatus and method for detecting cancer in tissue,” on February 5, 1974,

according to FONAR, which notes that Damadian held more than 70 patents related to MR scanning.



*Professor Raymond Damadian, M.D., wearing the Excellence in Medicine medal awarded him by the Chiari & Syringomyelia Foundation at a November, 2018 ceremony in London, England. Photo courtesy of FONAR*

Indomitable, his original MRI, was given to the Smithsonian National Museum of American History. On July 3, 1977, the first MRI body scan was conducted on a human. It took five hours to produce one image of the patient. After the scan, Damadian and his partner, Dr. Michael Goldsmith, named the machine “Indomitable,” a reference to their struggle to develop the technology.

## Background

In its feature biography, the National Inventors Hall of Fame acknowledged Damadian's service and academic work, noting, in part: “Damadian later served as a fellow in nephrology at Washington University School of Medicine and as a fellow in biophysics at Harvard University. He studied physiological chemistry at the School of Aerospace Medicine in San Antonio,



Spin echo nuclear magnetic resonance measurements may be used as a method for discriminating between malignant tumors and normal tissue. Measurements of spin-lattice (T1) and spin-spin (T2) magnetic relaxation times were made in six normal tissues in the rat (muscle, kidney, stomach, intestine, brain, and liver) and in two malignant solid tumors, Walker sarcoma and Novikoff hepatoma.

Texas. After serving in the Air Force, Damadian joined the faculty of the State University of New York Downstate Medical Center in 1967. His training in medicine and physics led him to develop a new theory of the living cell, his Ion Exchanger Resin Theory." The depth and breadth of his accomplishments were acknowledged by two presenters who shared their praise of Damadian's work during an award ceremony in London, England, in November 2018. The Chiari & Syringomyelia Foundation presented its award to Damadian through Professor Donlin Long, MD, former Chairman of Neurosurgery at Johns Hopkins University, according to a FONAR historical overview.

"As the discovery of penicillin was the most important discovery of medicine in the first half of the 20th Century, Dr. Damadian's discovery of the MRI was the most important in the second half of the century, and the single most important diagnostic discovery in the history of all of medicine," said Donlin Long, MD during the 2018 award presentation. Fraser C. Henderson, Sr., MD, a neurosurgeon, and member of the CSF Steering Committee, added: "Dr. Damadian has revolutionized medicine with his discovery and development of Magnetic Resonance Imaging (MRI)...has continued important research using the FONAR UPRIGHT Multi-Position MRI to image and measure cerebrospinal fluid flow...this research may have profound implications for Chiari malformation, Syringomyelia and some of the neurodegenerative disorders."

CSF noted that as a young child, Damadian watched his grandmother die painfully of breast cancer, acknowledging that this memory fueled his desire to find cures for some of the world's most devastating diseases. It credited his multidisciplinary approach, as a medical doctor and research scientist for his discoveries which were key to opening the door to MRI, noting his membership in the International Society for Magnetic Resonance in Medicine (ISMRM) and the American Association for the Advancement of Science (AAAS).

#### Early Life and History of Discovery

Damadian's first foray into the field of imaging began when, during a



postgraduate stint at Harvard University, he experienced excruciating abdominal pains. Doctors detected nothing using x-rays or other conventional methods short of surgery. Damadian decided a better way must be found to examine the inner workings of the body. The proverbial lightning bolt struck Damadian in 1969, after he used an NMR machine to investigate his ideas about electrically charged particles in the body. His associate Freeman Cope, a Navy physician and physicist, brought him to a small company on the outskirts of Pittsburgh where the two measured potassium, a common electrolyte, in a strain of Dead Sea bacteria. At breakfast a few mornings later, Damadian wondered aloud about what would happen 'where you have an antenna wrapped around the human body, where you can look at an atom, and then another atom, and then another atom — you could go from one tissue to the next and, without ever invading the body, get the chemistry of each organ.' Even Cope thought Damadian's idea far-fetched, but Damadian committed himself to the quest."

In 1978, Damadian founded FONAR, for "Field Focused Nuclear Magnetic Resonance," in Melville, NY, making it the first, oldest and most experienced MR manufacturer in the industry. In doing so, the company introduced the first commercial magnetic resonance imaging machine (a whole-body scanner) in 1980, and went public in 1981. Damadian's MRI was granted FDA approval for the device in 1984.

#### The Machine and FONAR today

As noted, Indomitable, his original MRI, was given to the Smithsonian's National Museum of American History. From 1995 to 2008, Damadian's first MRI machine was on display at the National Inventors Hall of Fame (NIHF) Museum (then in Akron, OH) on loan from the Smithsonian Institution. In 2008, after the museum moved to the campus of the United States Patent and Trademark Office (in Alexandria, VA), it was sent back to the Smithsonian Institution, according to the National Inventors Hall of Fame, in North Canton, OH, according to their staff. FONAR reports that it has new works-in-progress technology for visualizing and quantifying the cerebral hydraulics of the central nervous system, the flow of cerebrospinal fluid (CSF), which circulates throughout the brain and vertebral column at the rate of 32 quarts per day. This imaging and quantifying of the dynamics of this vital life-sustaining physiology of the body's neurologic system has been made possible first by FONAR's introduction of the MRI and now by this latest works-in-progress method for quantifying CSF in all the normal positions of the body, particularly in its upright flow against gravity. Patients with whiplash or other neck injuries are among those who will benefit from this new understanding.

According to the company, FONAR's substantial list of patents includes recent patents for its technology enabling full weight-bearing MRI imaging of all the gravity sensitive regions of the human anatomy, especially the brain, extremities, and spine. It includes its newest technology for measuring the Upright cerebral hydraulics of the central nervous system. FONAR's UPRIGHT Multi-Position MRI is the only scanner licensed under these patents. The company notes that FONAR is currently conducting research studies in a number of areas including Cerebrospinal Fluid Flow (CSF) Studies, Correlated Slice Protocol (CSP) and Scoliosis screening.

Source: Taken from *itn – Imaging Technology News*. For full article and further information:





# Artificial Intelligence Assessment of Heart Function is Superior to Sonographer Assessment

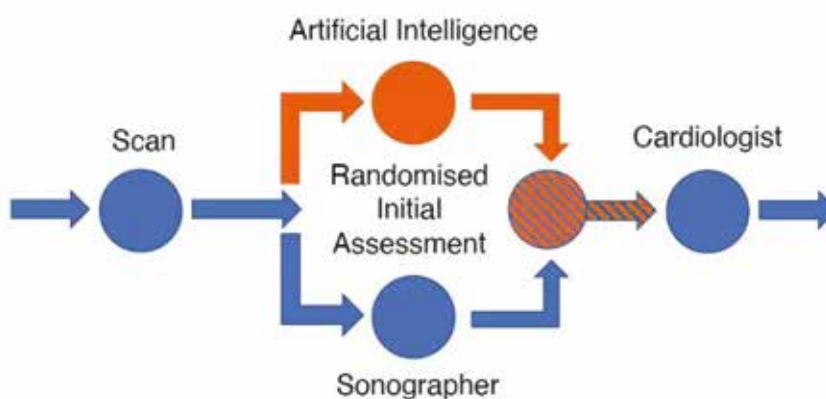
*EchoNet-RCT presented in a Hot Line Session at ESC Congress 2022*

**Barcelona, Spain – 27 Aug 2022.** In patients undergoing echocardiographic evaluation of cardiac function, preliminary assessment by artificial intelligence (AI) is superior to initial sonographer assessment, according to late breaking research presented in a Hot Line session at ESC Congress 2022.

Dr. David Ouyang of the Smidt Heart Institute at Cedars-Sinai, Los Angeles, US said: "There has been much excitement about the use of AI in medicine, but the technologies are rarely assessed in prospective clinical trials. We previously developed one of the first AI technologies to assess cardiac function (left ventricular ejection fraction; LVEF) in echocardiograms<sup>2</sup> and in this blinded, randomised trial, we compared it head to head with sonographer tracings. This trial was powered to show non-inferiority of the AI compared to sonographer tracings, and so we were pleasantly surprised when the results actually showed superiority with respect to the pre-specified outcomes."

Accurate assessment of LVEF is essential for diagnosing cardiovascular disease and making treatment decisions. Human assessment is often based on a small number of cardiac cycles that can result in high inter-observer variability. EchoNet-Dynamic is a deep learning algorithm that was trained on echocardiogram videos to assess cardiac function and was previously shown to assess LVEF with a mean absolute error of 4.1–6.0%.<sup>2</sup> The algorithm uses information across multiple cardiac cycles to minimise error and produce consistent results.

EchoNet-RCT tested whether AI or sonographer assessment of LVEF is more frequently adjusted by a reviewing cardiologist. The standard clinical workflow for determining LVEF by echocardiography is that a



*Figure: EchoNet-RCT trial design*

sonographer scans the patient; the sonographer provides an initial assessment of LVEF; and then a cardiologist reviews the assessment to provide a final report of LVEF. In this clinical trial, the sonographer's scan was randomly allocated 1:1 to AI initial assessment or sonographer initial assessment, after which blinded cardiologists reviewed the assessment and provided a final report of LVEF (see figure).

The researchers compared how much cardiologists changed the initial assessment by AI to how much they changed the initial assessment

by sonographer. The primary endpoint was the frequency of a greater than 5% change in LVEF between the initial assessment (AI or sonographer) and the final cardiologist report. The trial was designed to test for noninferiority, with a secondary objective of testing for superiority. The study included 3,495 transthoracic echocardiograms performed on adults for any clinical indication. The proportion of studies substantially changed was 16.8% in the AI group and 27.2% in the sonographer group (difference -10.4%, 95% confidence interval [CI] -13.2% to -7.7%,  $p < 0.001$  for

“ There has been much excitement about the use of AI in medicine, but the technologies are rarely assessed in prospective clinical trials. We previously developed one of the first AI technologies to assess cardiac function (left ventricular ejection fraction; LVEF) in echocardiograms<sup>2</sup> and in this blinded, randomised trial, we compared it head to head with sonographer tracings.

”

We are excited by the implications of the trial. What this means for the future is that certain AI algorithms, if developed and integrated in the right way, could be very effective at not only improving the quality of echo reading output but also increasing efficiencies in time and effort spent by sonographers and cardiologists by simplifying otherwise tedious but important tasks. Embedding AI into clinical workflows could potentially provide more precise and consistent evaluations, thereby enabling earlier detection of clinical deterioration or response to treatment.

noninferiority,  $p < 0.001$  for superiority). The safety endpoint was the difference between the final cardiologist report and a historical cardiologist report. The mean absolute difference was 6.29% in the AI group and 7.23% in the sonographer group (difference -0.96%, 95% CI -1.34% to -0.54%,  $p < 0.001$  for superiority).

Dr. Ouyang said: “We learned a lot from running a randomised trial of an AI algorithm, which hasn’t been done before in cardiology. First, we learned

that this type of trial is highly feasible in the right setting, where the AI algorithm can be integrated into the usual clinical workflow in a blinded fashion. Second, we learned that blinding really can work well in this situation. We asked our cardiologist over-readers to guess if they thought the tracing they had just reviewed was performed by AI or by a sonographer, and it turns out that they couldn’t tell the difference – which both speaks to the strong performance of the AI algo-

rithm as well as the seamless integration into clinical software. We believe these are all good signs for future trial research in the field.”

He concluded: “We are excited by the implications of the trial. What this means for the future is that certain AI algorithms, if developed and integrated in the right way, could be very effective at not only improving the quality of echo reading output but also increasing efficiencies in time and effort spent by sonographers and cardiologists by simplifying otherwise tedious but important tasks. Embedding AI into clinical workflows could potentially provide more precise and consistent evaluations, thereby enabling earlier detection of clinical deterioration or response to treatment.”

Article taken from: ESC-European Society of Cardiology



Notes: <sup>2</sup>Ouyang D, He B, Ghorbani A, et al. Video-based AI for beat-to-beat assessment of cardiac function. *Nature*. 2020;580:252–256.



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# Trained Radiographers May Be a Solution for the Radiologist Shortage



## At A Glance:

- Trained radiographers (technologists) perform well when double reading screening mammograms.
- Researchers analyzed a year's worth of performance data collected from 224 radiologists and 177 radiographers.
- No differences were found in the key performance metrics of readers from either professional group.

OAK BROOK, Ill. — When double reading screening mammograms, radiographers (technologists) trained for the task perform as well as radiologists in key areas, according to a study published in *Radiology*, a journal of the Radiological Society of North America (RSNA).

Double reading, the process of interpreting a radiological image with two or more sets of eyes, is the standard of care throughout Europe and it has been shown to improve cancer detection rates while simultaneously keeping recall rates low. The National Health Service Breast Screening Program (NHSBSP) in the United Kingdom (U.K.) has over 80 screening centers in England, where over 2 million women are screened annually.

To mitigate the strains put on the healthcare system due to increased workload and radiologist shortages, the NHSBSP has been utilizing non-radiologists as part of double reading since the 1990s. While the traditional role of radiographers is to perform the mammogram, the NHSBSP recruits radiographers who undergo extensive additional post-graduate training to interpret the mammograms. They also participate in the same quality assurance standards as radiologists.

"With the production of reliable individual reader performance data in recent years, it has been possible to produce a robust comparison of the performance of our radiologist and

non-radiologist readers in England," said study lead author Yan Chen, Ph.D., associate professor of cancer screening at the University of Nottingham School of Medicine in the U.K.

For this study, researchers analyzed a year's worth of performance data collected from 224 radiologists and 177 radiographers from the NHSBSP. Readers who also took part in the External Quality Assurance (EQA) scheme known as the Personal Performance in Mammographic Screening (PERFORMS) were eligible for this study, and they also gave consent for their individual real-life breast screening performance data to be accessed from the Breast Screening Information System.

Performance metrics that were analyzed were cancer detection rate, recall rate—the percentage of patients called back for follow-up testing—and positive predictive value of recall based on biopsy-proven pathological findings. Positive predictive value reflects the percentage of cancers found among exams for which biopsy was recommended or performed.

Each metric was analyzed according to the reader profession, years of experience and any interaction between them using analysis of variance. Analysis of variance is a statistical formula used to compare variances across the means (or average) of different groups.

Researchers found no significant difference in the performance of readers from either professional group. The cancer detection rate for radiologists was 7.84 per 1,000 examinations, while the cancer detection rate for radiographers was 7.53 per 1,000 examinations. Additionally, the average recall rate for radiologists and radiographers was 5% and 5.2%, respectively. The final performance metric, positive predictive value of recall, also showed no variation. The positive predictive value of recall was 17.1% for radiologists and 16.1% for radiographers.

"It has been really gratifying to show that there was little difference in the performance of readers from either professional group when we looked at the key breast cancer screening performance metrics of cancer detection rates, recall rates and posi-

” With the production of reliable individual reader performance data in recent years, it has been possible to produce a robust comparison of the performance of our radiologist and non-radiologist readers in England

tive predictive value of recall," said coauthor Jonathan J. James, FRCR, consultant radiologist and director of education and training at the Nottingham Breast Institute at Nottingham University Hospitals NHS Trust.

The results of this study also showed that reading performance was based on the years of experience of the readers. This suggests that appropriate focused training, participation in EQA schemes like PERFORMS, and experience are all factors that contribute to the performance of a reader, rather than simply having a medical degree and the broad radiology education undertaken by all radiologists.

"Many countries are experiencing a shortage of radiologists, and this is compounded by increasing demands and growing screening backlogs," Dr. Chen said. "The outcomes of this study may lead screening programs in other countries to consider the use of physician extenders in breast imaging."



Source: "Performance of Radiologists and Radiographers in Double Reading Mammograms: The UK National Health Service Breast Screening Program." Collaborating with Drs. Chen and James were Eleni Michalopoulou, M.Sc., Iain T. Darker, Ph.D., and Jacquie Jenkins, M.Sc.

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# International Day of Radiology

## November 8, 2022

*The International Day of Radiology (IDoR) is a yearly event commemorated on November 8, the anniversary of the discovery of x-rays, and promotes radiology's role in healthcare. The European Society of Radiology (E.S.R.), the Radiological Society of North America, and the American College of Radiology (A.C.R.) jointly launched it in 2012. Nearly 200 national sub-specialty and allied organizations around the world recognize and celebrate the International Day of Radiology. Every year, a theme is chosen that focuses on various radiology specialties.*

### HISTORY OF INTERNATIONAL DAY OF RADIOLOGY

Radiology, a discipline of medicine, utilizes medical imaging to diagnose and treat diseases that affect both animals and humans. On November 8, 1895, Wilhelm Conrad Röntgen, a German mechanical engineer and physicist, discovered x-rays by accident while exploring cathode rays, thereby establishing the groundwork for the medical specialty of radiology. Röntgen went on to discover and create electromagnetic radiation in the X-ray or Röntgen ray wavelength range, earning him the Nobel Prize in Physics in 1901.

The International Day of Radiology was established in 2011 as a follow-up to the European Day of Radiology. On Febru-

ary 10, 2011, the first and only European Day of Radiology (EDoR) was conducted to honor the anniversary of Röntgen's death. The European Society of Radiology hosted the event. Following the European Day of Radiology's success, the E.S.R. collaborated with the Radiological Society of North America and the American College of Radiology to create the International Day of Radiology. It was also determined that the anniversary of Röntgen's death should be relocated to the anniversary of his discovery of the x-ray.

On November 28, 2011, the three founding societies formally recognized the day during the annual Radiological Society of North America meeting in Chicago. November 8 was eventually picked, and all radiological

organizations around the world commemorate it.

In addition to the general recognition of radiology, a theme is chosen every year, focussing on various specialties and sub-specialties of radiology.

These themes have included:

2021: *Interventional radiology - Active care for the patient*

2020: *Radiologists and Radiographers supporting patients during COVID-19*

2019: *Sports Imaging*

2018: *Cardiac Imaging*

2017: *Emergency Imaging*

2016: *Breast Imaging*

2015: *Paediatric Imaging*

2014: *Brain Imaging*

2013: *Thoracic Imaging*

2012: *Oncologic Imaging*

### 5 INTERESTING FACTS ABOUT RADIOLOGY

1) X-ray procedure in America

In the United States, about 150 million x-ray procedures are performed each year.

2) Radiologic nun technologists

Nuns made up 37% of radiologic technologists in 1927.

3) Over 330,000 radiologic technologists

There are over 330,000 radiologic technologists in the United States.

4) First 3D mammogram

In 2011, the first 3D mammography exam was performed in the United States.

5) Radiation therapy

In 1964, radiation therapy was designated as a specialist field.

### WHY INTERNATIONAL DAY OF RADIOLOGY IS IMPORTANT

a) It honors radiographers and radiologists

The day honors the vital role that radiographers and radiologists play in the medical field. It recognizes their dedication, hard work, and numerous contributions to modern healthcare.

b) It is non-invasive

This type of medical imaging allows doctors to observe what's going on inside the human body. It's a non-invasive diagnostic procedure that can be performed on both animals and people.

c) Radiology is a rapid procedure

Medical analyses using X-rays are non-invasive and take only a few minutes to perform. The findings of x-rays can be visible nearly instantly.

Source: <https://nationaltoday.com/international-day-of-radiology/>

# Back on track – ECR 2023 dates moved to March 1-5, 2023



*Vienna, Austria – September 9, 2022 – The ESR Board of Directors proudly announced today that the European Congress of Radiology 2023 will now take place on March 1-5, 2023. This decision was made following careful consideration of all stakeholder feedback regarding the annual congress and after re-evaluating the requirements that made a summer congress necessary in 2022. ESR leadership look forward to welcoming participants back to Vienna for a Spring congress, with abstract submission and registration for the meeting due to open shortly.*

The decision to change the dates of the congress, which was previously scheduled to take place in July 2023, was made based on the valuable feedback received from the many stakeholders in the congress following ECR 2022, which took place on July 13-17 of this year. Although feedback from the congress was overwhelmingly positive, many stakeholders also indicated that

they would prefer future ECRs to again be held in March instead of July, due to the clash of commitments that arise during a summer meeting. Industry partners also expressed a considerable desire to move the dates of the annual meeting back to March.

ECR provides countless opportunities for learning, networking, and socialis-

ing that are only available onsite when colleagues in radiology come together in Vienna. Creating a hybrid meeting, accessible both online and onsite will remain a priority of all ECRs. However, congress organisers also wish to ensure that the opportunity to enjoy an onsite meeting experience remains available to as many attendees as possible in the future. For this reason, a return to the traditional March dates for the congress was determined to be the most practical solution.

“At ECR 2023 we will immerse ourselves in the congress slogan, “The Cycle of Life”, and continue to develop themes of previous congresses, including the “building bridges” multidisciplinary theme in 2022”, said ESR President Prof. Adrian Brady. “The entire ECR 2023 Programme Planning Committee are currently building a unique and exciting scientific and educational programme for the congress, and we cannot wait to welcome attendees back, sooner than expected, for a spectacular meeting next March”.

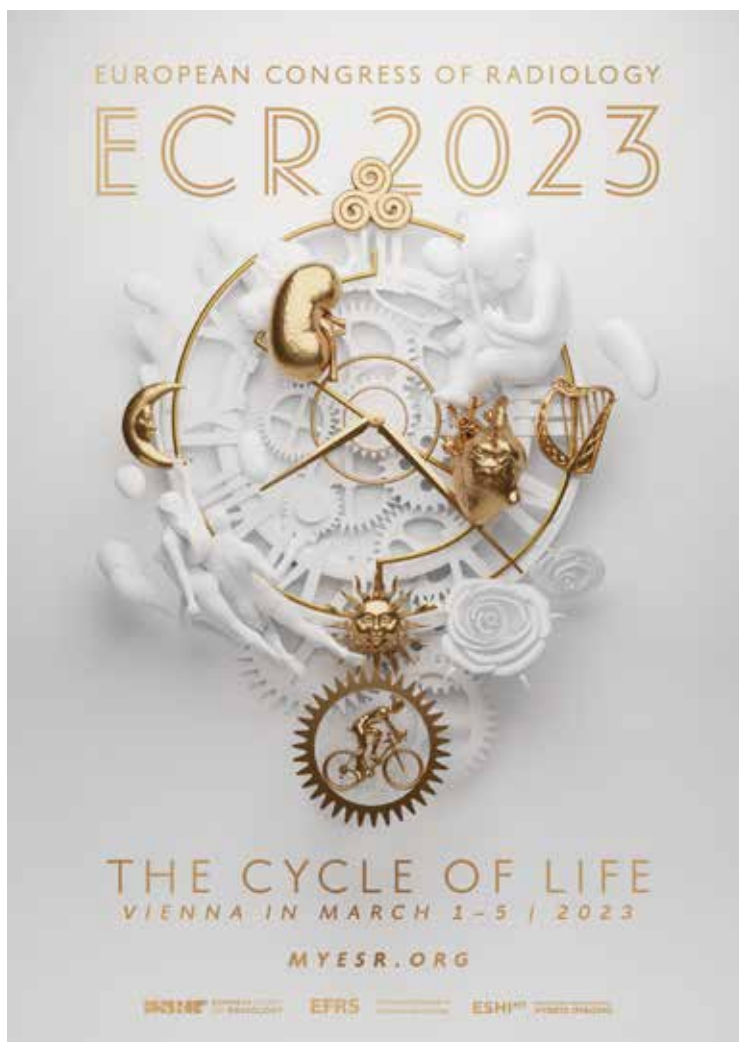
Abstract submission for ECR 2023:  
from Monday, September 14.  
Registration for the congress:  
from Wednesday, September 21.

## Media contact

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# market outlook

Constitutional  
monarchy with  
a unicameral parliament  
(Folketing) of 179 seats.

Head of state  
Queen Margrethe II  
and head of government  
prime minister  
Mette Frederiksen

Though member  
of the EU, Denmark's  
national currency  
is the krone.

In a 2000 referendum,  
53% of voters rejected  
adoption of the euro

Kastrup, near  
Copenhagen, is one of  
the busiest airports in  
Europe; it is a center for  
international air traffic

...  
Denmark consistently  
ranks among  
the happiest countries  
in the world

Public income is derived  
primarily from taxes on  
real estate, personal  
income, and capital, as  
well as through customs  
and excise duties. The  
heaviest indirect tax,  
which goes to the  
national government, is  
the value-added tax (VAT)



In 2019, about 70% of Danish adults reported being in good health, a proportion close to the EU average. However, as in other countries, people on higher incomes are more likely to report being in good health (81%), compared with 62% of those in the lowest

Denmark has two dependencies: Greenland and the Faeroe Islands.

They are both independent in health matters but follow the Danish national legislation



**Author: Silvia Borriello**  
Editorial Director  
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# Rethinking Healthcare



Equity is a value in the Danish healthcare system, and healthcare is an important part of its welfare system, resulting in a heavily financed public funds system, experiencing little inequality. But most of all Denmark has, long before others, realized the need to rethink its health system, and has radically transformed it to make it financially sustainable for the multiple challenges ahead, turning it into a more effective system than other developed countries, such as the U.S. and other European countries.



Denmark, officially Kingdom of Denmark, is just a small country of 5.8 million inhabitants and a high standard of living. Its per capita gross national product is among the highest in the world, with well-developed social services. The economy is based primarily on service industries, trade, and manufacturing; only a tiny percentage of the population is engaged in agriculture and fishing. Small enterprises are dominant.

**In the healthcare industry, many local manufacturers possess fair**

**shares in the global market. They specialize in the production of hearing aids, diagnostics, orthopedic and prosthetic devices. Denmark is also home to major companies in the medical device, biotech, and pharmaceutical industries. About 90% of the local production is exported.**

In its mixed welfare-state economy, private sector expenditures account for more than half of the net national income. Public expenditure is directed primarily toward health and

social services, education, economic affairs, foreign affairs, and national defense. The government does not have significant commercial or industrial income. War in Ukraine has, in short time, become a new and destabilizing factor in both the Danish and global economy. Even if Danish economy is generally robust (its pre-covid GDP growth was +2.1%, World Bank 2019 data), and able to manage new challenges, it is expected to enter a pause in growth or, even, risks a fall in activity.

	Denmark	EU
GDP per capita (EUR PPP*)	40,464	29,801
Relative poverty rate (% 2019)	12.5	16.5
Unemployment rate (%)**	5.6	7.1

*Note: \*PPP= Purchasing power parity (PPP) is defined as the rate of currency conversion that equalizes the purchasing power of different currencies by eliminating the differences in price levels between countries. / \*\*Percentage of persons living with less than 60% of median equivalized disposable income. Source: Eurostat database.*

### A Social Welfare State

One of the world's oldest and most comprehensive social welfare system, Denmark offers unemployment, disability, old-age, and survivorship benefits at virtually no charge to all Danes. Healthcare is part of the Danish welfare model and is grounded in the principle of solidarity amongst citizens, via their right to free healthcare and education. The state, or national level of government, controls all regulatory and supervisory power for healthcare. Health services are then provided by the 5 regions (Regioner) and 98 municipalities (Kommuner).

**Within its universal, decentralized, National Health System, that provides coverage to all citizens, all residents are guaranteed the same amount of publicly funded healthcare and are automatically enrolled in the healthcare system, free at the point of use, including primary, specialist, hospital (including inpatient prescription drugs), mental health, preventive, long-term care services, and dental services for children under age 18.**

Danish citizens may choose between two public insurance coverages. Most Danes (98%) opt for Group 1 cover-

age, completely free care provided by general practitioners (GPs) which function as gatekeepers, and patients need a referral to see specialists (except for few specialties). The remaining 2% of Danes prefer to pay a portion of their medical bills out-of-pocket for the privilege of choosing any GP or specialist they wish, so they choose Group 2 coverage, which allows access to specialists without a referral, although co-payments apply. Under both insurance options, access to hospitals requires a referral.

**As necessary healthcare is taxpayer-funded, personal expenses are minimal, and usually associated with co-payments for certain services, such as adult dental care, outpatient prescriptions, temporary home care, residential long-term care, corrective lenses, and travel vaccinations.** Those expenses are usually covered by private health insurance (2.5 % of health spending) or out-of-pocket payments (14.2% of total health expenditures). Cost-sharing (co-payments) limits for adults and for children create a safety net for Danes. **Unmet needs for medical care due to cost, distance or waiting times are very low, reported by fewer than 2% of the population, in 2019. There is also almost no differ-**

**ence in unmet care needs reported by people in the lowest and highest income quintile, while they are higher for services that are less covered by the public health insurance system, such as dental care.**

There is no nationally defined benefit package for healthcare. Decisions about levels of service and new medical treatments are made by the regions, within a framework of national laws, agreements, guidelines, and standards. Municipalities decide on the service level for most other welfare services, including

” The mortality rate from COVID-19 between early March 2020 and end of August 2021 was three-and-a-half times lower in Denmark than the EU average, in part because of better containment measures, responsive and flexible health system, and more widespread testing.

” Healthcare in Denmark sets a good example for elderly care in other countries. Danish senior citizens have the right to enjoy home care services for free, including practical help and personal care, if they are unable to live independently. Similarly, preventive measures and home visits can help citizens above 80 years old to plan their lives and care.

social care, within a framework of national regulation. In practice, most evidence-based treatments are covered. These include fertility

treatment (with some limitations) and necessary cosmetic surgery.

**The national health system is largely tax funded, with a decentralized organization:**

**The national government** - sets the regulatory framework for health services and is in charge of general planning, monitoring care quality, and licensing healthcare professionals. The state does not have a direct role in the delivery of healthcare services. Overall planning and regulation have gradually been centralized to the national level. For example, as part of the 2007 administrative reforms, which saw the merging of regions and municipalities, the number of hospitals was halved, creating fewer, larger, and more specialized hospitals. Improving quality and cost control provided the political impetus for these reforms to centralize and concen-

trate resources. Centralized direction also played a key role in the response to COVID-19.

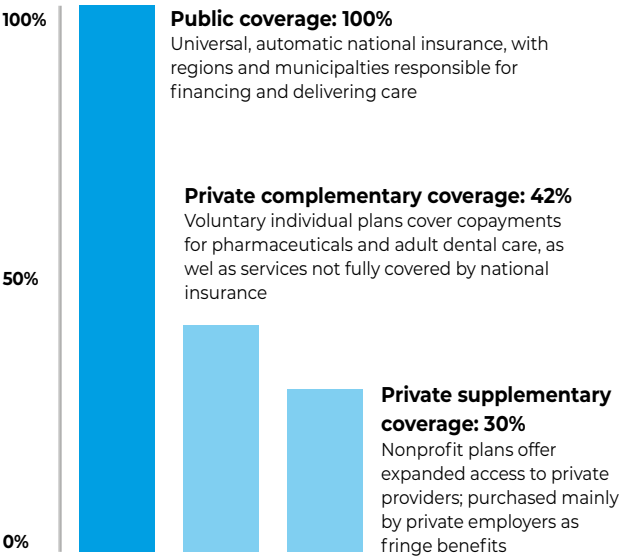
**The five regions** - governed by democratically elected councils are responsible for the planning and delivery of specialized healthcare services and play a role in specialized social care and coordination. The regions own, manage, and finance hospitals (although some specialized hospital services are managed centrally). They also finance the majority of services delivered by GPs, office-based specialists, physiotherapists, dentists, and pharmacists, as well as specialized rehabilitation. 80% of funding for the regions comes from the state, and 20% from municipalities.

**Municipalities** - are responsible for financing and delivering some dental services, school health services, rehabilitation, home care and long-term care, as well as health promotion and disease prevention.

Source: State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies

	Denmark	EU average
Total health spending as proportion of GDP, 2019	10.0%	9.9%
Spending per person (EUR), 2019	3,786	3,521
Share of out-of-pocket expenditure of total health spending, 2019	14.2%	15.4%

**Insurance Coverage (% of population)**



Source: [www.commonwealthfund.org/international-health-policy-center/countries/denmark](http://www.commonwealthfund.org/international-health-policy-center/countries/denmark)

**The Role of Public Health Insurance**

Denmark spends a similar share of GDP on healthcare to the EU average. Generally, the system appears to allocate and use its resources efficiently. About 84% of healthcare expenditure is publicly financed, representing 8.7% of GDP. **Overall, healthcare expenditures represent around 10% of GDP (including long-term care services), while nearly 16% comes primarily from private expenditure.** As a result of the COVID-19 pandemic, public spending on health increased by over 5% in 2020, while GDP fell by more than 2%, temporarily increasing the health spending share of GDP.

Healthcare is financed mainly through a progressive national income tax. Taxes are collected at the national and municipal levels, then re-allocated, mostly as block grants, with amounts adjusted for demographic and social differences, to hospitals and GPs within the regional level, and to local health centers at the municipal level. **Denmark has one of the highest tax burdens in the world; this fact is widely accepted among Danes, who highly support their welfare state. The majority of Danes are aware that collective wealth turns into well-being and that, through tax-paying, they are investing in their society and purchasing quality of life.**

## Public Health Coverage

	Denmark	EU average
Outpatient Medical Care	91%	75%
Inpatient care	90%	89%
Outpatient prescription drugs	43%	57%
Therapeutic Appliances	41%	37%
Dental Care	19%	31%

Source: State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies

TYPICAL PATIENT COPAYMENTS AND SAFETY NETS				
SERVICE	FEES PER ENCOUNTER/SERVICE		MAXIMUM OUT-OF-POCKET COSTS PER YEAR (SAFETY NET)	
Primary care visit	None		N/A	
Specialist consultation	Group 1 coverage: Zero with a general practitioner (GP) referral Group 2 coverage: Copayments vary: no referral from GP required		N/A	
Hospitalization (per day or visit)	None		N/A	
Inpatient drugs	None in public hospitals		N/A	
Outpatient prescription drugs	Incrementally increasing subsidies determine how much Danes pay out-of-pocket for outpatient drugs:		· DKK 4,030 (USD 548) per year (all patients)  · Terminally ill can apply for no-cost-sharing/full coverage for one year  · Additional variable assistance toward drug costs provided by municipalities	
	ANNUAL OUTPATIENT PRESCRIPTION DRUG EXPENDITURE	SUBSIDIES FOR ADULTS		SUBSIDIES FOR CHILDREN UP TO AGE 18
	DKK 0-965 (USD 0-131)	0%		60%
	DKK 965-1,595 (USD 131-217)	50%		60%
	DKK 1,595-3,455 (USD 217-469)	75%		75%
	DKK 3,455-4,030 (USD 469-548)	85%		85%
	Above DKK 4,030 (USD 548)	100%		100%

Source: <https://www.commonwealthfund.org/international-health-policy-center/countries/denmark>

	Denmark	EU
Number of doctors per 1000 population	4.2	3.9
Number of nurses per 1000 population	10.1	8.4
Physician visits per person, average per year (2019)	4.0	6.7

Source: State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies

Total no. of physicians	18,000
Total no. of GPs	3,600
Ratio GP per inhabitants	1:1,500
No. of solo GP practices, 2011*	1,250
No. of group practices, 2011*	2,300
Total no. of nurses, 2010	63,414
Nurses employed at public hospitals	60%
Nurses in outpatient care, social sector, nursing homes and other institutions**	19,218
Total no. of midwives, 2010	1,506
Ratio midwives per inhabitants	25,09:100 000

\*Organization of General Practitioners in Denmark, 2010 / \*\*Danish Council of Nurses, 2011; Sørensen & Wang, 2011.  
Source: Healthcare in Transition, Denmark, Vol. 14 no. 2 2012. Figures are approximate.  
N.B. Numbers vary according to different sources

### A Strong Tradition in General Practice

Denmark has more physicians and nurses per capita than the EU average. The number of physicians is regulated at the national level through limitations on the number of medical education training positions and the number of practicing physicians per region who can receive public funding. There are four medical schools, all public, offering medical studies lasting six years. None of them charge tuition fees. Physicians make a total of about 18,000, with 6,000 in training in the 30+ different specialties, and around 3,600 general practitioners (GPs).

**Recruitment of young doctors into general practice has been supported by an increasing recognition of general practice as a formalized specialty with growing scientific**

**activity, improved social and professional environments (with group practices) and an advantageous income compared with hospital doctors.** General practice is in fact a strong tradition in Denmark, for more than a century, and the GP is the central figure in the healthcare system, representing the point of first encounter for over 95% of the people. The current system was launched in 1973; approximately 22% of doctors work in general practice. Patients register with their GP for many years, less than 3% making a change per year. GPs are mostly self-employed, working on a contractual base with the government (region), with 46% of them in solo practices (2019). The practice structure is gradually shifting to group practices and multispecialty clinics.

Hospital beds per 1 000 population, 2019	2.6
Average length of hospital stay, 2019	5.7 days

Source: State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies

“ In 2020, life expectancy at birth in Denmark was 81.6 years – one year higher than the EU average, but lower than in other Nordic and many western European countries. Although the number of deaths was slightly higher in 2020 than in 2019 because of COVID-19, Denmark was the only EU country, apart from Finland, where life expectancy increased in 2020 despite the pandemic, albeit by just 0.1 years for both men and women.



### Restructuring Efforts

The majority of hospital beds (94- 97% %) are publicly owned and operated by the regions; the remainder are in smaller private specialty hospitals. Patients can choose among public hospitals, and payment follows the patient to the receiving hospital if the facility is in another region. Such implementation of nationwide free choice of hospitals, and maximum waiting times for hospital diagnosis and treatment, pressures the regions to deliver fast and equitable access, reducing disparities among geographical areas.

**Concerted policy efforts have also succeeded in shifting hospital-based care to primary care, and home-**

**based care, leading to a steady decline of hospital beds and average length of stay, as well as the number of hospitals, radically transforming the system to make it more financially sustainable.** One of the priorities, further increasing emphasis on primary care, is preventive care, included in the policy efforts to restructuring the national health system. Thus, in 1999, Denmark had 98 hospitals. Today it has 32. The future role of the hospital is thought of as a highly specialized place. Denmark has embarked on a new \$10.5 billion phase in healthcare reform to develop 16 new super specialized hospitals as the backbone of its future hospital structure.

	Denmark	EU
Life expectancy at birth, 2020	81.6	80.6
Adults with at least 1 chronic disease	31%	36%

Source: *State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies*

”According to the Danish constitution, “Any person unable to support himself or his dependents shall, where no other person is responsible for his or their maintenance, be entitled to receive public assistance.” The state welfare programs of Denmark should not be thought of as institutionalized charity, however. They are recognized both legally and in public opinion as morally just social rights that have been paid for by taxes and assessments.

### Average Wait Time to See a Doctor in Denmark

Like in many other countries, waiting times are one of the biggest issues of the public health sector in Denmark. However, to avoid longer waiting times, Denmark has created two different systems that allow patients to access specialists' care. One allows you to choose from any of the public hospitals in the country (to the extent of that hospital's capacity) which means patients can choose hospitals with shorter waiting times.

The other system allows you to choose among private and public hospitals and clinics if public institutions in your region take longer than 30 days to treat you. This last option is known as an “extended hospital choice,” and your referral letter should state whether or not you are entitled to it.

Even with these measures, waiting times to see a specialist are around 60 days. But in some cases, it can be more, with close to 20% of patients waiting for more than three months.

### Among main sources:

- *Healthcare in Transition, Denmark, Vol. 14 no. 2 2012*
- *State of Health in the EU, Denmark Country Health Profile 2021 -OECD, European Observatory on Health System and Policies © OECD and World Health Organization, the European Observatory on Health Systems and Policies) 2021*
- *Introduction to the Danish Healthcare System, by Maggie Pickard, <https://dukepersonalizedhealth.org/2021/07/introduction-to-the-danish-healthcare-system/>*
- *International Health Care Systems Profiles, Denmark by Karsten Vrangbæk, University of Copenhagen, <https://www.commonwealthfund.org/international-health-policy-center/countries/denmark>*
- *US Chamber of commerce: [https://2016.export.gov/industry/health/healthcareresourceguide/eg\\_main\\_092234.asp#:~:text=As%20of%202015%2C%20Denmark's%20health,which%20will%20be%20super%20hospitals.](https://2016.export.gov/industry/health/healthcareresourceguide/eg_main_092234.asp#:~:text=As%20of%202015%2C%20Denmark's%20health,which%20will%20be%20super%20hospitals.)*
- *“Financial review: Why Denmark is reducing hospitals while we are building more”, Jill Margo, <https://www.afr.com/work-and-careers/management/why-denmark-is-reducing-hospitals-while-we-are-building-more-20190219-h1bg9d>*
- *<https://borgenproject.org/healthcare-in-denmark/>*
- *Britannica, <https://www.britannica.com/place/Denmark/Agriculture-and-fishing>*
- *<https://www.nationalbanken.dk/en/publications/Pages/2022/03/Outlook-for-the-Danish-economy---War-in-Ukraine-dampens-growth-and-increases-inflation.aspx>*



Disinfection



Sterilization tests



Sterilization



Packaging



# INFECTION CONTROL

*Each surface a solution*

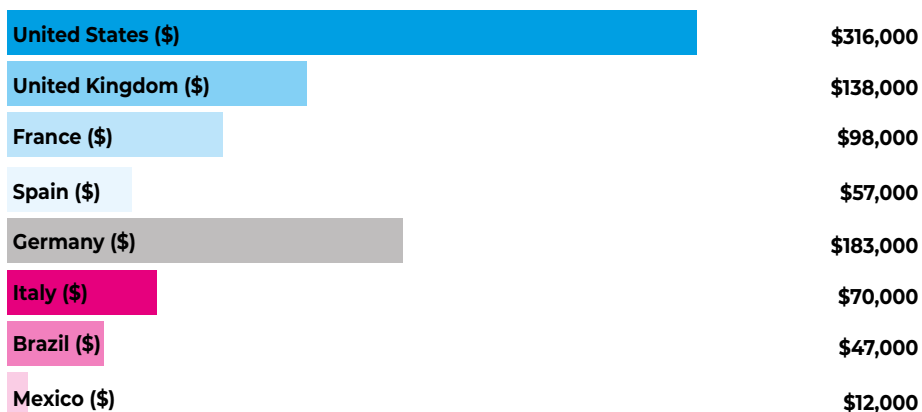
# International Physician Compensation Report 2021

Medscape

*Are Physicians top earners throughout the world? Where do doctors have it best? Medscape's US and international sites surveyed their physician members to learn about salary, job satisfaction, daily work challenges, and the impact of COVID on income.*

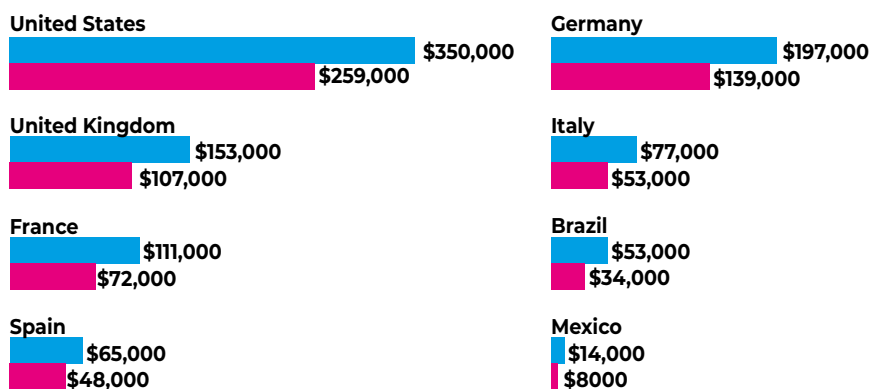
## How Much Do Physicians Earn (average)?

Actual purchasing power is related to that country's cost of living. Of the countries listed, the US and France have the highest cost of living index (70.1 and 76.6, respectively). Mexico and Spain have much lower salaries and also a lower cost of living index (34.3 and 54.7, respectively).

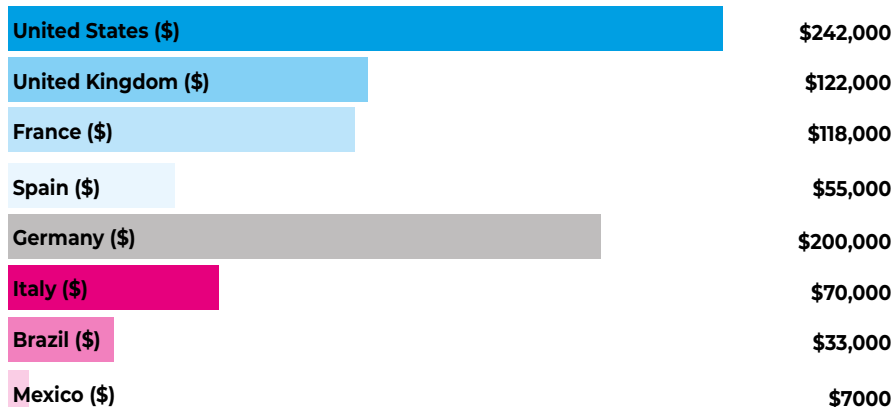


## Who Earns More, Men or Women Physicians?

Male  
Female



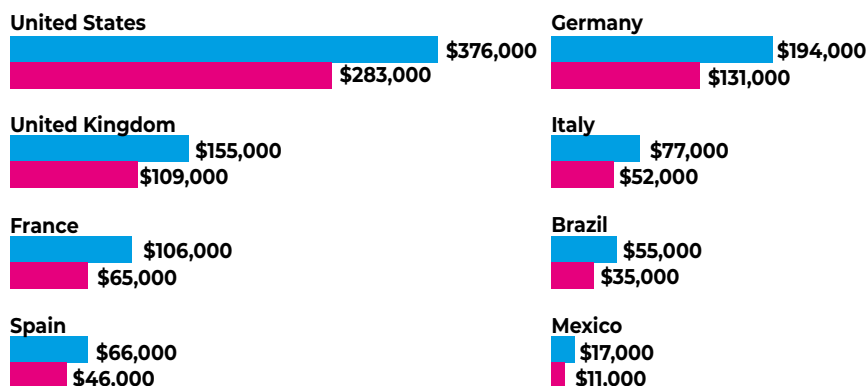
### How Much Do Primary Care Physicians Earn?



### How Much Do Specialists Earn?

Male  
Female

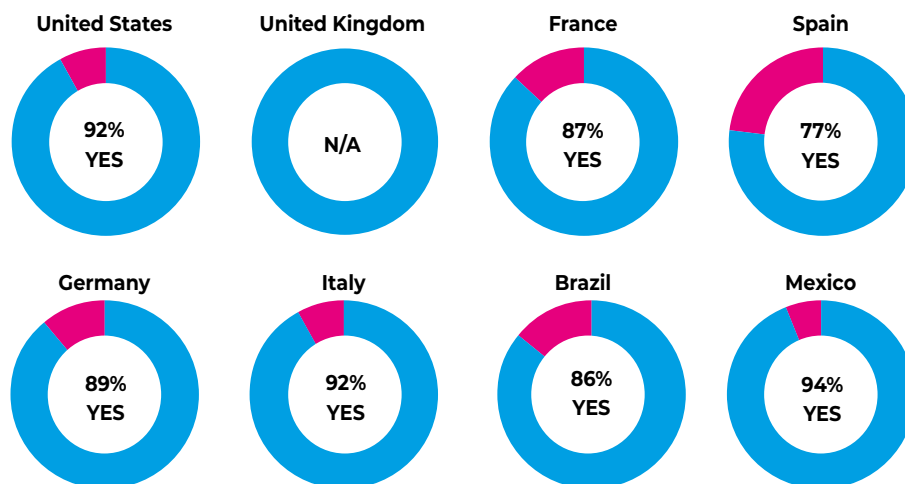
Specialists, like primary care physicians, in the US and Germany earn the most. The highest gender disparity occurs in France, where male specialists earn 63% more than women. The US has the lowest specialist pay disparity, with male specialists earning 33% more than women. The UK and Spain are closer to the US in gender pay disparity (42% and 43%, respectively).



### Was Your Income Drop Due to COVID?

At least 77% of Physicians whose income dropped said that Covid was responsible for the decline. Physicians from Spain were the least likely to blame COVID, compared with their peers in the other countries.

Yes  
No

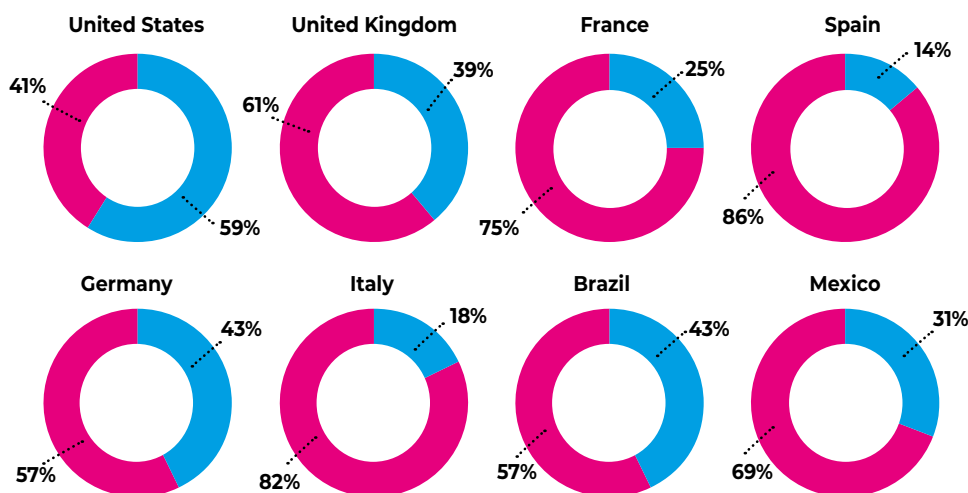




### Physicians Who Feel They are Fairly Compensated

US physicians have a much higher percentage of physicians who are satisfied with their compensation, followed by Germany, Brazil, and the UK. Among US physicians, oncologists, psychiatrists, plastic surgeons, and dermatologists were more likely to be happy with their compensation. Physicians in Italy, Spain, and France are most likely to feel dissatisfied.

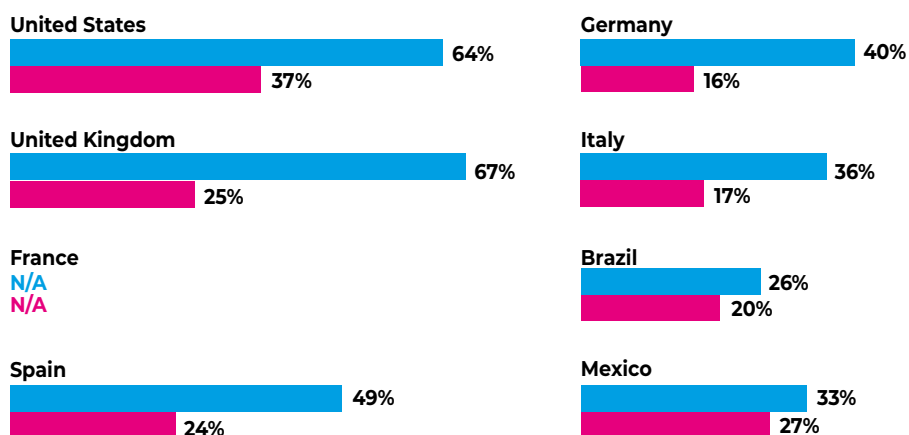
■ Yes  
■ No



### What Major Debts and Expenses Are Physicians Paying?

A mortgage on one's primary home is the most common debt for physicians in the US, UK, Spain, Germany, and Italy. Credit card debt is the leading debt in Mexico (52%). In Brazil, childcare (35%) was most named. Car loan payments rank second for physicians in the US, UK, and Spain, whereas for physicians in Mexico, medical expenses (35%) rank second. German physicians cited graduate school tuition (26%), physicians from Italy named tuition for children (21%), and physicians in Brazil named private school tuition for children (30%) as major expenses. (This question was not asked in France).

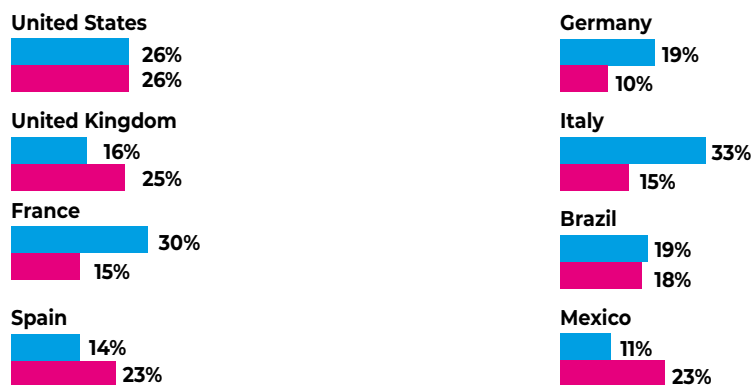
■ Mortgage on primary residence ■ Car loan payments



### What's the Most Rewarding Aspect of Your Job?

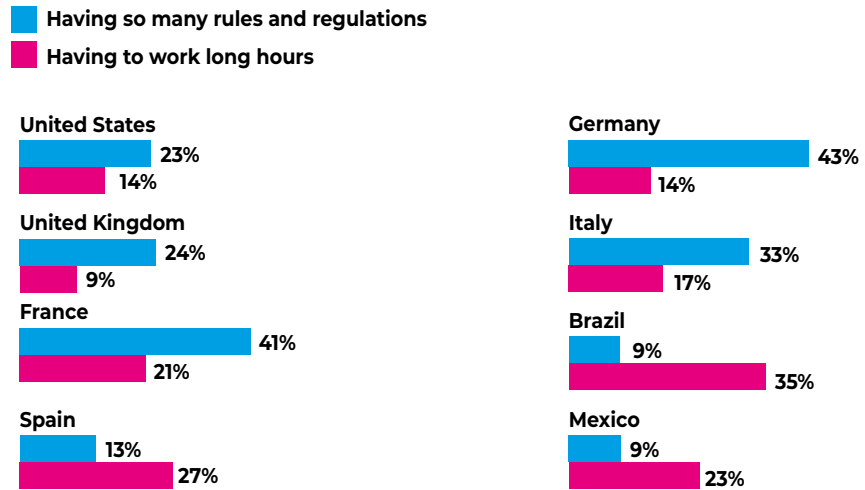
Being very good at what they do is one of the key motivators for physicians in the UK, Spain, Germany, and Mexico, for physicians in France and Italy it's gratitude/relationships with patients, and for Brazilian physicians it's making good money at a job they like. US physicians equally name gratitude/relationships with patients and making the world a better place.

■ Gratitude/relationship with patients  
■ Knowing that I'm making the world a better place (eg, helping others)



### What's the Most Challenging Aspect of Your Job?

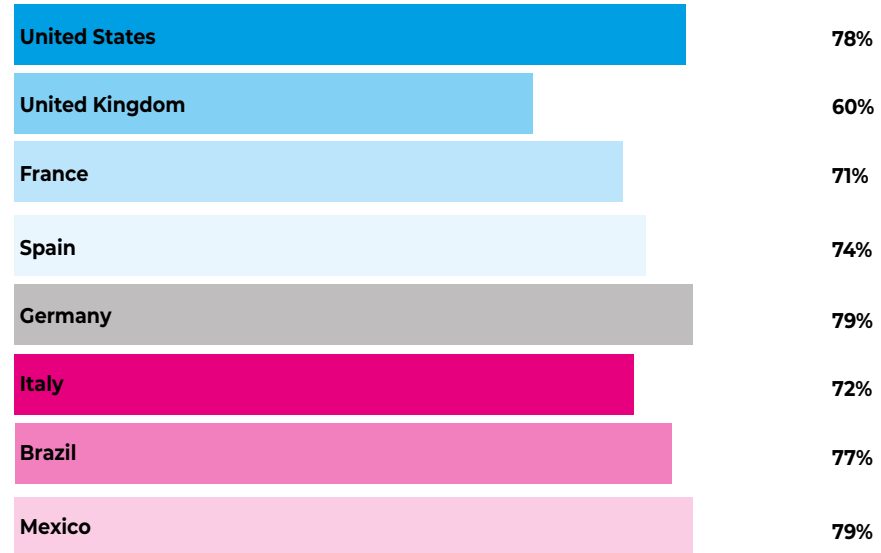
Having so many rules and regulations most annoy physicians in Germany, Italy, France, and the US; long hours most plague those in Spain, Brazil, and Mexico. Other top challenges for physicians include dealing with difficult patients, difficulties in dealing with insurers to get payment, and worry about getting sued.



### Would You Choose Medicine Again?

Overwhelmingly, most physicians would choose medicine again, although physicians in the UK were comparatively less likely.

#### PERCENT SAYING "YES"



#### About the Survey

U.S., European (UK, France, Germany, Spain, Italy) and Latin America (Mexico, Brazil) Medscape member physicians were invited to participate in a 10-minute online survey. Survey Demographics: U.S. 13,344; U.K. 1025; France 979; Spain 1260; Germany 707; Italy 895; Brazil 1342; Mexico 1195. Currencies have been converted to US dollars using an exchange rate date of December 22, 2020.

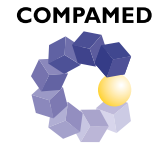
For full Medscape Survey visit [www.medscape.com/slideshow/2021-international-compensation-report-6014239](http://www.medscape.com/slideshow/2021-international-compensation-report-6014239)

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# Fascinating Presentations at the **COMPAMED** Innovation Forum 2022: How Medical Technology Combats Neurological Disorders



*When man and machine become one – an overview of some of the current developments*

**June 2022 - For years, Messe Düsseldorf and the IVAM Microtechnology Network have been the joint hosts of the COMPAMED Innovation Forum. Each spring, with a different content focal point each year, there is a first look at the topics for the coming season of the internationally leading expert trade fair for suppliers of the medical technology industry, COMPAMED in Düsseldorf, which will be held this year from November 14 to 17, in parallel with the globally leading medical trade fair MEDICA. The 2022 COMPAMED Innovation Forum which is dedicated to “Innovative technology for neurological applications” was held virtually on June 2.**

Presentations were focused on current products and their applications, some of which are still in the research and development phase, and some are already being put to use. In addition to implants, technical aids which are used to care for and assist people affected by neurological disorders play an important role. Addressing the participants of the forum, Christian Bigge, Senior Project Manager for COMPAMED at Messe Düsseldorf, was happy to pass on two messages: “We are planning for the event to happen in-person again and continue its success, enhanced by numerous digital services. Halls 8a and 8b, reserved for COMPAMED, will be completely booked out.” Neurological and psychiatric disorders of the brain are not a rare

phenomenon, but their frequency and their effects are still underestimated. These disorders affect the lives of many people and their families. According to an estimate by the WHO, a billion patients worldwide suffer from disorders of the central nervous system (CNS), such as depression, dementia, epilepsy, Parkinson's, or the sequelae of a stroke. Treatment cannot solely consist of relying on medication alone. Innovative medical technology can also improve the quality of life of those affected. Unlike medication, which helps to regulate the chemical balance within the human body, neurological implants target the electrical neural pathways within the spinal cord and brain.

## **Advances in brain-computer interfaces**

One important field of research for the Clinical Neurotechnology research section at the Charité university hospital in Berlin is the use of brain-computer or brain-machine interfaces

(BCI/BMI) in combination with non-invasive brain stimulation methods, such as transcranial electric or magnetic stimulation (TES/TMS). Professor Surjo R. Soekadar, head of the Clinical Neurotechnology research section and head of the clinical department of Translation and Neurotechnology at Charité, reported on the current level of technological advancement. In 1999, Professor Nils Birbaumer had already proven that fully paralysed patients – without the ability to move or speak – could, by changing the electric activity in the brain, select individual letters on a screen and thus write a complete message. This approach has made enormous developmental progress over recent years, thanks to more powerful, faster computers and the increase in their memory capacities, as well as due to the use of artificial intelligence (AI) and machine learning. The Professor Soekodar's research section, for example, focuses on the examination of neuroplasticity in the context of BCI applications. Here,



Neurological and psychiatric disorders of the brain are not a rare phenomenon, but their frequency and their effects are still underestimated. These disorders affect the lives of many people and their families.



“ A platform technology for a brain interchange system for neurological therapy has been developed by CorTec, in cooperation with clinical partners.

BCI systems are combined with other forms of neurological technology, e.g. non-invasive brain stimulation. Brain stimulation techniques have been used in a clinical environment for decades, in order to effect targeted changes in brain activity and thus promote neuroplasticity. The goal of combining both methods is to better understand and influence neuroplastic processes. This approach aims to yield new and effective therapeutic methods that offer individual treatment of disorders of the CNS with as few side effects as possible. Development over the recent years has proven that assistive and regenerative BCIs are effective clinical instruments for regaining movement. The combination of BCI and neurological modula-

tion, or non-invasive brain stimulation, can in this case illuminate the causal relationship between brain waves, brain function and behaviour. The path forward is also clear: “Right now, quantum sensors are the most promising technology for advancing non-invasive BCI applications. However, there are still some challenges that need to be overcome, such as shielding and isolation,” says Soekadar, speaking as an expert at the COMPAMED Innovation Forum.

#### **Brain Interchange platform technology**

A platform technology for a brain interchange system for neurological therapy has been developed by CorTec, in cooperation with clinical partners. The focus is on components and devices that can be used by industry, scientists and clinical professionals alike. The BIC consists of all components necessary to achieve an electric connection between the neuronal system and external information technology. The exchange of information is performed to modulate the nervous system. The completely implantable system is calibrated for both recording and stimulation using 32 channels. It is intended for long-term monitoring and electrical stimulation of the central and the peripheral nervous system. The CorTec Brain Interchange receives electric signals from electrodes attached to the nervous system, and reinforces, digitalises and transmits these signals to a computing unit through an external unit. “Data processing takes place outside the body,” explains Dr Martin Schüttler, CTO of CorTec.

The company has announced further developmental progress. For example, preclinical trials and developmental milestones have recently been successfully concluded. During the next phases, the technology is to be fine-tuned and ultimately prepared for the first-in-human studies. The American bureau of regulations for medical products, the FDA, is currently looking into approving the brain interchange platform technology. The spectrum of possible applications is large, for example if a range of differently designed electrodes are used, and ranges from applications for Parkinson's and

epilepsy to treating chronic pain and movement disorders, which can result from major strokes, injuries to the spinal cord or progressive muscular dystrophy (ALS).

#### **New mobility through brain waves and use of exoskeletons**

The French company STATICE is a developer and contract manufacturer focusing on specific solutions in microtechnology and medical technology, including neurology. Injuries to the spinal cord above cervical vertebra C8 carry a large risk of the patient becoming tetraplegic and being unable to use their arms and hands. STATICE is aiming to restore mobility in such cases by combining the interpretation of brain waves with an exoskeleton. Towards the end of 2019, the medical journal “The Lancet” published results from the clinical study of a BCI project, in which French scientists from the CEA research centre and STATICE have proven the feasibility of control of an exoskeleton for tetraplegics. WIMAGINE neurological prosthetics play a crucial role. These are long-term implants placed on the dura mater, which record brain activity. The implantable matrix consists of 64 electrodes.

In September 2021, two patients with a C5 lesion of the spinal cord received such implants. To determine the stability of the signal during implantation, special metrics were used to evaluate the signal. The time-frequency charts obtained from task-focused instances of motor activation were also evaluated to monitor the long term activity of the electrodes. “It was possible to prove the long term functionality of the WIMAGINE implants for chronic implantation. With the help of up-to-date tools for signal analysis, we can record good stability of ECoG signals for each patient, which looks promising for clinical examination with epidural recordings,” says Benoît Studlé, CEO of STATICE, summarising the results. These are to be confirmed in further patients. The next step follows naturally: a wireless bypass of the damaged spinal cord for paraplegics. The impulses of motor intention transmitted by the brain are to be deciphered via WIMAGINE and then translated to impulses sent directly to the nerves that control the legs, for example.



### Materials for implants and neurostimulation

Highly specialised devices and systems used in medical technology always need better and more highly functional materials. One supplier of such solutions is Sandvik. The company has a Medicine business unit, which focuses specifically on delivering materials for the cardiovascular, neurostimulation, remote monitoring and electronics fields. For example, Sandvik manufactures coated stainless steel fine wiring for the electrode arrangement, as well as cable and coil configuration for transmitting signals, and ball electrodes in hearing implants (cochlea). They are also working on is deep brain stimulation (DBS). This is a neurosurgical procedure which implants a neurostimulator to treat movement and neuropsychiatric disorders. "To stimulate nerves, we produce wires made of a platinum-iridium alloy and high quality conductive wires with a prolonged operating life," explains Dr Cacie McDorman, Process Engineer Manager at Sandvik Materials Technology.

### Order components the size of a grain of sand

For 40 years, Valtronic has been a global full service licensed manufacturer of electronic products with a wealth of experience in ready-to-use production, microelectronic assemblies and miniaturisation. "Active implantable medical products are a challenge, from the design to manufacturing; just imagine the extreme miniaturisation, for example our DBS probes with a length of only 400 mm and a diameter of just 1.3 mm," says Michael Fink, Consultant Business Development at Valtronic. Another example of this trend is the development of a thumb-sized device that sends programmable electric impulses to patients suffering from chronic pain, urinary incontinence and functional disorders of the limbs. The solution consists of minimised circuit complexity, and components reduced to the size of a grain of sand.

### Mobile seizure detectors for recognising epilepsy

Epilepsy is a collective term for a group of functional disorders of the

“Epilepsy is a collective term for a group of functional disorders of the brain, which arise from the interaction of pathological excitation and lack of inhibition of excitation in the neuronal clusters of the CNS.

brain, which arise from the interaction of pathological excitation and lack of inhibition of excitation in the neuronal clusters of the CNS. Between 2 and 4 percent of all people suffer a single, isolated epileptic seizure. Between 0.5 and 1 percent develop manifest epilepsy, meaning that they have more than one seizure. Epilepsy is therefore one of the most common neurological disorders, affecting around 50 million people worldwide, with 800,000 in Germany alone. This considered, the Centre for Epileptology at the neurological clinic at the University Hospital of RWTH Aachen is researching seizure detection devices for affected patients. "The risks for epileptic patients are injuries, early death and damage to neurons, including the development of cognitive deficits over time," says Prof Yvonne Weber, head of the epileptology section at the neurological clinic. Quite often, these risks lead to a lack of integration into social and working life, as well as to stigmatisation.

EEGs have been used to detect epileptic seizures up until this point. However, in recent years, the heart rate, which is increased in 60 to 70 percent of all cases, the variability of the heart rate, and also oxygen saturation and respiration levels have provided new measurands to detect epilepsy. In the Monikit ("monitoring kit") project, the University Hospital of the RWTH Aachen, the Kleinwachau Centre for Epilepsy and the University Hospital of Tübingen University are developing a mobile seizure detection device for automatic detection and documentation of epileptic seizures that occur during daily activities. The comprehensive monikit system consists of a sensor array and an innovative algorithm. The sensor device is attached to the chest with adhesive electrodes or by belt, and picks up ECG and motion

data. These data form the basis for the monikit algorithm and are transmitted to the patients' mobile phone. "The small size of the sensor allows it to be worn underneath clothing. It has to be removed before taking a shower, though," says Weber. The monikit algorithm recognises special patterns of both generalised and focal epileptic seizures from the ECG and motion data. This is made possible by machine learning methods, for example neuronal networks, which are trained on thousands of hours of patient data, which enables them to detect new digital biomarkers. The algorithm can differentiate between epileptic seizures and every day activities, like sports or stress. The monikit app automatically documents and evaluates any detected seizures. The app also sends messages in the event of a seizure, determines access rights, and collects statistical data about seizures. Thus, doctors involved in treatment receive adequate and objective information about seizures during patients' everyday activities for the first time. This makes optimum adjustment of the therapy possible. Once doctors have been legitimised and given access by the patient, they receive insight into seizure information through their internet browser, including evaluations of the course, type of seizure and other information – secured and encrypted according to standards. The project receives 1.86 m Euro in funding from the German Federal Ministry of Education and Research (BMBF), through the operating company Life Science Inkubator GmbH.

### The market for neurostimulation is growing by more than 10 percent per year

There can be no doubt that the possibilities and possible applications for neurostimulation are increas-

ing. According to findings by Allied Market Research, the global market volume for corresponding systems was estimated at around 4.4 billion US dollar in 2018, and is expected to expand to approximately 11.3 billion US dollar by 2026. This corresponds to annual growth of 12.5 percent. Factors such as an increase in life-style diseases like depression and chronic pain, the growing number of neurological disorders, and investments in neuroscience and neuro-scientific development are regarded as the drivers behind the growth. Other factors are the rising demand for minimally invasive surgery, the introduction of technologically advanced products and the rising age of populations, which makes them more susceptible to neurological disorders like epilepsy, Parkinson's, Alzheimer's and chronic pain. According to statements by GlobeTech, neurological applications account for approximately 24 percent of the

total market for active implantable medical devices (AIMD). The largest segment belongs to spinal cord stimulators (SCS) with a 35 percent share in the market, followed by inner and middle ear stimulators (cochlear and BAHA) with 21 percent, deep brain stimulators (DBS) with 14 percent and sacral nerve stimulators (SNS) with just under 10 percent.

#### **COMPAMED: The most important industry meet-up is back, live in Düsseldorf**

The technological progress in combating neurological disorders is quite remarkable, as proven by the COMPAMED Innovation Forum 2022. More advanced products from the innovation-driven supplier industry for medical technology will be presented at COMPAMED 2022, which will take place in mid-November again, in halls 8a and 8b of the Düsseldorf trade fair centre. The main themes will be: Micro and micro system technol-

ogy, new materials, processing them and functional surfaces, additive manufacturing/3D printing, manufacturing and packaging as well as a wide range of services. These themes also provide the content framework for the two integrated expert forums: the COMPAMED HIGH-TECH FORUM by the IVAM Microtechnology Network and the COMPAMED SUPPLIERS FORUM by the Devicemed professional medium.

**Information on COMPAMED 2022 (14 – 17 November) online:**  
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## Strengthening Healthcare

*The story of global health in the last decades is the story of staggering inequality.*



- Every day, about 830 women die from preventable causes related to pregnancy and childbirth.
- 13 million women are using modern contraceptives with support from CARE
- Our 2030 Goal: 50 million people globally increase the fulfillment of their right to health, and 30 million women their right to sexual and reproductive health
- 65 thousand girls have been able to avoid unwanted pregnancy with CARE's support

In poor countries, 4 out of 1,000 women will die in childbirth. In Sierra Leone, 1 in 17 women will die while giving birth. That's 97 times more likely than women in the United States. In Sub-Saharan Africa, 1 in 13 children will die before their 15th birthday, 16 times more than children in countries like the U.S. We know how to solve these problems but have not yet gotten those solutions to the poorest and most vulnerable people in the world.

Unfortunately, millions of young people around the world are vulnerable to threats like early marriage, school dropout, unemployment, violence, HIV, and unplanned pregnancy. Twenty-one million girls get pregnant before the age of 19 every year. The problems are about more than wealth, access, and infrastructure. Gender inequality plays a huge role. 21% of girls will get married before they are 18, and 40% of girls in poor countries. 1 in 3 women around the world experiences gender-based violence. Conflict and crisis contribute to the problem, with women and children making up 76% of people who are forced to leave their homes because of crisis.

CARE goes beyond providing health services and works to address the barriers that prevent the most vulnerable people from accessing quality, equitable health care. With communities at the center, CARE is working to support more effective and motivated health workers.



We also increase health systems' ability to serve the people who are hardest to reach and to respond to crisis. We know local communities are experts on their own situations and working together is the best way to build strong, self-sustaining, and equitable health systems.

### About CARE

CARE works around the globe to save lives, defeat poverty, and achieve social justice. CARE is a global leader within a worldwide movement dedicated to ending poverty.

We are known everywhere for our unshakeable commitment to the dignity of people.

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