# Digital Medicare + Healthcare: Today & Tomorrow

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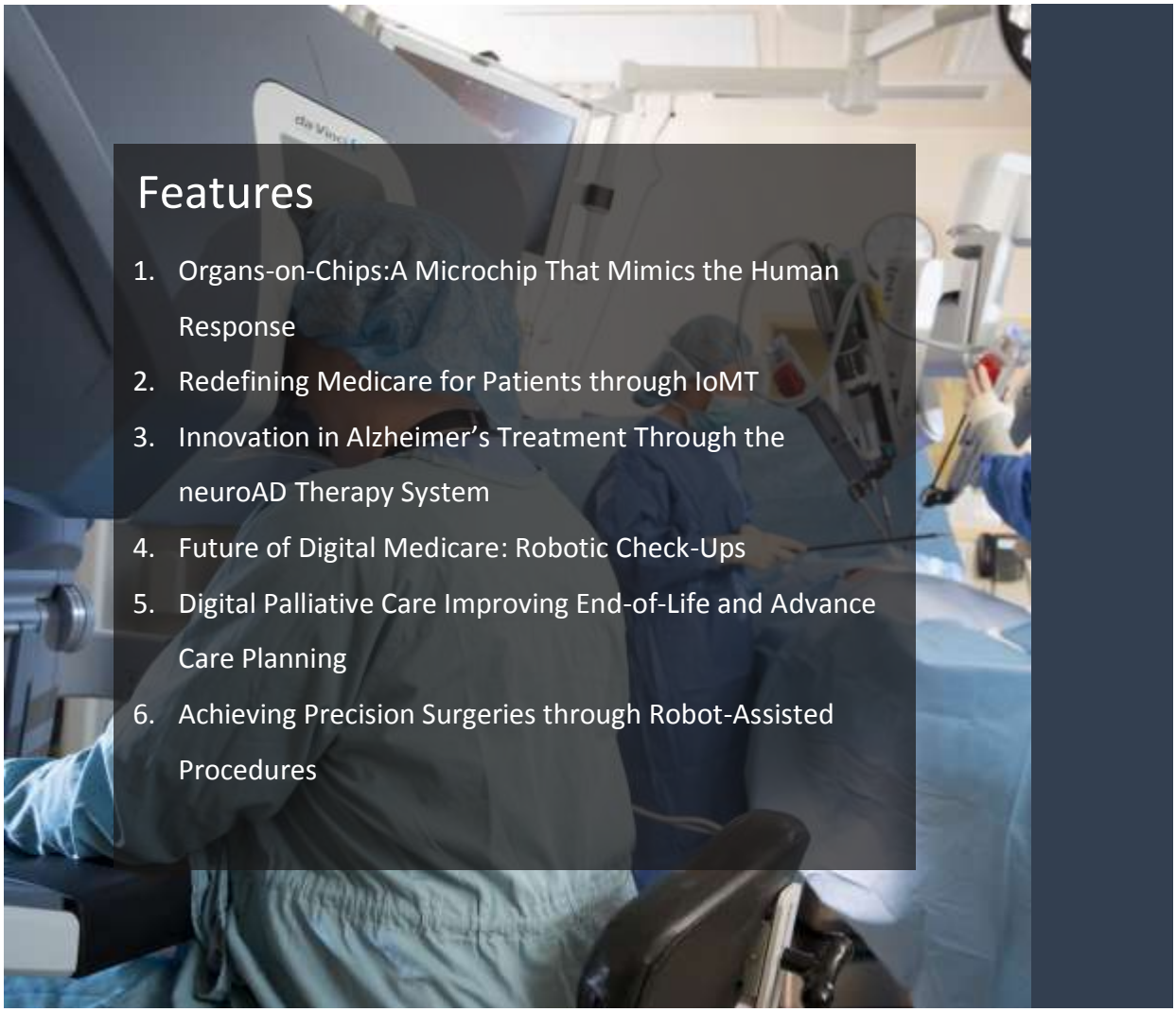

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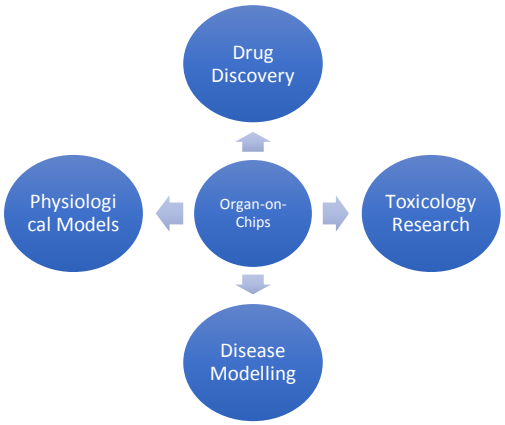
# Organs-on-Chips:

## A Microchip That Mimics the Human Response

**Role of Organs-on-Chips**




"It mimics the human response, it's amazing to watch," says Geraldine Hamilton, senior staff scientist at the Wyss Institute for Biologically Inspired Engineering (i). Revolution in drug development started 4 years ago in Boston, Massachusetts at the Wyss Institute for Biologically Inspired Engineering, when a group of researchers invented 'Organs-on-Chips' (OOC) technology.

This technology is made possible with the development of silicone, plastic, and glass chips, and related microfluidic control systems, which pushes the limits of science. OOC devices integrate microfluidic technology in a three-dimensional (3D) configuration with living cells from a human source. A clear and flexible polymer forms the rectangular chips about the size of a memory stick. Small channels pass through chips, like miniature ribbons, bordered by living human cells, which vary depending on the organ being modeled.

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OOC technology can deal with the lack of easily translated preclinical models by imitating organ-specific tissue microarchitecture. OOC helps to accelerate research in pharmaceuticals. As testing is a major challenge in drug development, these microchips simulate the activities and mechanics of entire organs and organ systems and helps to reduce the time to market for new drugs.

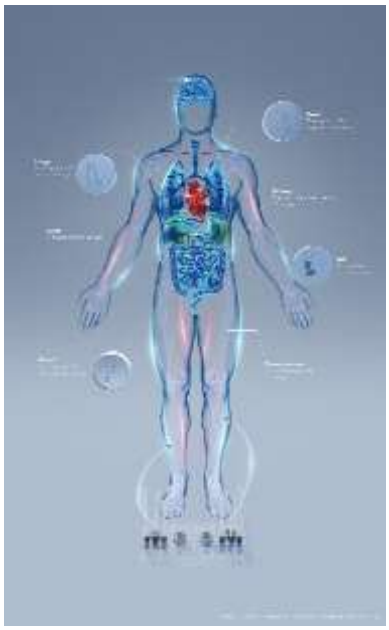
Speaking on the success of the technology, Donald Ingber, the Founding Director of the Wyss Institute for Biologically Inspired Engineering at the Harvard University said, "We took a game-changing advance in microengineering made in our academic lab, and in just a handful of years, turned it into a technology that is now poised to have a major impact on society.

A start-up launched by the Wyss Institute, Emulate, Inc. has licensed the technology and is now developing and marketing organ chip technology and automated tools to biotechnology, pharmaceutical, cosmetics, and chemical companies, academic institutions, as well as hospitals to advance personalized medicine with the help of these important research tools.

The OOC technology has the ability to host and combine different cell and tissue types. OOC provides an ideal microenvironment to study molecular and cellular activities that underpin the function of the human organs and mimic human-specific disease states, as well as to identify new therapeutic targets in vitro. It recreates the interfaces of therapeutic significance, such as the alveolar-capillary interface and the blood-brain barrier to investigate the drug delivery and to discover new therapies.

### Target Customers of Black Rice

In addition to being used in drug research by pharmaceutical companies, OOC models are used as test systems to develop non-pharmaceutical treatment approaches, such as radiotherapy or hyperthermia for cancer. It is also used to develop new cosmetics or food additives, and to analyze environmental contamination toxicology.



OOC is now being considered worldwide as tools to precisely predict drug effectiveness and toxicity in order to improve the accuracy and efficiency of preclinical drug testing. As an alternative to conventional in vitro and in vivo studies with limited predictive value, the trend towards OOC technology appears irreversible. In the context of value chains in food, medical foods, and pharmaceuticals, this technology informs the companies early on if a product under development is unlikely to result in a clinical setting known as "fail quick, fail cheap".

Linking organoids and OOC technology with the capacity to control the micro-environment can provide even more opportunities for predictive, high-performance screening.

In addition to improving R&D efficiency in general, OOC platforms could be valuable in supporting and accelerating the diagnosis of rare diseases, and the efforts in stratified medicine and nanomedicine, which is currently the growing interest of many. In the coming years, we will see the integration of OOC with other emerging disease modeling techniques, such as patient sourcing cells to develop induced pluripotent stem cells (iPSCs), or the modification of normal stem cells with new gene editing tools, which will facilitate the exploration of these additional applications.

- Challenges in the journey of Organs-on-Chips development:
  - Presentation of architectural complexity of human tissue and organs in a miniature manner
  - Arrangement of interconnection between tissues and organs on a small chip

### Case Study

Recently, a study related to the Integration of Multi-organ OOCs was carried out by the Department of Biomedical Engineering and Department of Medicine(iv), Columbia University in New York. The study concluded that cells and organ systems communicate with the circulatory system by secreting soluble factors and extracellular vesicles that mediate the peripheral crosstalk. Biomimetic integration methods are, therefore, important for the establishment of physiological interactions between organs in OOC platforms. The interconnection of individual OOCs through microfluidics imitates the in vivo role of vascular perfusion and allows to control the culture environment to recapitulate certain aspects of homeostasis. These links allow the interplay between the organs of interest and facilitate a more physiological approach to the supply and consumption of drugs.

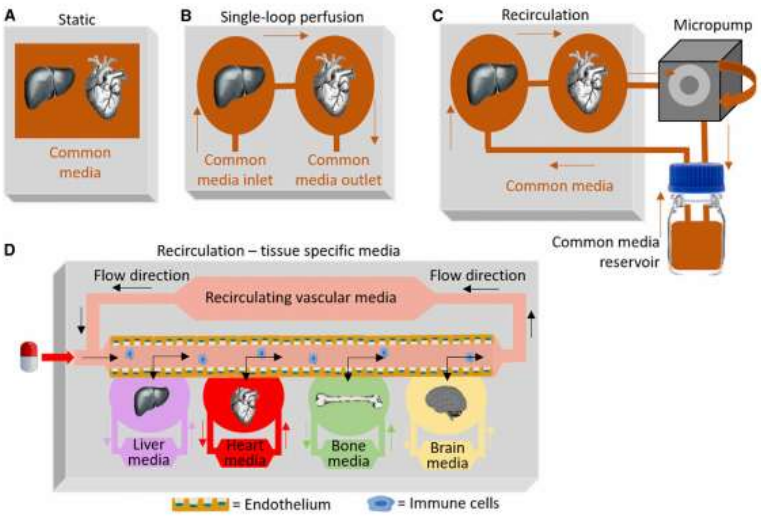


**Figure:** Integrating Multiple OOCs toward a Body-on-a-Chip (A–C) Methods to integrate multiple OOC systems include (A) static culture, (B) single-loop perfusion, or (C) recirculation of a common media capable of supporting all organ systems. (D) The development of individual OOCs connected to a selective membrane barrier, such as an endothelial layer, would enable integration of OOCs with perfusion that connects all OOCs while preserving the tissue-specific media composition for each OOC. The recirculating media can include more biomimetic components, such as circulating immune cells.

### Recent Launch

A team of scientists from the Northwestern University has recently developed EVATAR, a 3D OOC model of the female reproductive tract that imitates a normal 28-day hormone cycle. This chip organ consists of an ovary, fallopian tube, uterus, cervix, and a liver. EVATAR provides a platform to study the effects of medications and helps to learn more about diseases, such as endometriosis and cervical cancer. It is anticipated that the palm-sized model can help improve the health and fertility of women. This is just one example of the enormous impact that OOC has made on the future of drug discovery, disease research, and personalized healthcare.

- ❖ Limitations of OOC Technology: Organs-on-Chips produces slower results. Also, the number of experiments performed and studies done are less owing to its miniature form.

### Inference

In order to maximize the future impact of the OOC technology on drug development, it is crucial to make rational decisions about the qualities and characteristics of OOC, although the technology is now at its nascent stage. Different stakeholders in the development of OOC such as engineers, biologists, regulatory scientists, and pharmaceutical researchers, are likely to have different perspectives on how to maximize the impact of this futuristic technology.

Different aspects of OOC development, such as operating costs, raw materials, design features, cell source, data types, and compatibility with the existing technology, are likely to be judged by different stakeholders differently.

Hence, early Health Technology Assessment (HTA) is necessary for the vital assimilation of such possibly differing views in the technology development process. There is still an argument on whether a comprehensive MCDA (Multicriteria Decision Analysis) needs to be carried carry out for the development of OOC to maximize the impact of this technology in future on the pharmaceutical industry.

For wide and effective use of OOC systems in the drug development process, discussions on how to establish cell quality standards guaranteeing their reproducibility and robustness is indispensable. "Good Cell Culture Practice (GCCP)" is a viable solution.

Many cosmetics and pharmaceutical companies have shown interest towards using OOC. Some have even partnered with the developers of OOC such as L'Oréal, Pfizer, AstraZeneca, Roche, and Sanofi.

OOC technology has completely replaced the animal models for clinical studies. In near future, this technology is set to support tissue differentiation and recapitulate the tissue interface, as well as the living organ's mechanical environments to study and research towards giving a new life to human beings.

# Redefining Medicare

## for Patients through IoMT


The Internet of Medical Things (IoMT) also known as Healthcare IoT, is a subdivision of Internet of Things (IoT). IoMT refers to a completely connected infrastructure between medical devices and software applications that have the ability to communicate with the various healthcare IT systems. This digital healthcare technology is sought to modernize the face of medicare for patients.

In order to better understand IoMT, it can be thought of as something as simple as a person wearing a FitBit. FitBit tracks and tabulates the number of steps of the wearer on their iPhone via Bluetooth technology.

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This data is then available to be shared with their personal doctor through a Wi-Fi connection as automated reporting data.
Other options to view data by family and close friends is also available.

One of the aims of healthcare is to collect patient data and develop records with the data collected. According to Dr. Gopal Chopra, MD, CEO of PINGMD, and Associate Professor at the Duke University's Fuqua School of Business in Durham, wearable sensors and medical devices are simply an advanced way to collect this data. He mentions that sensors and wearable technologies including mobile applications could be as basic as an alert sent to the individual's healthcare provider in case of an accident with the patient such as a fall. There are bandages available that can detect the pH levels of the skin and detect that the wound is getting affected. These bandages are also capable of sending alerts to the care providers. "Anything we are currently using where a smart sensor could be used is part of that solution, says Dr. Chopra. He also adds, "We're able to take a lot of these data points to see if something abnormal is happening.

### A brief look at some current statistics of IoT & IoMT

- 30.3% of all IoT devices are used in healthcare, since the introduction of IoT.
- The financial impact of IoT in all industries will rise from about $3 trillion to $6 trillion by 2025.
- It is estimated that 31 billion devices and 4 billion people will be connected via IoT by 2020.
- The global worth of IoT in healthcare is predicted to reach $2.5 trillion by 2025.
- With about 60% of healthcare organizations having introduced IoT already into their patient care activities, the healthcare industry stands as the third most advanced industry to implement IoT.
- IoMT is going to be one of the most sought after technology platforms in the next two years with 87% of healthcare organizations around the world planning to implement IoT connected services by 2019.
- IoMT has helped to increase the workforce productivity, and reduce Medicare costs considerably.
- According to studies, 73% of the organizations utilize IoT primarily for patient monitoring. The main concern involves the security of sensitive medical data as it is estimated that 89% of the healthcare IoT users have experienced some kind of security breach.

### The Advances in IoMT Improving clinical efficiency

Hospitals and many dedicated clinics use connected devices to enhance the Medicare reach and delivery. These devices help keep track of the treatments and thereby make possible automated electronic charting. Doctors are able to track their scheduled patient visits as well as the history of visits. They are even able to access EMR from remote locations. IoT sensors that can be used for tracking the location of patients and medical equipment in real-time are also available. Pill bottles have been developed using IoMT to track the patient's adherence to medications.

### At home monitoring

IoT technology has enabled direct-to-consumer marketing, which aids in self-monitoring and gathering all necessary biometric data that can be accessed in the required situations. An example of this is the Smart thermometer, which uses temperature sensors in smartphones and other devices to read the temperature and keep a record of all the readings.

There are devices currently in the market that can help take an ECG (electrocardiogram) at home. These devices help to track and collect patient information right from their homes without the need for the patient to travel all the way to their doctor, while the doctor can assist through telemedicine.

### Ushered in an era of sensors and wearables

Connected biometric sensors are being implemented in clinical and hospital settings, such as heart patches that help in monitoring heart readings andarmlets for reading blood pressure. These sensors can even be connected to clinical monitoring devices in distant locations.

Another advancement in IoMT that has gained massive popularity are fitness wearables such as the FitBit, or fitness tracking apparels, and other consumer wearables. These devices not only collect the person's data but also regulate their fitness regime through smartphones, hence making them the most-sought-after IoT technology.

- Adoption of IoMT: Due to the widespread clinical acceptance and health policy, remote location-enabled technologies have been rapidly adapted to the market. Owing to the country's large market share in conventional medical devices, the Internet-based medical device and remote healthcare segments first flourished in the U.S.

**FitBit: A Case study**

"SAFe has been a successful story for us. It allowed us to grow our team in a seamless way that integrated cross-functional groups and aligned with the company's long-term strategy. Fitbit has grown significantly since we adopted SAFe, and we were able to scale the process and still deliver high achievement every PI. My VP calls it the scaffolding that has helped moved our team forward,"(iii) said Damian Brown, the Senior Director of Program Management Office of FitBit.

FitBit is a consumer technology company that released 4 new products in the market in 2016 that received massive positive response from the consumers. Over 22 million devices were shipped by the company. This was a milestone for the company as it delivered the highest number of products ever in one single year. This success was completely due to the company's commitment and successful adoption of SAFe® (Scaled Agile Framework®). SAFe® is a set of workflow patterns that helps guide enterprises, such as these, in scaling lean and agile practices, and aid the team to scale up and improve targets.

The main challenges faced by the FitBit team was delivering the high target numbers in the festive seasons when consumer shopping is at an all-time high. During such holidays the target days are completely inflexible in regards to developing software and firmware that would support every major platform – Android, Windows and iOS.

Damian Brown stated "With our growing team and global presence, we knew our Scrum efforts were not going to scale." He further added,

"The question was, 'How do we keep the organic culture people like about Fitbit while addressing the needs of the business and our global community of users?"(iv)

Since 2007, Fitbit has helped millions of people worldwide lead healthier, more active lives by empowering them to achieve their goals with data, guidance, and inspiration.

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Adopting a Scaled Agile Framework, Fitbit fulfilled its delivery objectives by scaling the process of the delivery teams in the following ways:

1. Create a flexible and fast flow across the entire ecosystem of FitBit
2. Create an ecosystem-wide team system working together to deliver rapidly
3. Scale up to adopt growth in the team
4. Improve visibility with a two-month vision of what each team will work on
5. Create mechanisms for stakeholders and teams to identify team dependencies and add items to the backlogs of other teams as needed
6. Align key business dates across all programs, including safety, data center movements, compliance and marketing

Thus, Fitbit successfully achieved the process evolution with the help of SAFe and was able to create an unsurpassed product.

- ❖ IoMT's adoption barrier:
  - The regulatory landscape continues to adapt to new technologies that IoMT vendors and developers must keep in mind.
  - A lack of relevant digital talent among IT employees may affect the ability of an organization to deploy IoMT devices.
  - Increased risk of cyberattacks as more medical equipment and other systems become connected.
- ❖ Technology yet to launch in IoMT
  - Biosensor technology
  - Implantable sensors

Micro-electric mechanical systems (MEMS)

**Advances in Neurotechnology:**

Researchers are working on developing high-tech cranial wearable products as IoT devices are also capable of reading brainwaves, thereby helping track and transmit mood altering neuro signals, which would help cope with the growing mental health problems globally, and also enable real-time monitoring of mental health of patients.

Other advances in neurotechnology include non-evasive brain wave reading and recording to help analyze drug efficiency in individual patients. The research on this technology is currently ongoing.

**Conclusion**

Advantages such as round-the-clock patient monitoring and care deliverance has already saved or at least improved many lives. Apart from saving lives, IoMT has made Medicare facility very convenient, improved drug management, and contributed to visible improvements in disease management through real-time monitoring. Apart from the obvious advantages, the future necessities require increasing the security of all types of data being transferred and stored in the connected devices to maintain patient confidentiality.

# Innovation in Alzheimer's Treatment

## Through the neuroAD Therapy System

The treatment of Alzheimer's disease is considered as one of the biggest unmet medical desires in the world today, with only a few medicines available, often limited by side effects, and offer partial clinical relief. This disease alone affects more than 5 million people in the U.S. and is estimated to affect more than 30 million worldwide.

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### How It Works

This treatment is generally combined with Alzheimer's medication and gives new hope for an improved quality of life for the patients. It starts with an MRI scan, where the six brain areas that play a key role in memory, logic, and language are identified. A dose of TMS is given in each round of tests, to stimulate the small parts of the brain using electromagnetic induction. An electric current is generated by a pulse generator and transported by a coil near the head of the patients. This is a complete brain-memory enhancement exercise. The initial treatment for neuroAD consists of 30 hours of daily treatment followed by infrequent maintenance.

### The neuroAD Therapy System

The neuroAD therapy system is set to be the first medical system in the world for the treatment of mild Alzheimer's developed by a company called Neuronix, to help patients forge new pathways around the areas of brain damage. The non-invasive system combines brain stimulation with mental exercises to improve the cognitive performance in patients suffering from Alzheimer's, in particular Transcranial Magnetic Stimulation (TMS), following an involvement practice for six weeks, five days a week, and one-hour session a day.

**Function of neuroAD Therapy System**

### Development of neuroAD System

After many years of R&D conducted on 131 patients in some of the world's most prestigious Alzheimer's research centers, to include nine medical centers in the U.S. and one in Israel, and several previous successful clinical trials, there was sufficient evidence to prove that the neuroAD therapy system offers significant additional potential benefit to Alzheimer's patients. Eyal Baror, CEO of Neuronix said, "With these positive findings, we have applied to the FDA for marketing clearance under the Employee Assistance Program (EAP), and expect to have the neuroAD Therapy System cleared in 2017, and if the device is approved, "very early" pricing estimates are between $6000 to $10,000 per patient for 30 sessions of a full course of treatment, depending on factors such as location. This will bring new hope for the millions of Alzheimer's patients and their families who find themselves in a race against time searching for an effective treatment to manage the effects of this debilitating and incurable disease."

Dr. Alvaro Pascual-Leone, Professor of Neurology at Harvard Medical School, and Chief of the Division of Cognitive Neurology at Beth Israel Deaconess Medical Center, is the key researcher for neuroAD therapy system. His work is aimed at preventing age-related cognitive decline, reducing the risk of dementia and neurodevelopmental disorders such as Alzheimer's. According to Health Management Systems, Inc., Dr. Pascual-Leone ranks number one among TMS and non-invasive brain stimulation authors. Dr. Pascual-Leone is of the view that, "While there is still no cure for Alzheimer's disease, neuroAD is a non-invasive option, with minimal side effects, which has the potential to help patients maintain their cognitive abilities and the independence that so many of us take for granted."

neuroAD has the potential to improve the cognitive abilities of patients and to increase their daily activity levels, especially for a clinically well-defined subgroup at milder stages. Dr. Marwan Sabbagh, Director of Alzheimer's and memory disorders programme, at the Barrow Neurological Institute in Arizona said, "The Study shows that treatment with the neuroAD Therapy System shows very mild and transient side effects, and can be administered without interruption to on-going pharmacological interventions."

- If, neuroAD therapy system is approved by the FDA, then it would be the first medical device ever to treat Alzheimer's disease.
- Studies and positive outcomes clearly show that neuroAD has the potential to recover the cognitive abilities of Alzhiemer patients and to upsurge their daily activity levels.

### A Real "Game Changer"

The neuroAD therapy system has been approved for use in Europe and in other territories. It is available commercially or in clinical trials in Europe as well as in Israel, Hong Kong, and Korea at the leading Alzheimer centers. However, neuroADTM therapy system is an experimental device in the U.S. and is not available for sale. The first patient treated with neuroADTM therapy system was 61-yearl-old Eileen Brannigan, 61 year old, who said it had "changed her life.

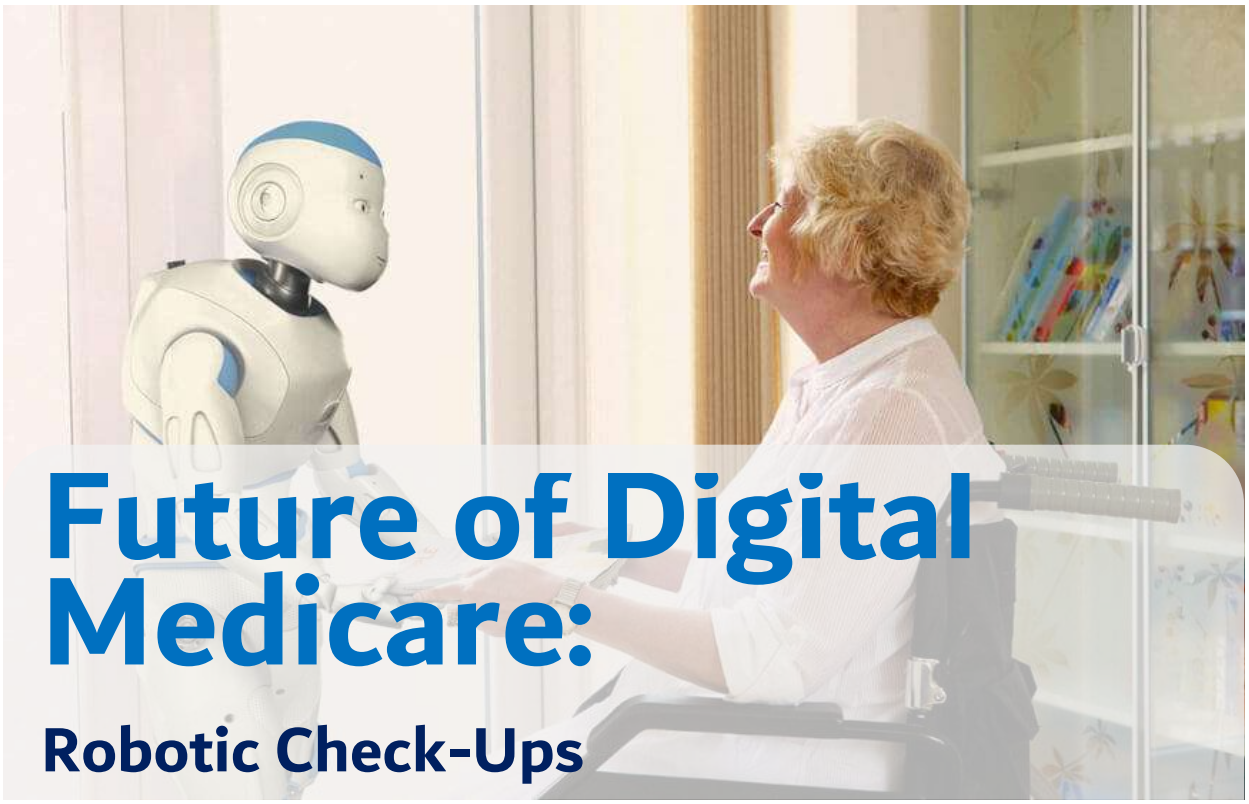
Currently, there are around 850,000 people suffering with dementia in the U.K., of whom around 500,000 have Alzheimer's. The neuroAD therapy system is available at Phoenix Health Mental Services, U.K. for adults, children, adolescents, and old-age patients. Around 16 patients were treated with the system and all showed significant improvement in their cognitive function. In the coming years, neuroAD therapy system is going to change the lives of Alzheimer's patients.

Dr. Wayne Kampers, Medical Director and Consultant Psychiatrist of the London Neuronix Centre said, "Alzheimer's disease is one of the greatest challenges facing practitioners due to an aging population that is living longer; our patients and their families are looking for new treatments that can improve the symptoms of this disease."

- The neuroAD therapy system is brings a new hope and a real change towards the battle against Alzheimer's.

### Future Scenario

Many clinical trials and positive outcomes of studies confirm the commercialize use of this digital and innovative system in Europe and Asia, which is potentially useful for Mild Cognitive Impairment (MCI) or other forms of dementia. There is a multi-site clinical trial going on across the U.S. for the use of NeuroAD, electromagnetic stimulation device. The treatment of Alzheimer's is very expensive across the globe, with annual expenses estimated at $600 billion. The number of Alzheimer's patients is expected to double by 2030, therefore, there is vast growth possibility for the neuroAD therapy system in the coming future.



# Future of Digital Medicare:

## Robotic Check-Ups

Medical robots, such as hospital mobile robots, surgical robots, xenex robots, and interactive body assistance robots, are used in medical science for a wide range of specific applications and are designed accordingly. Medical robots can carry out patient checks without direct human assistance. Doctors have turned to technology to offer innovative advances in the medical sector. Robotic check-ups do not require direct human intervention and contains a two-way video screen so that communication is easy no matter where the doctor or patient is. It also reduces the waiting time, spread of diseases, and is a cost-effective innovative technology.

### Robotic Check-Ups

Robotic check-up technology does not aim to replace human doctors, but to make it easier for doctors to check in with their patients and for patients to have quick access to their personal doctors. The robotic check-up device consists of cameras, microphones, 3-D mapping sensors, and a stethoscope. The face of the doctor appears on the screen of the robot, and he or she interacts with the patient via the video hookup in real time.

The need of robotic check-ups has grown as there are not enough doctors to go around to each hospital. The Johns Hopkins experiment in the Hospital of Maryland University involved 60 patients who recovered from surgery, and 30 of the patients were randomly chosen to receive visits from the robo-doc once instead of their doctor's actual visit. Most of the patients are very comfortable with this innovative robot check-up technology. Cost of each robot is $4,000 to $6,000 per month or less.

### Technology Scalability

iRobot Corp. and InTouch Health jointly produced a robot, which is an autonomous navigation remote-presence robot to receive FDA clearance for hospital use. Dr. Louis Kavoussi, a professor of urology at Johns Hopkins and the study's lead author said “Generally, the robot checked up on patients, asked them how they were feeling, inspected their surgical sites to ensure proper healing, and answered questions.

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Russ Taylor is considered as the "Father of Medical Robotics." In the coming future, medical robots will be most widely used in the field of medical science, which did not exist 40 years ago. "I believe that robots are changing the medical practice the way they changed manufacturing over the last few decades. We're creating a partnership between humans and machines that has changed how and where surgeries can be performed," says Taylor.

Robotics has a vast potential in medicine. Soft robotics that can redefine slightly invasive surgeries are capable of collaborating with humanoid robots and acquire information to interact with humans safely and effectively. Medical robots increase human productivity and offer a broad platform for innovation. However, its acquisition and operating costs can be quite excessive. Doctors on a daily basis (approximately 80% of their time) are involved writing prescriptions, performing diagnostics, and patient monitoring. New robotic technology frees them for other work and increases the productivity of the doctors.

The list of potential robotic technology devices is quite long. From open-source prosthetic technologies that can feel and interact with substances to microscopic robots called microbots that perform definite tasks within the body, robotics has great potential in the medical industry in future.

### Revolution in Medical Robotics:

For at least the last two decades, medical robotics has gradually revolutionized the treatment process. At-home nurses or caregivers are using robots to enhance the practice of innovative technology of telemedicine and care for those who are unable to go to hospitals or are restricted to their homes. For example, The Vasteras Giraff, a two-way call system mobile communication tool, similar to Skype is used by doctors to communicate with the patients. Robots are not new to the medical industry, in fact manufacturers have introduced a number of innovative robots to provide remote patients with better care, to help them with various physical therapies and also to carry out surgeries. Magnetic Microbots, is a group of small robots used for different operations, such as to remove plaques from the arteries of a patient, or to help with eye conditions, and also for infection screening.

## Types of Medical Robots

### Mobile Robot:

Development of mobile robots have numerous advantages over humans such as 24-hour availability, impermeability to infection, and the facility to serve as a virtual telepresence and communication channel for one or more patients using a PDA, touch screen, and teleconference system. Several functions that determine the potential use of mobile robots in healthcare are self-recharging capacity, the ability of being controlled remotely using a joystick and other developed methods. Mobile robots can follow physicians' hospital wide using a Ultra-Wide Band (UWB) radiofrequency identification system incorporated in them. Mobile robots have been developed and tested for to be sent to patient rooms in quarantine as well.

### Xenex Robot

The Xenex robot is helpful in destroying deadly microorganisms causing Healthcare Associated Infections (HAIs) by using special UV disinfection and actively triggering cellular damage inmicroorganisms.

### da Vinci Surgical System

According to CDC Organization, in the U.S., the number of people dying from HAIs is approximately the same as from breast cancer, AIDS, and auto accidents combined.

- Medical robots improve the precision in medical checkups, treatment, and surgery, making it less invasive and speeding recovery.

da Vinci Surgical System is one of the important developments in medical robotics. It is used by the surgeon at the time of surgery to work with improved vision, precision, and control. The device has a magnified 3D high-definition vision system and a small wristed apparatus that bends and revolves far greater than the human hand. Surgeons are 100% in control of the robotic system at the time of the surgery and are able to carry out surgeries more precisely.

### TUG Robot:

TUG robot is designed to help healthcare personnel in hospitals carry around a multitude of racks and carts up to 1,000 pounds in the form of laboratory specimens and medications. TUG robot operates with the help of a screen. Using a touch screen they can be sent to any location in the hospital as needed.

- ❖ According to Robotic Industries Association, medical robots purchased in North America were 32% more in the first quarter of 2017, than at the same time a year before.

### RIBA Robot:

RIBA (Robot for Interactive Body Assistance) is used to care for the patients who need assistance. The robot can move and lift patients in and out of bed or a wheelchair. It can help patients stand or turn them to avoid bed sores as often as necessary. RIBA can lift and carry patients up to 134lbs**.**

A 62-year-old man had high-grade transitional bladder cell carcinoma. A year earlier, he had nephrectomy due to left kidney carcinoma using traditional open surgery. His remaining kidney works poorly, which makes him dialysis dependent. In such a situation, there is a need for resection of the bladder. Due to risk of cancer in future, it was advised that the malfunctioning kidney, bladder, and prostate, all be removed.

The entire procedure was performed with a minimally invasive robotic technique by means of five 1-cm incisions and a larger incision to remove the organs. All three organs were successfully removed together with the ureter in one piece. After a year of the process, now the patient is cancer free and doing well.

- ❖ In healthcare, robotics technology is used in a variety of ways, however, majority of robotic systems are still in the research stage.

### Challenges:

With a large number of positive results, the future of medical robots still faces a few challenges. Some of them relate to the use of new materials for the production of new generation robots, the growing levels of autonomy and related legal and ethical barriers to medical robots that needs to be overcome, and some key technological issues towards the development of robots.

### The Future of Medical Robots:

New digital robots are still coming into the picture for an expanding range of healthcare applications. At the Worcester Polytechnic Institute, associate professor Gregory Fischer and his team, are working to develop a compact, high-precision surgical robot to improve the precision of the prostate biopsy in the bore of the MRI scanner and the electronic control systems and software. Fischer and his team have had to overcome many technical challenges for the development of advanced digital robots that can work inside an MRI scanner. There are many other ongoing researches for the development of expanded variety of robots with a wide range of application for a better future.

# Digital Palliative Care Improving

## End-of-Life and Advance Care Planning

Digital palliative care uses predictive analytics and artificial intelligence to identify appropriate patients and to train and organize palliative care professionals, mainly nurses and social workers on how to engage with the patients in the community. Palliative care is used to treat the mental and physical well-being of the patient. It also focuses on improving the communication between the patient, the patient's family, and medical staff. It addresses all emotional and spiritual needs.

Palliative care involves patients with chronic diseases and family members who have lost a loved one and are burdened with a host of decisions during the time of grief. Leading healthcare providers and digital healthcare companies are now progressively focusing on end-of-life planning and advanced care planning to better arrange healthcare resources for patients and families to promote a better experience. According to data from the National Palliative Care Registry, an average of 3.4 percent of admissions receive palliative care services in hospitals.

The potential advantages of digital technology has resulted in saving social costs for aged people and has improved patient reporting results, as the trained doctors and nurses make regular visits to the patient at home, taking care of checkups and providing medications.

It is equally important that patients with chronic diseases remain stable enough to avoid hospitalization and receive non-critical care at home. Healthcare management companies provide the best to prevent hospitalizations by encouraging and supporting chronic disease self-management and provide medical services at home.

"Now when any member of the clinical team is taking care of a patient who has an advanced disease, a patient who has just passed away, or if a patient is going home with a care plan focused on comfort, we are now able to make a

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referral to the Grace team and introduce this valuable service to the patients' families" says, Dr. Bradley Rosen director, office of care transitions, medical director, and supportive care medicine at the Los Angeles-based Cedars-Sinai Medical Center.

The Worldwide Hospice Palliative Care Alliance (WHPCA) is an international non-governmental organization dedicated exclusively to the development of hospice and palliative care. They organize World Hospice and Palliative Care Day, a federated day for hospice and palliative care around the world to be celebrated and supported every two years on the same date. The next palliative care day is on October 12, 2019.

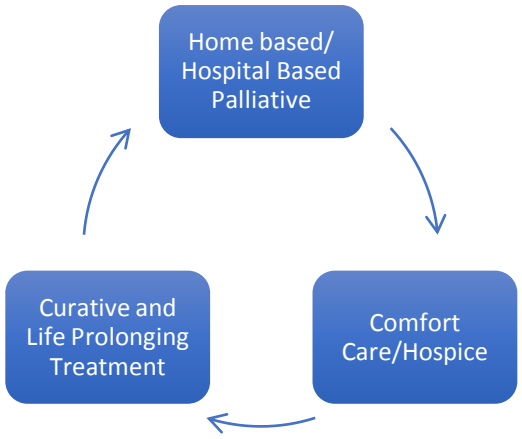
There is also an ongoing political movement within the healthcare industry to educate and empower patients and providers on the importance of advance care planning. According to a survey on loneliness by the AARP Foundation, published in 2010 and now updated, approximately 42.6 million U.S. adults aged 45 and older suffered from loneliness. Both public and private sectors are taking initiative and paying more attention to the problems, which are driven by population aging, changes in the structure of the family, reliance on technology, instead of face-to-face discourse and other forces.

Many surveys are carried out to know the impact of palliative care as in end-of-life studies. A 2013 national survey found that 90 percent of Americans believe that it is important to have discussions with their families on end-of-life care, but less than 30 percent actually did so. Another study in 2014 reported that only 26 percent of Americans surveyed completed an advanced directive, such as a living will or other legal documents stating their end-of-life wishes. 70% of Americans say they would rather die at home, even though only 25% actually do so.

According to a study reported in the New England Journal of Medicine in 2010, early palliative care patients with lung cancer had less depression, improved quality of life, and survived for 2.7 months.

### Facts Related to Palliative Care:

- About 68% of Medicare costs relate to people with four or more chronic conditions— the typical patient with palliative care.
- In the U.S., if palliative care was fully integrated into the hospitals of the nation, total savings would amount to $6 billion a year.
- The increase in palliative care in hospitals is exponential. The number of teams increased by 164 percent over 12 years due to the work of the Center to Advance Palliative Care (CAPC). There are over 1,700 hospitals with a palliative care team to date.
- About 61% of all hospitals with more than 50 beds or more currently have a palliative care team.




**Palliative Care Zone**

- The Medical Institute is responsible for ensuring that end-of-life care is compassionate, affordable, sustainable, and of the best possible quality. "Whole person care" is not just care goals of palliative care.
- Palliative care is not possible without skilled nurses: Evidence supports that nurses play an important role in palliative care teams or as independent practitioners. Nurses can be active in focused tasks (e.g. pain management) or in broad roles (e.g. case management). Particularly, for patients with cancer and their families, nurses can play a critical role in alleviating the pain.

Community-based Palliative Care (CBPC) is a specialized care for those suffering from a serious or advanced disease. It helps to relieve symptoms of stress, sets goals for care, and improves communication and care coordination, all of which improves the quality of life of the patients and the caregivers. The digital palliative care approach offers a systematized palliative care process that provides health plans for patients through accountable care organizations with consistency across geographical regions. Medicare Advantage (MA) guidelines have been expanded by the Centers for Medicare & Medicaid Services (CMS) to cover more additional benefits that could potentially address certain Social Determinants of Health (SDoH), including a combination of genetic, environmental, economic, political, and social factors, such as isolation and solitude. In addition to isolation, other key determinants for people with severe or advanced diseases include economic instability, poor education, poor social support, poor housing, hunger, lack of transport, and limited access to quality care, all of which have an impact on a wide range of health and functioning outcomes.

### Technology in Palliative Care

A host of web and mobile applications for palliative care are available to support clinicians, patients, and their families. As in any health information system, end user satisfaction is essential for the successful implementation of the system.

The Institute of Medicine (IOM) reports that people close to the end of their lives are often seen and admitted to hospital in several healthcare settings. Therefore, it is important that their health information is shared and transferred efficiently between different locations to ensure continuity of care. Interoperable Electronic Health Records (EHRs) and other digital health systems can support this process and improve the communication between different professionals, minimize delays, and prevent replication of services.

Interpersonal communication and the sharing of feelings is another important aspect of palliative care. Many people, including health professionals, do not feel comfortable or competent to talk to the dying person and/or their family members about difficult existential issues. Digital health can provide training tools that help educate and guide patients and caregivers through conversations that are potentially difficult.

Telehospice has been described as the "newest telehealth delivery frontier." Remote communication, such as a telephone or video conference, can be used to carry out certain services that would require a hospital visit. This adds a new dimension to palliative care services.

As people are experiencing an increase in the use of digital technologies for the management of population health, aging at home, wellness and preventive medicine, they must always be aware of the importance of human interaction. The best management companies in healthcare are those with the most dedicated, trained, and empathic caregivers.

Vital Decisions, Vynca, WiserCare, Cake, Everplans, and Grace are the companies utilizing digital technology to manage patient and family together. They actively encourage people to engage in end-of-life planning in the face of unresolved barriers to adoption., With the recent attention to the topic, increasing comfort with digital care models, and affordable healthcare costs, all have the potential to make end-of-life companies a success.

- Actions for increased palliative care: Solution is possible by delivery of basic palliative care services from non-specialty clinicians and by increasing the workforce of trained palliative care clinicians through traditional and alternative mechanisms. As the demand for palliative care integration increases, the scarcity of specialist physicians poses a significant barrier to patient-centered, serious illness care.

**Future Prospects**

An increasing proportion of senior citizens, rising chronic disease, increasing incidence of cancer and many other diseases, and the recognition of the need for supportive and symptomatic care in diverse pathophysiological diseases will lead to the growth of palliative care in the coming years. Hence, it is essential to include palliative care into the healthcare system, medical education, and societal framework.

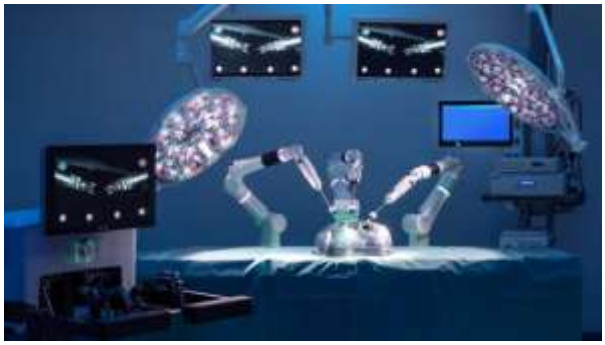
# Achieving Precision Surgeries through Robot-Assisted Procedures

In science-fiction movies, however, it is far from science fiction and quite a reality now. Robotic surgery has been helping surgeons perform surgery for the past three decades. It is probably the biggest technological advancement in modern medical industry, with digitalization constantly working towards enhancing the lives of the patients.

Surgeons have been making use of tactfully designed robotic assistants as a great high-tech solution to make surgical procedures more accurate, simpler, and less distressing for their patients. Millions of operations using robotic assistants are performed across the globe. Da vinci robots are currently the face of robotic surgery around the world. These robots help hold surgical instruments and visual aids with the many mechanical arms they have.

### Robotic Surgery: A Case Study

A 63-year-old cancer patient, Christine Lockton, suffering from colon cancer had to undergo surgery that involved a hysterectomy and had a part of her colon also removed simultaneously. This double surgery utilized the robotic system – Da Vinci Surgical System and took place at the Royal Marsden Hospital in London. Two surgeons manipulated different robots simultaneously during Christine's operation. Just two days after the surgery, Christine was able to return home due to the less invasive nature of the robotic surgery.



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One of Christine's surgeons, Dr. Shahnawaz Rasheed, is a colorectal cancer specialist at the Royal Marsden Hospital in London and is of the view that using robots in surgery helps reduce the recovery time for patients.

"Robotic surgery is not autonomous but is controlled by us the surgeons. We introduce the 'arms' surgically. These have instruments attached, including a high-definition 3D camera. The surgeons will go to the robotic console, while at least one assistant will stay by the bedside. We control the arms from the control console, manipulating tissue, much in the same way a surgeon would when carrying out open surgery, and remove the cancer,"(i) explains Dr. Rasheed.

**Dr. Shahnawaz Rasheed**

"There are a number of benefits of this minimally invasive procedure, importantly for our patients. They lose less blood, experience less pain, recover quicker, and leave hospital sooner. The robotic surgery allows us to see in close detail in 3D-magnified images, and with its three arms maximizes surgical precision, added the doctor.

### Robotic Surgery in Modern Medicare

Robot assisted procedures has grown more popular with the technological advancement. By September 2017, there were about 4,271 Da Vinci Surgical Systems installed in hospitals around the world. Of these, approximately 62% are in the U.S. and 17% in Europe.

Apart from the Da Vinci surgical systems, the other advancements in robotic technology include:

The Mazor Robotics' Renaissance Guidance System: The Renaissance Guidance System by Mazor Robotics has been designed to provide comprehensive surgical solutions for spine surgeries. As the spine requires most delicate handling, surgeons can't afford to take chances when working on the patient's spinal cord. Renaissance offers a direct outline for the spinal surgical processes, tailor-made to fit each individual patient best. The guidance system helps to increase the accuracy and lowers the complication rates with a faster recovery period.

Some procedures that make use of the renaissance guidance system include –

- Spinal Fusion – In this procedure, the system helps in guiding the surgeon's tools for absolute accuracy making the implantation procedures much easier and reduces the risk of complications.
- Kyphoplasty – In this procedure, the system helps pinpoint the exact location to inject the bone cement, thereby reducing complications that might arise if the cement is injected in the wrong area due to human err.
- Others – Other procedures include biopsies and scoliosis surgery, where the renaissance robotic system helps in providing extra safety, minimizes soft tissue damage, and improves the precision in corrective procedures.

- The technology of robotic surgery is totally different as it distances the operating surgeon, the operating field, and any assistants or learners physically.
- Ten years of robotic surgery was celebrated at The Royal Marsden. From January 2007 to January 2015, 1989 surgeries have been performed.
- Shortcomings of Robotic Surgery:
  - Many optical devices used in all trocars.
  - Limitation in movement can be maximized by focusing on more flexibility.
  - Large scars due to impact of using large trocars, which should be avoided.

### The Smart Tissue Autonomous Robot – STAR:

Invasive procedures mean a lengthy recovery period, prolonged pain and discomfort, and often large scars. The biggest driving factor behind using robotic technology in surgery is to reduce these kinds of extremely invasive procedures.

While the most widely used robot technology in surgery, such as the da Vinci Surgical System, requires the surgeons to operate and control them, the newer developments in robotic surgery are trying to achieve self-driven medical robots instead, like the Smart Tissue Autonomous Robot (STAR). The STAR lights up its surroundings inside the body using lights similar to infrared, and follows an imaging strategy known as "plenoptic imaging" to be able to design a 3D model of the surrounding using the several viewpoints through its cameras.

With just human supervision, the robot is able to make linear sutures connecting sections of the small intestine together. This small surgical procedure means great things for the future of precise surgery, especially in the humanly inaccessible smaller regions of the body.

### Virtual Incision Corp's Miniature Robot:

The miniature robot designed by Virtual Incision Corp., a privately held company received the "Game Changer Award" in 2015 from Robotics Business Review for its innovative nature.

This robot can be the answer to making minimally invasive colon resecting procedures. These procedures are ideal for people with Crohn's disease, diverticulitis, ulcerative colitis, and colon cancer. The robot was successfully able to complete its first colon resection on a human in March, 2016.

Unlike the arm-like design of other surgical robots, the miniature robot by Virtual Incision can be completely inserted inside the body of the patient's abdomen through just a tiny incision. This small robot uses prevailing techniques and tools familiar with the surgeons present, and also does not require a dedicated operating room to carry out the procedure. Hence, this robotic surgery costs much lesser than some of the alternative robotic surgery options.

### The Future of Robotic Surgery

Considering advanced surgical solutions, it seems that the future has already arrived! Robots have emerged to help surgeons perform their jobs better. In short, robots make the surgical procedures less invasive and reduce the probability of risks though accuracy and precision.

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# Appendix

1. **Organs-on-Chips: A Microchip That Mimics the Human Response**
   (i), (ii) Wyss Institute, Center for Life Science Bldg

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3. **Innovation in Alzheimer's Treatment Through the neuroAD Therapy System**
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   (ii) https://engineering.jhu.edu/news/2014/01/01/surgical-precision/#.XEsIO1UzbIU

5. **Digital Palliative Care Improving End-of-Life and Advance Care Planning**
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6. **Achieving Precision Surgeries through Robot-Assisted Procedures**
   (i) https://www.healthline.com/health-news/how-robotic-surgery-is-helping-patients-doctors#3
   (ii) https://www.healthline.com/health-news/how-robotic-surgery-is-helping-patients-doctors#3

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