
patient@home
Get Updated on the
Largest Nordic Research and Development Project
on Healthcare Technology
AT THE INTERSECTION
OF RESEARCH AND
INNOVATION

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FOREWORD

Denmark is facing major challenges within the healthcare sector, including a growing need for new thinking and innovation that can provide better prevention, rehabilitation, more outpatient treatments instead of hospitalizations, and effective patient care – possibly in own homes.

One of the barriers to effective innovation and implementation of novel medical technology solutions is to get solid data on the effectiveness of the critical interaction between users, therapists, manufacturers and inventors.

Innovation Fund Denmark is a co-investor in the Patient@home project, which is an example of cooperation between public and private companies that by means of test facilities and quantitative knowledge sharing can build bridges between all the players.

Within the first half of the duration of the project, the framework for quantitative and uniform testing of promising new technologies was created. A number of interesting sub-projects have been initiated, which can potentially reduce the hospitals' resource consumption and increase patients' active involvement in their own health.

In the latter half of the project all this will be translated into more concrete trials and implementation of new technologies and services for the benefit of all parties including citizens, the healthcare sector and industry.

The examples are advanced healthcare technology solutions that support the empowerment of cardiac and diabetes patients through co-responsibility and self-care, and technologies that can help acutely ill, geriatric patients to remain in their own homes. They are expected to contribute to the introduction of specific improvements within the healthcare system in the foreseeable future.

I hope you enjoy the publication.

Director Peter Høngaard Andersen,
Innovation Fund Denmark

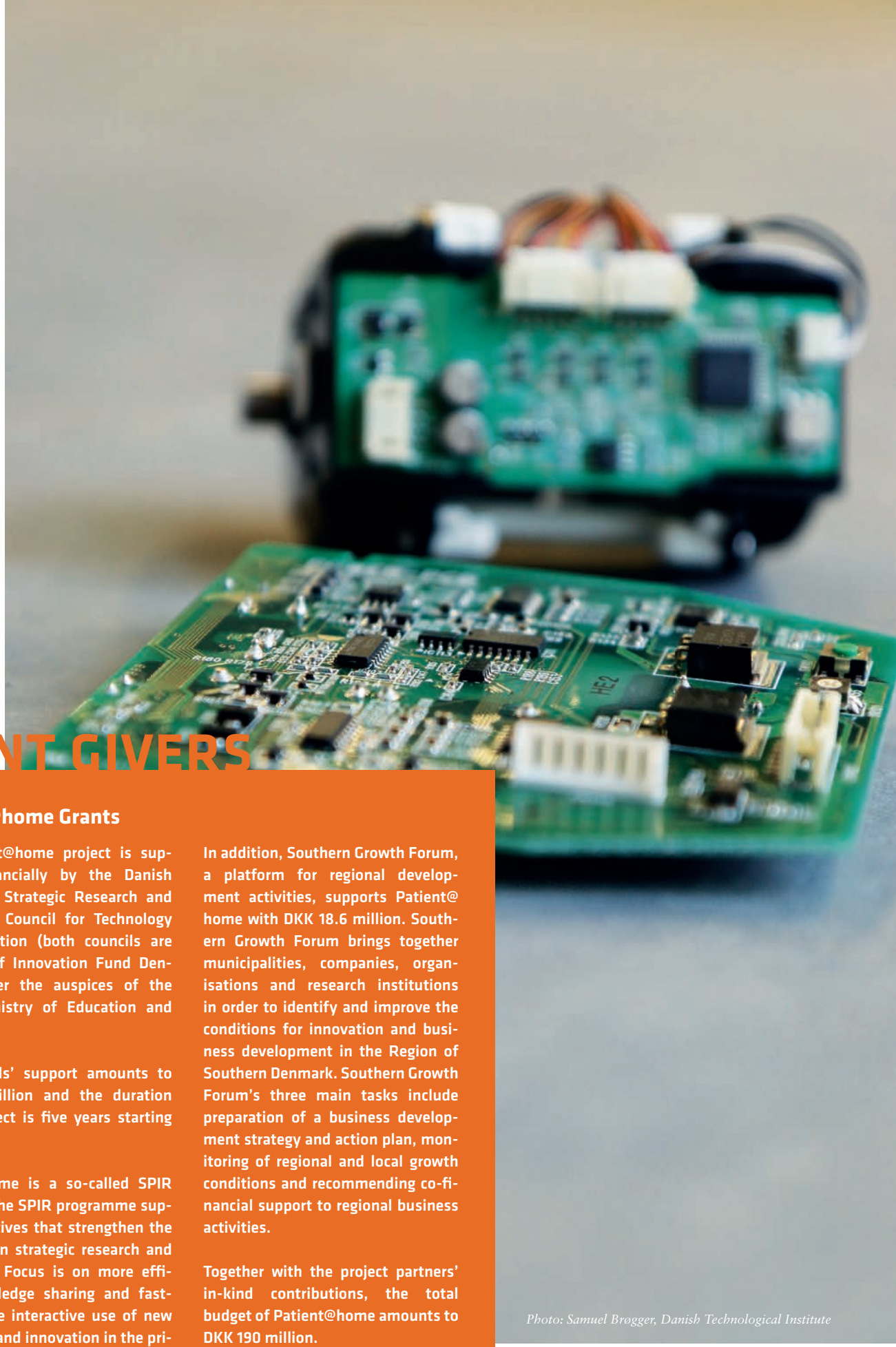


Photo: Samuel Brøgger, Danish Technological Institute

GRANT GIVERS

Patient@home Grants

The Patient@home project is supported financially by the Danish Council for Strategic Research and the Danish Council for Technology and Innovation (both councils are now part of Innovation Fund Denmark) under the auspices of the Danish Ministry of Education and Science.

The Councils' support amounts to DKK 70 million and the duration of the project is five years starting March 2012.

Patient@home is a so-called SPIR initiative. The SPIR programme supports initiatives that strengthen the link between strategic research and innovation. Focus is on more efficient knowledge sharing and faster and more interactive use of new knowledge and innovation in the private and public sectors.

In addition, Southern Growth Forum, a platform for regional development activities, supports Patient@home with DKK 18.6 million. Southern Growth Forum brings together municipalities, companies, organisations and research institutions in order to identify and improve the conditions for innovation and business development in the Region of Southern Denmark. Southern Growth Forum's three main tasks include preparation of a business development strategy and action plan, monitoring of regional and local growth conditions and recommending co-financial support to regional business activities.

Together with the project partners' in-kind contributions, the total budget of Patient@home amounts to DKK 190 million.

PATIENT@HOME

– At the intersection of research and innovation

Patient@home is the largest Nordic healthcare research and technology innovation project focusing on developing new technologies and services for especially rehabilitation, care and monitoring within the Danish healthcare sector. The Patient@home platform includes more than 60 national and international partners from both public and private sectors.

Through an interdisciplinary and open public-private research and innovation cooperation among healthcare professionals, patients, private companies and research institutions Patient@home will develop a number of new healthcare technology products and services that may actively reduce both the number and duration of hospital admissions in Denmark.

Aim

The aim is to develop 40 new products and services that can support the healthcare sector's increasing need for better and faster rehabilitation, more outpatient treatments and in-home care and admissions. The development of such technologies should minimise the pressure on hospitals' financial and human resources as well as increase patients' active participation and motivation for taking responsibility for their own health.

In addition, these technologies will ensure that healthcare professionals throughout the sector may have both valid and consistent data for the assessment of the individual patient's need for treatment. Besides, Patient@home will provide Danish companies with access to the latest knowledge, laboratories and real-life test facilities, i.e. an optimal starting point for building strong international market positions in terms of innovative and intelligent healthcare technologies and services.

Cooperation ensure relevance and impact

The platform includes more than 60 national and international partners from the public and private sectors.

The project's strong focus on close co-operation among health professionals, patients, private companies and research institutions will ensure relevance and impact of the developed products and services. This kind of cooperation is a guarantee that all products and services are designed in compliance with user needs and acceptance, and that all results are based on the latest research findings as well as the companies' and especially the hospitals' development and business plans.

The project's business partners will get a unique opportunity to move one step closer to the latest knowledge on healthcare technology mainly rehabilitation, care and monitoring of patients in their own homes. The project's hospital partners will be able to follow the development and maturation of tomorrow's healthcare technologies and services, and the project's local partners will get a unique opportunity to take part and make an impact on the development of a wide range of cutting-edge technologies that are based on the in-home rehabilitation needs of citizens and patients.

Five major action areas and six thematic project categories

Patient@home combines targeted research and innovation in a variety of healthcare technology projects, all of which focus on user-driven development of technologies that help patients to take responsibility for their own health and treatment. In addition, the projects add enhanced quality to the healthcare sector through technology-assisted treatment, monitoring and rehabilitation in patients' own homes – before, during and after admissions.

Target areas

New ways of thinking: Improvement of the healthcare sector through technology-assisted treatment, monitoring and rehabilitation patients 'own homes – before, during and after admissions

Innovation: Targeted development of new technologies and services together with companies, healthcare professionals, end users and research institutions

Empowerment: User-driven development of technologies that helps patients to take responsibility for their own well-being and treatments – and allows them to be patient in own home

Knowledge exchange: Transfer of new research and knowledge to Danish companies – for the benefit of development and maturation of new healthcare technologies and market areas

Research: Creating new research and knowledge on development and use of healthcare and related technologies – based on interdisciplinary collaboration with end-users, research institutions, companies and healthcare professionals

Project categories:

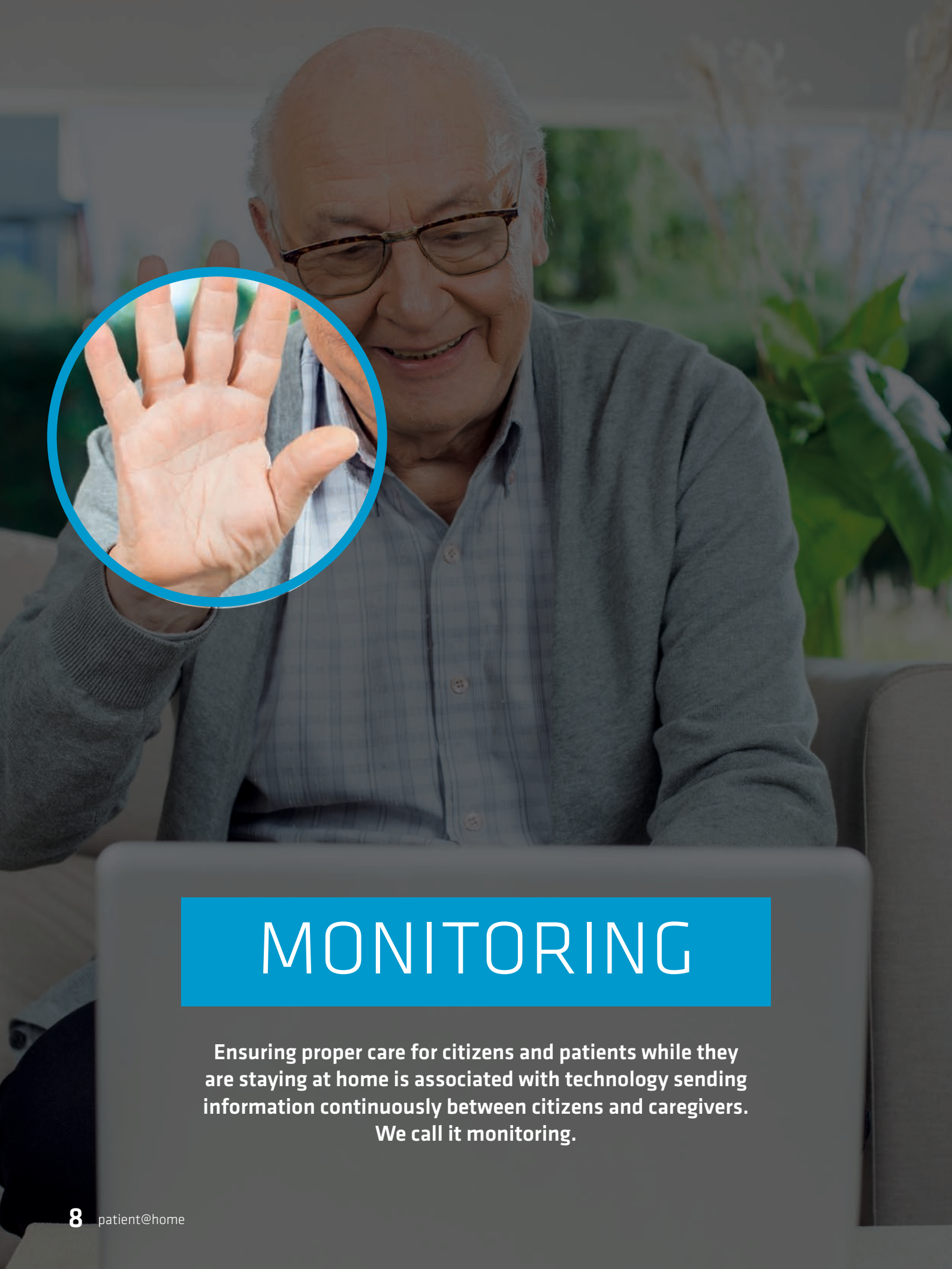
- **Monitoring:**
  Remote follow-up of the patient's condition
- **Care at home:**
  Technology that supports patient care and stay in own home
- **Rehabilitative training:**
  Physical training using modern technology
- **Knowledge and information management:**
  Data capture, data analysis and data visualisation
- **Information and communication technologies:**
  Development and Design of Smart-Home technology that can support admissions in own home
- **Fast Track:**
  Fast and flexible testing or implementation of new technology

FACTS

Since the start of Patient@home in 2012 more than 60 active research and development projects has been launched. 13 products and services are now completed and 41 companies have participated in the development activities – and new businesses keep coming and showing interest in the project.

In the second half of the life of the Patient@home project extra attention will be paid to innovation projects. As the research activities come to an end, focus will be directed towards use and activation of research results in various projects.

How companies use and activate the new knowledge and research that have been developed in the project's first period will continue to be a major area of attention. Active involvement by both companies and end users of the new products and solutions will, therefore, remain an important subject.



MONITORING

Ensuring proper care for citizens and patients while they are staying at home is associated with technology sending information continuously between citizens and caregivers. We call it monitoring.

By Peder Jest
Medical Director,
Odense University Hospital
Member of the Executive Board of
Patient@home

A growing number of older adults suffer from chronic conditions and the number of health professionals is declining. If patient treatment and quality of life are to form a synthesis in the future, it is necessary to introduce self-monitoring and remote monitoring concepts. Hence, the use of monitoring technologies are expected to increase steeply, i.e. surgically implanted equipment transmitting messages on required adjustments and replacements, functionality and new high-tech measuring tools for mobile devices.

This scenario does not only reflect enthusiasm for technology but new treatment methods with the aim of ensuring that the patient can live as independently and self-reliantly as possible. This requires not only technological developments and technological opportunities but also ethical considerations and commitments to cultural changes as we move into the foreseeable future.

Patient@home focuses on new types of health technology. The overall goal of all research projects is to develop new solutions and practices for the benefit of the individual citizen, to enable the patient to stay at home in periods of illness or when handling a chronic condition. Such solutions will not only benefit the individual patient, but also the underlying systems like healthcare services in municipalities and hospitals. Thus, the interest in new solutions reflects an area with many facets.

Ensuring proper care for citizens and patients while they are staying at home is associated with technology sending information continuously between citizens and caregivers. We call it monitoring.

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Some might perceive such monitoring as surveillance as it can be intense and frequent. This is an ethical dilemma which we as members of society and as individual citizens must relate to. Already today, many patients with chronic conditions are monitored and many do it themselves and the results are reported back to the caregivers. As an example, people with diabetes regularly control their blood sugar levels and send part of the data back to the doctor or hospital. At hospitals, patients accept being monitored or kept under surveillance, for example in terms of continuous registration of their heart function. The same is the case for modern types of pacemakers that remotely control patients' heart rhythm disorders. Many care centres and hospitals have introduced modern cameras that can alert caregivers and enable them to prevent elderly and disabled from falling and potential harm from falls. Maybe the future and the use of new technology will bring even more solutions, such as chip implants that can control and regulate functionalities remotely.

Every time we work with projects and new technologies, we should have a discussion about the impact of the technology. Patients must take independent decisions on their specific treatment options but also decide whether they will let others influence their lives. It's about empowerment, which is the ability to gain control over and take responsibility for one's own life and situation.

Data ownership is another challenge associated with monitoring as it can be challenging to determine who owns the data. As a result of monitoring, a large amount of data is gathered e.g. blood pressure checks and it is important to avoid that caregivers and citizens are overwhelmed. It is important to ask certain questions such as: What kind of data agreement should be signed between the therapist and the citizen? Who is responsible for the data? How much data should be collected? And when and how should we act on this data?

These issues are discussed and handled in the project category "Monitoring" in Patient@home. It is important that we perform research in this field to create a common framework for rules and rights, but also to ensure some level of freedom in the introduction of new medical technology.

HOSPITAL HOME

The Patient@home project Hospital Home is testing technology that supports home hospitalisation of acutely ill, elderly medical patients, a group that accounts for a large proportion of the total admissions to Danish hospitals, and the number of patients is rising steadily. This situation creates challenges in relation to future hospitals where we will have significantly fewer beds, and there is thus a need to test alternatives to traditional hospitalisation routines. Moreover, weakened, older people are often more vulnerable to hospital-acquired infections and confusion, which in turn increases the risk of falls and disability during and after hospitalisation.

The solution that project Hospital Home offers is based on close cooperation between the treating team from the Geriatric department at OUH, specially trained employees working in Odense Municipal's home service, and a number of researchers, who investigate the use of telemedicine and sensor and monitoring technology. In addition, the development and testing of the technological set-up is carried out in collaboration with the enterprises Systematic ANYgroup and Lindpro and the healthcare sector.

When an ill, elderly patient is admitted to hospital, the first day will be spent on determining diagnosis, treatment and hospitalisation. If treatment can be performed at home, interested patients can be hospitalised at home. In such cases, the patient is accompanied to his/her home assisted by a project nurse from the Geriatric Department of OUH and a medical student, who will stay in the patient's home for the first 8 hours.

A digital lock with an ID-card key attached to it is installed in the patient's home, so that all employees who enter the home will be registered. In addition, the following technologies will be installed: emergency call, webcams, fall sensors, laptop for communication and data collection. When the patient is discharged, the equipment is removed again and the patient referred to home-care service.

The project is a feasibility study – in which the main question is: Is it at all possible? An important element in the project's DNA is to develop along the way and to try and find alternative solutions, in case something is not working. And there are challenges. First of all, it has proved difficult to find suitable patients; many are too ill and unstable to stay in own home. Another challenge is the technological solutions. If the sensors

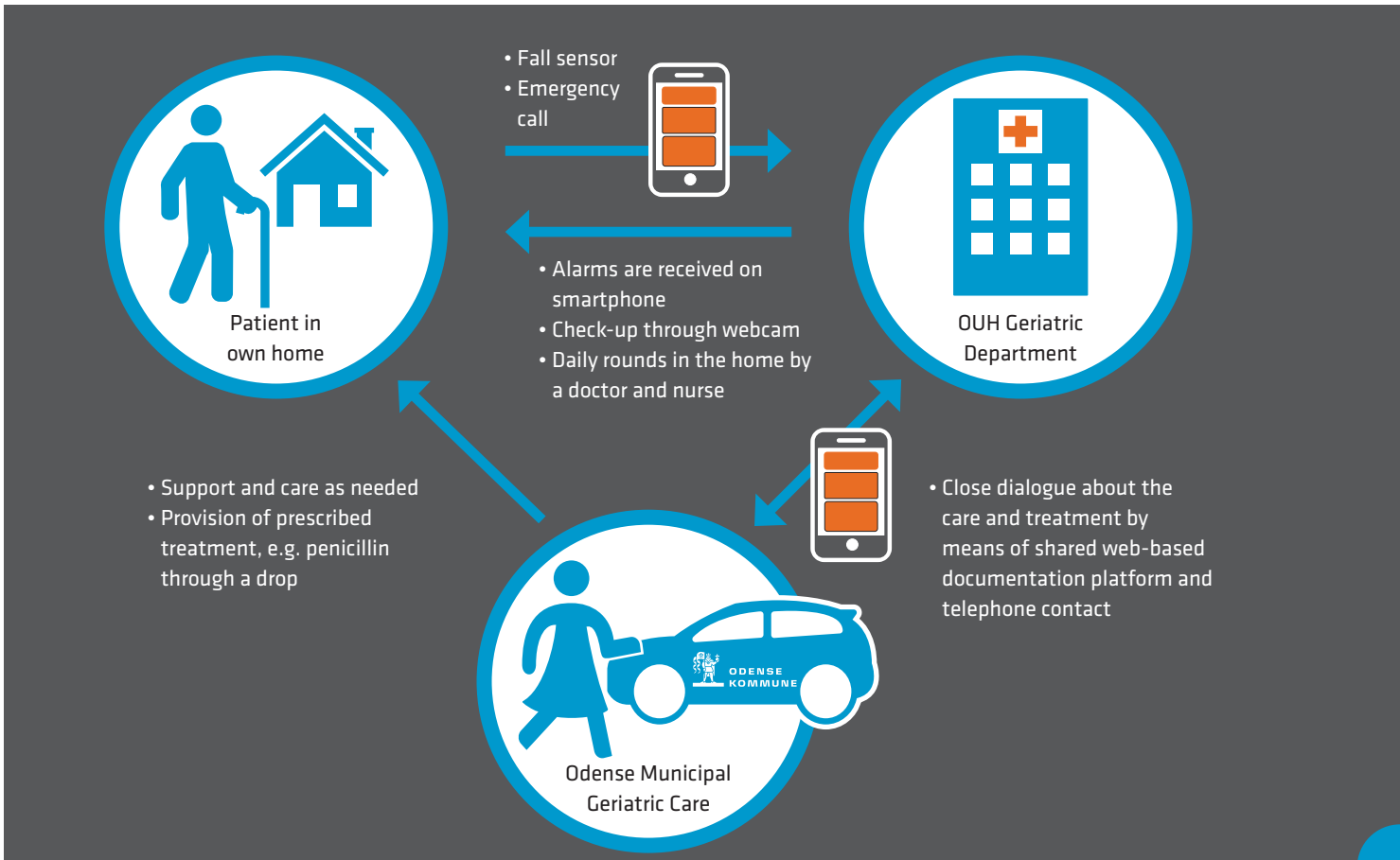
are too "sensitive" it will send too many false alarms, which is another burden on busy health professionals. But if the sensors are not sensitive enough, there is a risk that there will not be responded to a dangerous situation in due time. It takes several attempts to strike the right balance. Finally, the effort demands a new form of cross-sector organisation whose success depends on shared understanding and knowledge about the treatment of the acutely ill, elderly patient and the use of new technology. It's hard to obtain routine when there are so few patients and that creates uncertainty about the task both at the hospital and within the municipality. Through continuous sparring between the project team from Odense University Hospital, Odense Municipality and the companies behind the technological solutions, everybody tries to optimise the technique.

Project Manager and Consultant Jens-Ulrik Rosholm, the Geriatric Department of Odense University Hospital, says:
- Most patients are too ill to participate in project Hospital Home and to be hospitalised at home instead of at the hospital, and this situation is difficult to change. Perhaps home-hospitalisation is offered too late in the process? With a better opportunity for detection and diagnosis of ill, elderly citizens in primary care, Hospital Home could conceivably be established even earlier in the disease process – and in-hospitalisation may be avoided completely in some cases.

Conny Heidtmann, Innovation Network RoboCluster,
who is an Innovation Manager, says that many companies have shown great interest in Hospital Home right from the beginning of the project that is one of the flagships of Patient@home:
- At one point of time we had 11 interested companies, all with appropriate technological solutions for Hospital Home; the companies were divided into two groups that both presented a variety of solutions, and a selection committee from Odense University Hospital and Odense Municipality chose solutions presented by the following companies: NETomsorg, Yesgroup, Access Technology ApS, which have now been merged into ANYgroup, and Systematic and Lindpro.

Henrik Klode, CEO of ANYgroup, has benefitted greatly from participating in Hospital Home:
- Hospital Home has been a kick-starter and has contributed greatly to our success and growth as we have been able to use the project as a reference. Now, we have more than 10 municipalities and 3 hospitals as customers, and in 2015 we have included a number of Norwegian distributors, and we expect to introduce more distributors soon. We have partnered with Lindpro in terms of installation tasks and as a distributor of our products in Denmark.

The project is also supported by the Velux Foundation.



INNOVATIVE TECHNOLOGY USED FOR **TREATMENT OF WOUNDS**

Testing of 3D camera in clinical practice

Diabetic foot ulcers constitute a growing health problem in Denmark concurrently with an ageing population and an increase in diabetes prevalence. Diabetic foot ulcers are among the most serious and costly complications of diabetes. It is estimated that 85% of non-traumatic lower-limb amputations are preceded by diabetic foot ulcers. Several studies have found that the wound size, including depth, is one of the major etiologic factors for delayed wound healing. Previously, the 2D measurement methods have been used to assess wound healing.

We have recently published a review in which we have described various 3D measurement techniques, which have made it possible to evaluate the process of wound healing in relation to all dimensions including depth. None of 3D measurement methods have been widely used due to low accuracy, high cost level and complexity to use for the clinicians.

In our project, we use a newly developed 3D camera that can measure the wound perimeter, area and volume, as well as assess the wound characteristics. A pilot study has examined the wound characteristics in 36 wounds in 30 patients using the 3D camera. The study found better correlation to clinical assessment compared to the 2D images (iPhone 4s) used in telemedicine.

Purpose

The aim of the project is to evaluate the accuracy and variability of the wound measurements using the 3D images. A large cohort study investigates whether wound measurements by the 3D images can be used for monitoring the wound healing process in diabetic foot ulcers.

Method

Physician and PhD student at the Department of Endocrinology, OUH, Line Bisgaard Jørgensen, tells:

- In the first part of the project we conduct a validation of the wound measurements using the 3D camera. Forty-eight patients with various types of wounds are measured by four clinicians using the 3D camera, and compared with standard measurement methods. In the second part of the project, we follow a group of newly referred patients with diabetic foot ulcers at the University Centre for Wound Healing at OUH. The patients are monitored for 1 year or until complete wound healing, amputation or death. At baseline, patient data is collected and wound examinations are performed including measuring the wound size using the 3D camera. This is repeated at regular intervals. Patient and wound characteristics are correlated to the wound healing, and we try to illuminate the clinical variables that are associated with wound healing in diabetic foot ulcers.

Perspective

Line Bisgaard Jørgensen tells that they will test the 3D camera in their daily work at the clinic, which should give them an opportunity of commenting on clinically relevant variables with impact on the wound healing. Their setup provides a validation of the equipment, which has not been sufficiently described earlier.

- We expect that the 3D camera can be used in clinical trials to investigate the effect on wound healing by various wound-care regimens. This is an area with weak evidence.

The 3D camera is not yet commercially available, but the future vision is that the handheld 3D camera can be used in a telemedicine approach by wound-care nurses treating patients in their own homes and at the hospital for treating chronic wounds including diabetic foot ulcers.

The project is a collaboration initiative between the Department of Endocrinology at Odense University Hospital and the company Teccluster A/S.

SPIROMAGIC

Electronic spirometer can monitor COPD patients and register their condition

The electronic lung function measuring device, Spiromagic, ensures better treatment and prevents attacks and hospitalisations of people suffering from COPD. The spirometer records changes in conditions over time so that action can be taken early on in case of changes/deterioration in the patient's condition.
By detecting changes in lung function at an earlier stage, it is possible to prevent attacks and deterioration. Linking cause parameters with measurements leads to an increased knowledge of own lungs and thus an opportunity to avoid or limit the causes that could lead to deterioration or attacks. Besides, "bogus" causes, which might have been believed to be involved, will also, to some extent, be identified and thus allow the user greater activity and fewer visits to the doctor's.

Home monitoring of lung function

In Denmark, the latest estimates show that about 436,000 people may have COPD (Chronic Obstructive Pulmonary Disease), spread over approximately 166,000 with mild COPD (at this stage they might not have symptoms yet, but will often get some if they continue to smoke), approximately 230,000 have moderate COPD, and about 40,000 have severe and very severe COPD and will often have daily symptoms such as shortness of breath. 23,000 hospitalisations per year are due to COPD.

In the health strategy "The sooner – the better", the Danish government has listed two ambitious goals towards 2025: (1) The number of acute admissions per COPD patient must be reduced by 20%; (2) The reduction in admissions is expected to be managed by using telemedicine solutions that detect early signs of the disease and thus can react before hospitalisation is needed.

Spiromagic is an electronic lung function measuring device that encourages and promotes patient involvement and improve home monitoring so that the patient and the therapist get a more effective information basis for tailoring the treatment.

User involvement in focus

Spiromagic is created in close cooperation with users and the healthcare sector (patients, doctors, nurses and physiotherapists) and the Danish Lung Association has been involved in the entire development process.

Under the umbrella of Patient@home, Health Innovation Centre of Southern Denmark has participated in the process, carrying out courses with user participation and gathering feedback on spirometer, user interface, instruction and the matching app. Furthermore, both Næstved Healthcare Centre and the Danish Lung Association have helped to recruit people with COPD as participants in the Patient@home activities, providing valuable feedback on Spiromagic.
Conny Heidtmann, Innovation Network RoboCluster, who is Innovation Manager in Patient@home, says that the company behind Spiromagic has a great understanding of the need for user-driven innovation. Furthermore, the company has throughout the process been very quick to implement the changes that have been proposed by the citizens and the end-users that have used Spiromagic.

The final product

Business Development Director Jørgen Ole Kjær from the company Move Innovation Ltd., who is in charge of Spiromagic, says:

- Spiromagic is an affordable telemedicine spirometer achieved and serviced by the citizen himself. Data from the spirometer is transmitted wirelessly to a smartphone, for example, and can then be shared with the therapist. Spiromagic will create greater security and independence, a better quality of life and prevent emergency admissions. The spirometer is not really a diagnostic tool, but rather a sophisticated tool to be used to detect changes in conditions over time, so that action can be taken if there is a change/deterioration in the citizen's condition.

Spiromagic is now CE marked and will be upgraded with a clinical CE Mark as "Class I with a monitoring function".

The project is carried out in cooperation with various players from the partner group of Patient@home, including Innovation Network RoboCluster, the Danish Lung Association, Health Innovation Centre of Southern Denmark, Næstved Municipality's healthcare centre and the company Move Innovation ApS.

TECHNOLOGY-ASSISTED CARE IN OWN HOME

Patient@home covers several research and innovation activities aimed at developing technologies and robots that in various ways can support and assist outpatients with their activities of daily living (ADL)

Photo: Fraunhofer, IPA, Jens Kilian

By Jørgen Løkkegaard
Centre Manager, Centre for Welfare and Interaction Technology, Danish Technological Institute (DTI), Innovation Manager in Patient@home and a member of its Board of Directors

The overall objective of Patient@home is to develop technologies and services that will enable patients to be treated in their own homes. The development of such solutions, will enable people, who have previously been hospitalised for shorter or longer periods of time, to stay in their own homes despite temporary or long-term disabilities caused by surgery or chronic diseases e.g. COPD, diabetes and dementia.

Patient@home covers several research and innovation activities aimed at developing technologies and robots that in various ways can support and assist outpatients with their activities of daily living (ADL), thus making patients less dependent on care and practical help – in short, the goal is to make future patients more resourceful by means of new technology.

An example of the platform's research and innovation activities within this field is the German-made service robot, Care-O-Bot, which is developed by the Fraunhofer Institute for Manufacturing Engineering and Automation. The robot is being further developed under the umbrella of Patient@home and tested by DTI and University of Southern Denmark, and will gradually be involved in more activities of daily living and increasing complexity. The goal is to make the robot understand spoken commands, to interact, to find its way around a home and to perform simple service tasks such as retrieving a glass of water and help a person out of bed.

The market potential of healthcare technology products that are developed and manufactured by Danish companies is large and soaring, and may pave the way for a more intelligent healthcare sector – nationally as well as internationally. The importance of the Danish healthcare technology trade is well documented, and it constitutes a significant part of Denmark's employment rate and export portfolio. The estimated number of Danish companies that produce healthcare technology products is 1,400-1,500.

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The expectation is that Patient@home, directly and indirectly, will contribute to innovation and product development of future solutions that can help patients remain self-reliant in their own homes despite illness and loss of functional capacity.

The aim of continuously demonstrating the latest research and innovation results achieved by Patient@home e.g. at the premises of DTI's CareLab in Odense, is to make Danish companies as well as hospitals, municipalities and patients aware of the possibilities of future healthcare technologies and robotic assistants. In this way, customers and businesses will get a unique opportunity to witness and experience how it may be possible to create new products or services on the basis of the platform's results.

The expectation is that Patient@home, directly and indirectly, will contribute to innovation and product development of future solutions that can help patients remain self-reliant in their own homes despite illness and loss of functional capacity. Patient@home will thus be instrumental in bringing technology-assisted care into a Danish nursing home in the foreseeable future and help older people with physically demanding activities of daily living so that they can enjoy an independent and resourceful life in their own homes.

EXOSKELETON FOR THE ARM AND SHOULDER REGION

Patient@home project on development of new and customised exoskeletons for patients with paralysed or reduced arm function

Arm paralysis is a frequent and growing disorder. It typically occurs due to traffic accidents, falls and sports activities – such as mountain biking – when athletes cause damage to nerve fibres placed between neck and arms. Therefore, young and active adults constitute the great majority of the patient population, who might be left with a serious and lifelong disability and sharply reduced ability to work. Similar paralysis or disability of the arm and shoulder region also occurs as a result of strokes, some neurological disorders and general aging; and affect thousands of people with considerable personal and social consequences.

The inhibitory paralysis and disabilities – both partial and complete – may mean that those affected need help from others to cope with the most basic daily activities such as eating, drinking, combing hair and doing other personal hygiene tasks.

Skilled orthotics professionals are sometimes able to customise orthoses capable of restoring a degree of the user's elbow function with elastic mechanical elements such as rubber bands or springs.

Purpose and vision

New and personalized technology can help people with paralysis that need either rehabilitation or support in their everyday lives – both during and after hospitalisation.

Through the project "Exoskeleton for arm and shoulder region" Patient@home has focused on exploration, development and design of a compact and lightweight exoskeleton that can support and balance the movements of the arm and shoulder region of the above-mentioned patient group. The project uses a number of advanced computer models of the human body, which enable the design of individual and personalised exoskeletons for users who typically are disabled to the extent that they cannot bring the hand up to their mouth. In this way the project extends the possibilities of the orthoses from elbow to shoulder.

The project aims to design and develop a prototype that is lightweight, inexpensive and comes with a relatively simple design that restores the ability to perform everyday tasks in patients with a very small residual strength in their arms.

Ph.D.-student Miguel Nobre Castro, Department of Mechanical and Manufacturing Engineering, Aalborg University

Project status

Solving the task requires research in diverse areas from computer models of the human body to the creation of complex geometries. The results are tested regularly by implementing them in prototypes. Currently, the second prototype is being produced and its most important characteristics are that it has been 3D-printed to match the user's body shape, and that the mechanical springs have been replaced by soft rubber elastic bands. Attempts have also been made to design a prototype that can reach as many points as possible in a large working area in front of the body.

- We are constantly working in an intersection between creating something that is simple to produce and use and yet provides a great improvement for the user, says Project Manager and Professor John Rasmussen from Aalborg University.

- New technologies like 3D printing and body scanning with Kinect cameras (known from Microsoft's Xbox gaming console) will have a major impact on customised solutions in many areas in the near future and this Patient@home project has many exciting prospects, concludes John Rasmussen.

The project is conducted in close collaboration with Aalborg University, Department of Mechanical and Manufacturing Engineering, the Orthopaedic Research Unit of Aalborg University Hospital and the Prosthetic Centre of Risskov. Recently, a new collaboration was established overseas with Nemours/Alfred I. DuPont – Hospital for Children in Wilmington, Delaware: not only one of the best children's hospitals in the United States, but also the creators of the Wilmington Robotic Exoskeleton (WREX).

PATIENS@HOME ILLUSTRATED

Anni – relative of Poul (74 years):

My husband was treated for an aggressive prostate cancer last autumn. One of the consequences of the illness was that he had a debilitating complication in the form of a spinal-cord injury that caused paralysis in his legs and loss of sensation. Today, he is doing well considering the circumstances, but he is partially bedridden (requiring transfers in bed) and he has at times difficulty urinating. Via the hospital we were invited to participate in a trial where his bed has been equipped with very modern sheets that can detect leaking body fluid. In the beginning I was very sceptical, I guess, but during the trial both Poul and I have realised that the new technology and the delicate sensors make a difference. If a urination accident happens during the night, the sensors will alarm the caregivers. The intelligent sheets can also detect other instances of fluid losses. Obviously, all this has not been easy for neither Poul nor me and the children, but because Poul gets the care he needs – and the technology helps us – then he can be staying in our home. And that means everything.

DETECTION AND IDENTIFICATION OF **BODY FLUID**

Development, testing and evaluation of existing technology for detection of fluid loss in relation to new patient groups

Sensors for use within the field of care and disease prevention have great potential, and many sensor-based solutions are already everyday technology for many people. Examples include measuring blood pressure, heart rate, oxygen saturation, and blood sugar. They are all measurements, which simply and effectively can be carried out at home today. A pacemaker is also a good example of a well-developed sensor technology that constantly monitors the heart rhythm. As soon as the sensor detects absence of heartbeat, the pacemaker stimulates the heart.

Sensors detect various physical impacts like pressure, stretch, temperature, humidity, magnetism, light, sound etc. These are all parameters that can be detected with the correct sensor type. As soon as a measuring or monitoring need is identified, it will usually be possible to develop a system based on commercially available sensors. However, there are still needs that require a more basic development of the sensor itself, and not just of the measurement system.

Within the field of care – both at home and in hospitals – there is a need for detecting bodily fluid in the bed. It will create greater security for the citizen/patient and allow for better care, because action can be taken earlier if necessary. Types of bodily fluid include vomit, urine, sweat, blood, and exuding wounds.

Objectives and results

The Patient@home project "Detection and identification of body fluids" is, therefore, examining how to further develop technologies from the company Astrid Leisner & Son and make them more responsive to out-patients' needs. The project examines whether there are new patient groups that can be monitored and cared for in their own homes, if detection and identification of leaking body fluids is added to their regimen. In addition, early detection and subsequent alarm of fluid loss will make it possible to be patient in own home. Generally, creating security and a good night's sleep for patients in own homes, is high on the agenda.

The project, which started in 2013 in collaboration with Danish Technological Institute and Health Innovation Centre of Southern Denmark, is expected to lead to the development, testing and adaptation of technology aimed at specific target groups and to involve patient groups directly in the development and testing pathways, so that the final product can be adapted to specific patient needs.

Director of Astrid Leisner & Son, Sune Erik Leisner, says:

- Work on the project "Detection and identification of body fluids" runs according to plans. A needs analysis has been made, which also includes the technology benefits of the citizen, and we partnered with a company outside of Denmark and have started trials that test solutions using a technology that is different from the one that Astrid Leisner & Son has and markets today. The experiments are promising, and we have decided to continue to work together, and we are now about to start producing prototypes which use their application. In addition, we are working to optimise both price and quality.

Consultant at Centre for Welfare and Interaction Technology at Danish Technological Institute, Lars Vincent Jørgensen, says about the project cooperation:

- Detection and identification of body fluids has great potential, and here at CVI, we have a great interest in participating in this sensor development work. The next step includes building a prototype, where, in addition to the technical specifications, we also focus on price and quality. It is important that Astrid Leisner & Son now has a framework for cooperation with a potential producer that may also be part of the development work.

"Researchers involved in Patient@ home activities are presented with a unique opportunity to solve specific and relevant issues for the clinical environments in hospitals and municipalities – in close cooperation with companies, innovation hubs, researchers and health professionals. This composition is important to promote a cross-disciplinary collaboration between professionals and researchers. It also opens up new opportunities for user involvement, testing of results and taking developments from the prototype level to becoming useful products – all in close cooperation with enterprises.

#Uffe Kock Wiil (Professor at The Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Project and Research Manager in Patient@ home and a Board Member)

OPERATING SYSTEM FOR PEOPLE WITH **REDUCED COGNITIVE FUNCTIONS**

Development of an operating system for smart phones/ tablets that guides people with impaired cognitive functions through everyday activities

Simple everyday tasks can be challenging to remember for people with impaired cognitive functions. Therefore, they need the help of relatives and or caregivers. The company Tele Call has developed a smartphone named DoMyDay. It has a very simplified operating system and it is targeted at people with mild dementia. The system supports and relieves some of the challenges that people with impaired cognitive functions encounter in their everyday life, thus making them able to better take care of themselves.

The system contains a few simple functions, for example a calendar with images which helps citizens to remember agreements, various guides on how to perform everyday activities such as making coffee or doing laundry, and a life-history function that by means of pictures can relay different episodes in the citizen's life.

Vision and purpose

In the project "Operating system for people with reduced cognitive functions", Patient@home continues to optimise the results and experiences from the project "Dementia in the home".

The project's goal is to improve the life of citizens with impaired cognitive functions so that they perform everyday activities without depending on help from relatives or caregivers. The intention is to stimulate their existing cognitive functioning. The vision is to increase dignity and life quality of citizens with impaired cognitive functions.

The project is expected to lead to the following specific results:

- A survey of which citizens with impaired cognitive functions are in need of a simplified operating system (besides citizens with dementia)
- Further development, testing and adjustment of the operating system to suit the needs of the citizens
- Integration of external input by way of, say, sensor inputs
- One or more new commercialised products from Tele Call

Director of the company Tele Call, Henrik Bryld, says:

- In our business, we focus on technology that provides safety and better quality of life for the elder and disabled citizens. To ensure the continued development of communication aids we participate regularly in projects that focus on how the latest technology can help create a better everyday life for the individual citizen. Our participation in the Patient@home platform has meant that we have found new ways of collaboration across disciplines. Technology and innovation are key concepts in Patient@home and core competencies at Tele Call.

Centre for Welfare and Interaction Technology at Danish Technological Institute is project collaboration partner in the project. Consultant Lars Vincent Jørgensen explains:

- The project has got so far now that Tele Call has a product that is ready for market introduction and real-world testing at the premises of several good, local contacts. The product appears well thought out, and most importantly, very user-friendly. And there are many possibilities of further development, not least in view of the upcoming market introduction and future results.

Patient@home develops Innovative Technologies that help patients do workouts and rehabilitation exercises at home – and check the results!

REHABILITATIVE TRAINING

By Per Kjær
Associate Professor, Centre for Muscle and Joint Health, Department of Sports, Science and Clinical Biomechanics, University of Southern Denmark
Work Package Leader for Rehabilitative Training in Patient@home

The Danish health sector is facing major challenges with an increase in age-related disorders, and lifestyle diseases as well as highly specialised and expensive examinations and treatments. In the years to come, resource priorities will be mandatory within the health care sector resulting in hospital departments, doctors, physiotherapists and chiropractors being much more engaged in diagnostic procedures and evaluations rather than treatment – and citizens and patients will become much more responsible for their own rehabilitation and training. Self-management is the new trend.
The first good news is that exercises and training are effective interventions for the health conditions that are the most costly for society: back and neck pain, osteoarthritis of the knee and hip, other muscle-joint disorders and activity limitations following stroke. The other good news is that citizens and patients are increasingly interested in taking responsibility for their own health, asking "what can I do?" The third piece of good news is that the development of technologies that can support rehabilitation and training is rapidly growing.

The challenges connected to prevention, rehabilitation and training activities are many, such as finding a patient's starting point, composing a suitable exercise programme, adjusting gradually the amount of training needed and, finally, strengthening the patient's own motivation. Whether the goal is to prevent overweight (and subsequent diabetes and cardiovascular diseases) or to initiate rehabilitation after a stroke, a broken hip or a herniated disc in the neck, the patient must always start at the right physical level and use the training programme best suited to the patient's condition and age.
A good example of this is the many apps for fitness training and running, as they register a starting point and prepare a programme that takes into account the patient's starting level and age. Similarly, a physiotherapist will assess the forces in arms or legs when planning training for a patient with paralysis of one side of the body following stroke. Similarly, a professional therapist will recommend pain relieving exercises that can help the patient in acute pain from a disk herniation. The two latter examples are time consuming, and it is a challenge, for instance, to measure forces in arms and legs, movements in the neck and how they change precisely over time.

When the starting point for training and rehabilitation has been identified, long and intensive training schemes are initiated. So far the implementation of such schemes has been very resource-intensive, but the emergence of new robotics and sensor technology can be instrumental in helping such patients to train and do the many exercise repetitions at home and without an expert standing nearby.
In the Patient@home work package Rehabilitative Training we have investigated how to measure the rate of force development during training and how to adjust very precisely the level of resistance by means of robots. Robots can also guide movements of body parts which paralysed people cannot. This means therapist time saved. We have also looked at how we, by means of sensors, can measure movements in a patient's neck and lower back as well as changes in the rate of force development, thus obtaining the necessary background for choosing the most appropriate exercises for each patient while monitoring how the patient performs and how pain, if any, appears and disappears. Adjusting exercises regularly can serve several purposes: When doing fitness and weight training, the intensity must be increased to improve performance. The same goes for rehabilitative training, but additional factors play a role here. Exercises may have been designed to reduce pain, but doing exercises against increasing pain is probably not appropriate, because pain changes the way muscles are functioning. Therefore, we have tried to develop apps that provide users with instructions on how to change strategy and exercise intensity when the pain increases.
The greatest challenge for all kinds of training is motivation. How does one stay motivated? Exercises are not just something that should be done a single day or two. It is a long and continuous process, if results are to be achieved on performance, pain and functionality in everyday activities. We have looked at several motivating factors. Fun and games play an important role in the project by means of interactive tiles with games (as described in this publication), while use of apps with information and instructions is another strategy we have been considering. More information is available on the following pages (e.g. on RehApp). And it seems that the cause of motivation differs a lot from person to person.
There are already many products on the market that can support training and rehabilitation. However, a common feature of them all is the lack of the interactive aspect, or the interaction between the patient's training level, pain and response to training exercises. Likewise, there is no research available that documents sensors' and robots' precision capabilities in terms of measuring movements and force, and no documentation on whether the effectiveness of exercise and rehabilitation is improving when technologies are integrated. In the work package Rehabilitative Training companies, researchers and patients work together with the aim of developing such innovative training and rehabilitation tools – as well as documenting their precision capabilities and elucidating the potential treatment advantages and economic benefits.

DEVELOPMENT OF 'REHAPP'

A technology-supported guidance and exercise application for patients with neck pain and radiation into the arm

Each year 8-10,000 more Danes suffer from arm pain arising from the neck. The pain can be caused by an affected nerve root from a herniated disc or osteoarthritis changes in the neck. About a fifth of these patients are referred for surgery, while the vast majority are offered patient education and therapeutic exercises.

In the acute phase, these patients often experience severe symptoms and limitations in their activities. Therefore, there is a need for close monitoring and supervision to detect deterioration that may require surgery, to prevent the development of chronic pain and to help rapid relief of pain. It is also vital that the patients experience control over their own situation and are able to maintain a normal life. The pain makes it often difficult for the patient to attend examinations and treatment. The use of information and communication technology (ICT) may therefore be beneficial for patients.

Project manager, physiotherapist Hanne Rasmussen says:

- The purpose of this Patient@home project is to develop RehApp, a technology-supported intervention. The development takes place in an innovative process that maps out the scientific evidence for the efficacy of treatment, involves patients, healthcare professionals, engineers and companies in order to investigate its usability and relevance among patients with nerve root complications in the neck. If the developed prototype of RehApp is found appropriate and useful, a future study testing the effectiveness of RehApp can take place. In this way, the effect of the newly developed intervention can be scientifically documented in relation to the existing treatment for pain, activity improvement and reduction of health costs."

Project methods

A prototype of an information and exercise application was developed in collaboration with researchers from The Maersk Mc-Kinney Moller Institute, researchers from Institute of Sports Science and Clinical Biomechanics at University of Southern Denmark, the IT-company ExorLive, and patients and clinicians from The Spine Centre of Southern Denmark. Principles from the innovation process were used, so that the process concentrated on identifying and gathering knowledge about relevant technologies, practices and user needs. On this background several versions of RehApp were developed and tested. The process alternated between testing, interviews and adjustments of RehApp.

The finished RehApp prototype was then tested at The Spine Centre of Southern Denmark among 15 patients with evidence of nerve root involvement in the neck. The participating patients completed questionnaires about pain management and activities. They were given information and instructions on how to use RehApp and they tested it at home for two weeks. The patients were then seen at a follow-up visit at The Spine Centre of Southern Denmark where they completed questionnaires on RehApp's relevance and user friendliness. For comparison 11 control patients went through the usual procedures in the back centre.

Project manager, physiotherapist Hanne Rasmussen tells about the results:

- 15 patients were involved in the testing of RehApp. The overall assessment of RehApp was positive, both in terms of user friendliness and relevance. All patients believed that RehApp was a useful remedy and that it gave them good guidance and increased confidence in their situation. The patients expressed a need for communication directly with a clinician through RehApp, improved audio options, information about their neck problem and choice of exercises.

Expected results

Preliminary results from the pilot study show that RehApp is a possible intervention for patients with nerve root involvement in their neck. After development and adjustment of RehApp, based on the results from the pilot study, a larger study testing the effectiveness of RehApp can be carried out. If it shows positive results, RehApp can be implemented and adapted to rehabilitation programmes in primary care or in clinics for physiotherapy and chiropractic care.

Besides having potential benefits for the patients, it might help the clinicians in developing treatment approaches based on feedback from RehApp and the pa-

tients' preferences and delivering a more tailored treatment approach. The results from this project may therefore provide basis for developing more sophisticated technologies that can improved the treatment outcomes for not only patients with CR, but for other groups with musculoskeletal problems.
RehApp will also have potential of decreasing costs not only for the individual patient, but also in the health care system and society because of decreased health care consultations and sick leave.

PATIENT@HOME ILLUSTRATED

Jytte (72 years)

Last year, I fell in my home. I had horrid pain in my left hip and I could neither walk nor get up. Luckily my daughter came by and had me taken to the emergency room. The following day I had a hip-fracture surgery. I was already up and around 24 hours after surgery, and a week later I was discharged together with a training screen that should assist me during my daily rehabilitation training. I'm really happy that I can train every day at home using screen training for my exercise programme. Sometimes we are a group of 'patients' that train together via a single video call and a physiotherapist. Such training sessions are motivating in a different way, they make you do your exercises and the physiotherapist guides and corrects you, if improvements are needed. It has helped me a lot and saved many trips to the rehabilitation centre in town.

Patient@home acts as a collaborative platform for more than 60 partners across organisations and disciplines to develop new technology. Many of the findings appear within the umbrella of Patient@home, but the platform also inspires the partners to perform a number of research and development activities outside Patient@home, just as a number of more permanent cooperation constellations have been established among the partners at this half-way point. Patient@home thus provides a boost to the whole development of new healthcare technology.

#Louise Skovborg Just (Head of Secretariat of Patient@home)

Photo: Hanibal-Bach

REHABILITATION WITH **INDUSTRIAL ROBOTS** – UNIVERSAL ROBOTRAINER

Study of rehabilitation possibilities of injuries caused by stroke by means of industrial robots

Rehabilitation of disabilities linked to strokes is a demanding task for the patient and a costly healthcare-sector challenge.
Rehabilitation studies have shown that many repetitions of exercises are an effective way of getting the brain to learn to control muscle groups with a view of improving the patient's functional capacity.
The project Universal RoboTrainer focuses on the use of industrial robots for rehabilitation, because these robots are designed to be flexible and to perform many repetitions.

Rehabilitation with industrial robots

With the support of the robots, patients can make specific movements that let them regain functional capacity. Sensors in the robots automatically help to determine the degree of support that the patients need to be able to perform their exercises.
Focus is also on making it easy for therapists to set up individual training programmes and to make the training motivating for the patient.

Project objectives and results

The project provides a good picture of what is required to rehabilitate people with the assistance of industrial robots, and it brings in new perspectives on how to make the programming of the robot easy for the therapists. This provides an insight into how the interaction between human and robot can be achieved, inter alia, by means of motion.

Associate Professor, PhD, Jacob Nielsen, The Maersk Mc-Kinney Moller Institute, University of Southern Denmark, says about the project's current status:
- Right now we are working to emulate some simple exercises. Therapists define the exercises, for example, through video sequences, illustrating each exercise from several angles. This will then be the engineer's template in relation to finding out how the robot can best help the patient to perform the same exercise.
The various exercises proposed by the therapists visualise rather well the diversity of exercises and tools we've seen used by the arm-rehabilitation team, and it is a direct consequence of the diversity of disabilities that patients have.
The need for individualisation is comprehensive and it has led to the development of a way by which the therapist and the patient, together with the robot, can record the training path required. This is done in two ways: The patient can hold the hand of the robot or he/she can be connected to the robot; the therapist subsequently helps the patient to perform the exercise, while the robot records it all. The exercise is then saved under the patient's profile. The therapist can set various parameters for the exercise, for example the speed and how much assistance the patient needs.
An interface to the robot is being developed which will help the therapists to create patient profiles, record and store training exercises and set training parameters, while the patients themselves will be able to start/stop their exercises and track their own progress and follow their training history.
The next step is to make the robot reliable and safe enough to perform pilot trials with patients. The first trials that investigated the robot's interaction with ordinary, healthy people started in the autumn of 2015.

Conny Heidtmann, from the Innovation Network RoboCluster, Innovation Manager in Patient@home, emphasises:
- This project has a good and close interdisciplinary collaboration with therapists from Odense University Hospital's Neuro Rehabilitation Department at Hospital Svendborg, which has been a decisive factor for the project's achievements so far.

Development Therapist Anne Friis Hansen from Hospital Svendborg says:
-The Neuro Rehabilitation Department at Hospital Svendborg has been a cooperation partner on the project since the autumn of 2014. It is an exciting project with the development of the robot and the associated interface. The robot is still under development, but we are looking forward to testing it in the Neuro Rehabilitation Department.

"Having reached the half-way point of Patient@home's lifetime, it is a great pleasure for me to note that the project is on track. As we all live longer and more citizens suffer from chronic diseases, new innovative solutions are required to support people so that they can stay longer in their own homes. This is the background for establishing Patient@home, which, in an exemplary way, connects public knowledge institutions, treatment centres, private companies, staff and patients with the view of developing and testing new healthcare technology solutions that can work in real life for the benefit of patient involvement, the quality of treatment and rehabilitation programmes, resource optimisation, and the growth of Danish companies. It has been exciting to follow the development of Patient@home, and we, the members of the Board of Patient@home, have enjoyed watching an extraordinarily focused and result-oriented management team of Patient@ home and among the project participants.

#Ole Skøtt (Dean, Faculty of Health Sciences, University of Southern Denmark, Chairman of Patient@home)

The project is conducted in close cooperation with Odense University Hospital's Neuro Rehabilitation Department at Hospital Svendborg, The Maersk Mc-Kinney Moller Institute, University of Southern Denmark and Innovation Network RoboCluster.

GAME TECHNOLOGY FOR REHABILITATION

Development of method for impact evaluation of welfare technologies

New healthcare technologies created for health preventive and rehabilitative training at hospitals will continue to enter Danish homes and municipal training units. But, can technologies for rehabilitation and prevention be moved from hospitals' controlled environments and into the care sector and private homes?

And can reliable impact measurements and useful training exercises using new technologies be performed in uncontrolled environments such as a citizen's own home? These are just some of the questions that the development and introduction of new healthcare technology brings about. A research project under the Patient@home umbrella looks into the problem.

The vision

Based on existing training technologies – modular, interactive tiles – the project examines the methodological options for transferring healthcare technologies from the hospital sector's controlled environment and to local governments – and ultimately also to the citizen's own home.

Through a series of specific exercises performed on an intervention group and then compared with those of a control group without training, the project provides the basis for an overall methodical study of whether training with technological tools provides the same effect when performed at the hospital, at the municipal level and in the citizen's own home. The results will ultimately lead to a greater understanding of the possibilities of using new healthcare technologies all the way through i.e. from the patient is admitted to hospital and he/she is back in own home.

Besides an overall methodological understanding of the extent to which training technologies have an impact both in and outside the hospital, the project also examines the applied tiles' ability to offer customised exercises that suit the individual citizen's needs.

Professor Henrik Hautop Lund from Centre for Playware at Technical University of Denmark says:

- Impact tests on older people's ability to function when using modular interactive tiles have shown that even short-term play on the tiles provides significant improvement in balance ability among the elderly, and that in so doing they also improve significantly their strength, stamina, mobility and agility. This is very important in terms of falls prevention. When playing on the tiles the elderly forget time and place, and hence also the daily limitations in physical activity. Just a short time of playing and training on the modular, interactive tiles, lead to a very large improvement in their balance ability.

The first pilot tests in private homes have indicated that older people can perform the playful training on the tiles in their own homes and prove very persistent in the initial pilot tests. A set of 10 tiles is placed in the bedroom, living room or hallway of the elderly, after which they play and train on the tiles as they like – and the pilot tests show that older people very often like using the tiles.

To simplify the implementation of the tiles at institutional and domestic levels, the project has developed, together with business partner Entertainment Robotics, a new version of the modular tiles which are lighter and thinner, and via connection to a tablet can document the user's activity on the tiles. Access to this ongoing documentation of the use and users' drive can for example be made from any central office of therapists, doctors and project managers via a server. The new product will be produced by Entertainment Robotics, based in Odense. Entertainment Robotics has already received orders for the first 40 sets of the new version of the tiles, which are to be delivered to Danish municipalities in late 2015.

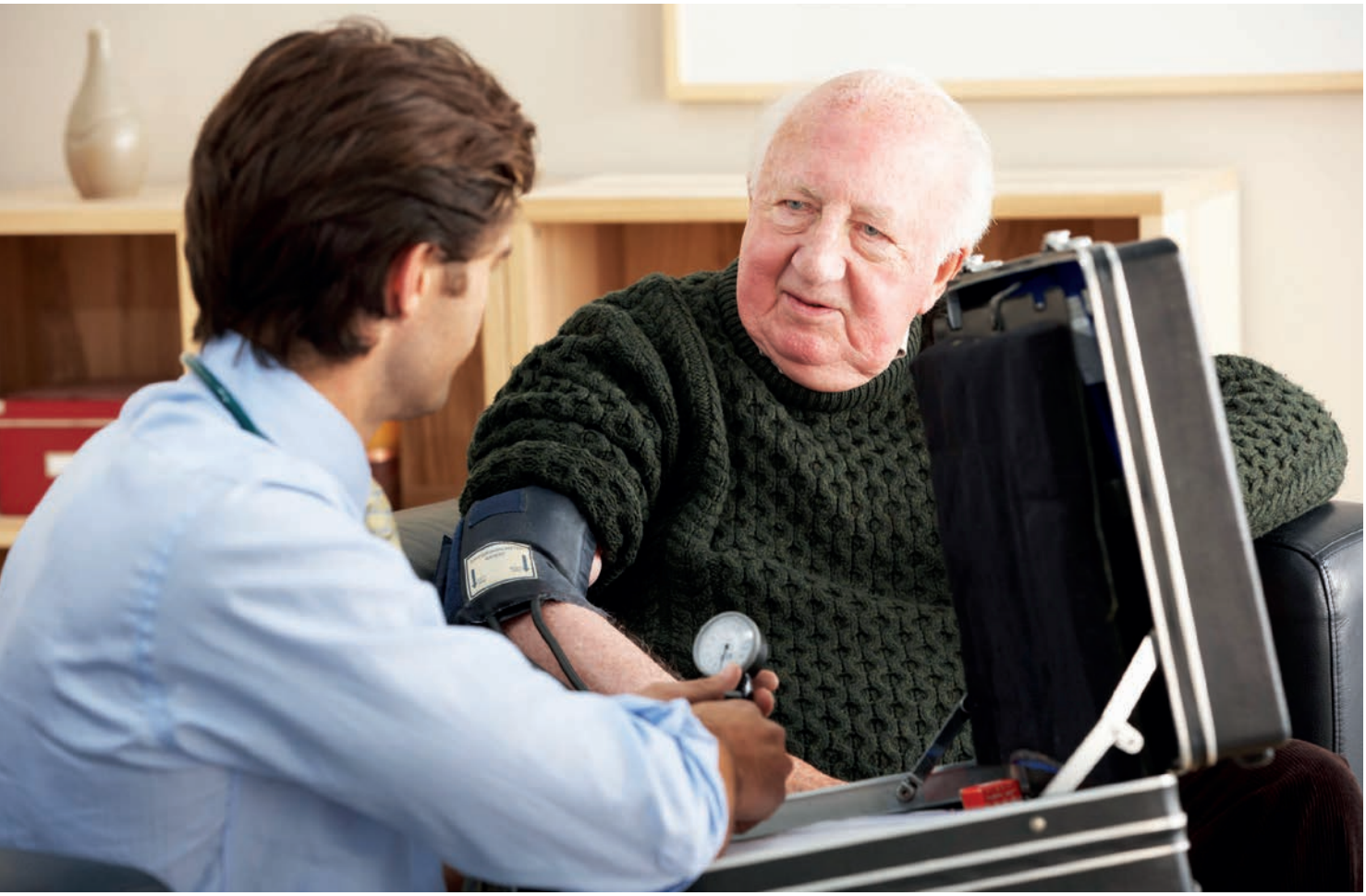
With a broad US patent grant achieved, as well as international trademark protection and CE, ROHS, ASTM and a variety of EN certifications, Entertainment Robotics wants to continue the development and distribution of the tiles in Denmark, while opening export markets in 2016-17.

Project partners: Centre for Playware at Technical University of Denmark, and Entertainment Robotics.

External partners: University of Siena, Trivulzio Hospital Milan, Gentofte Municipality, and the Health Department of Copenhagen University.

Patient@home sets the framework for how companies in cooperation with the users of their products in the health sector with the best possible basis for being able to sell their products. The companies get closer to the latest research and closer to the relevant resource persons who can positively contribute to that they can develop and sell their products below. As project manager of Patient @ home is exciting to see how all parties have the benefit of Patient @ home – and how the Patient @ home benefit Denmark. All players are united under a joint project with the sole purpose to bring innovative technology solutions to market. Patient @ home ensures that resources to developing innovative solutions used in the best possible and thus helping to meet the challenges that we are going to see in the future of health.

 # Søren Møller Parmar-Sielemann (Senior Consultant, Welfare Tech, a member of the management of Patient@home)



PATIENT@HOME MAKES A **MIDWAY EVALUATION**

By Anders Lyck Fogh-Schultz
Senior Consultant at Centre for Health and Human Interaction Technologies, Danish Technological Institute

The demographics and the general health situation in Denmark are changing.

We are living longer and longer and the number of people above the age of 65 is growing rapidly. Recent research shows that each year our life expectancy increases by approx. 3 months. This changing age structure together with the growing number of elderly people and the resulting smaller workforce will be felt by Danish hospitals because the number of elderly people who develop chronic conditions like diabetes and heart/vascular diseases will also grow. Lack of physical activity, poor diets and unhealthy lifestyles, such as smoking and alcohol intake, have created a global increase in chronic non-contagious diseases. Figures show that the majority of people over 65 suffer from two or more chronic conditions. When we look at the 75-year-olds and onwards, they typically suffer from three or more chronic diseases. In fact, the number of individuals with two or more chronic conditions is greater than the number of those with just one. And patients with chronic conditions often have comprehensive care and treatment needs, and it puts pressure on the healthcare sector as never before.

Demographic challenges and technology-driven innovation

In 2015, Patient@home reached its halfway point. The basic ideas behind the project are about development of new technological solutions that can reduce the pressure on hospitals' financial and personnel resources and support the healthcare sector's increasing need for better and faster rehabilitation as well as more outpatient treatments and hospitalisations of patients in their own homes. The new technologies will ensure that

healthcare professionals throughout the sector can get both valid and consistent data when required for assessing a patient's need for treatment. In addition, the new technologies, products and services will help increase the patient's active participation and motivation to take responsibility for own health.

Patient@home is, in other words, about patient health and technology-driven innovation.
I met Peder Jest, medical director at Odense University Hospital and a member of the management board of Patient@home, for a chat about the prospects of the project. The conversation quickly fell on the design of the future health sector and how technology, research and innovation can solve many of the demographic and resource challenges that we as a society will meet in the coming years. Peder Jest says:

- The group of older people in Denmark is rather big, and we expect more and more in-patients and hospital-based treatments, but we do not have enough financial resources and not enough staff to meet these requirements, and we must therefore find other ways of supporting especially the elderly. Starting with the large healthcare and innovation project, Patient@home, the goal is to involve patients much more in terms of treatment and rehabilitation, so that the patient's own role becomes much more obvious and necessary. The goal is to treat a large group of patients as outpatients or directly in the patient's own home. To realise this scenario, we must develop related technologies and improve the many digital healthcare solutions currently available. The technology must be useful, and we must tell both patients and non-patients that it is ok to be assisted by technology and that it can be a direct collaboration partner. The technology should lead us as citizens to take responsibility for our own treatment, because the technology helps us and makes things easier in our everyday life. A patient or a healthcare system that uses technology as an aid in a given treatment must be familiar with it, and it must work. We communicate daily by phone, tablet, Internet, and we take and send pictures via smartphone almost constantly. We can do the same in a treatment situation. We just need to take responsibility and participate actively. However, I believe that tomorrow's citizens are and will be able to do it. And technology supports us already very much today. Let me give a few examples: Diabetes checks are reported via telemedicine solutions, patients with certain types of foot ulcers can take pictures of the healing process and of new wounds, if any, with their smartphone and send them to the therapist, who can then remotely monitor developments. New homes for elderly have high-tech fall alarms and sensors in the floors that can alarm nursing staff if a patient falls in the home. New technology can detect patient fluid loss by means of sensors in bedding textiles. Many of us have a pedometer or an app that measures our physical activity and stores the data online. Others have a heart-rate monitor or WI-FI-connected scales that both save and transmit data on body weight and body-fat percentages. And with the latest Bluetooth technology we can both detect cardiac activity and ECG (Electrocardiography) and send data directly to the caregiver's mobile phone. In other words, the technology makes knowledge and data mobile for both sender and receiver – and mobility ensures that patients carry their data with them everywhere, explains Peder Jest.

We must find other ways of supporting especially the elderly. Starting with the large healthcare and innovation project, Patient@home, the goal is to involve patients much more in terms of treatment and rehabilitation, so that the patient's own role becomes much more obvious and necessary.

Peder Jest, Medical Director, Odense University Hospital

Technology that works – also in the future

The prevalent idea of Patient@home is that technology – along with active patient and public involvement – can help reduce the number and duration of admissions to Danish hospitals, due to the patients' active participation and responsibility for own treatment. In more concrete terms, this means that healthcare technology can support patients and reduce pressure on the healthcare sector in three different fields: (1) before hospitalisation or outpatient treatment at the hospital – such as observation of the citizen's physical condition; (2) during treatment, in preparation for discharge to own home; and (3) after early discharge or outpatient treatment – such as continued observation of a patient's health status and in connection with assisted rehabilitation. I asked Peder Jest how a research and innovation project like Patient@home can be implemented in Danish hospitals, and what it requires in terms of technology:

- When we talk about future hospitals and patients, we have already started to create the new setup. The new, large OUH is being erected on the southern outskirts of Odense. Today, an empty field, but in seven years' time the empty field will have been transformed into a new university hospital covering 224,000 m2. The number of beds in the new hospital will be less than we have today, so outpatient treatment – for example in own home – will be both ordinary and necessary but also beneficial in several ways. Some patients experience e.g. that a telemedicine video consultation with the same doctor every time provides a higher sense of nearness than a consul-

tation at the hospital, where patients see a new doctor every time; and the video consultation that takes place in the patient's drawing room can be watched and listened to by family members. In addition, the patient saves both waiting time at the hospital and transportation time and costs. But the technology must be far more sophisticated than just a secure video connection. And this is where Patient@home will make a difference, says Peder Jest.

40 emerging technologies

The aim is to make the various project partners develop at least 40 new products and services during the life of Patient@home, and the must be developed according to user needs and user acceptance. It is also a requirement that all results are based on both the latest research and the hospitals' development plans and requirements. Patient@home has prepared an innovation model that supports the development of new technologies. The innovation model ensures that the new technology works and makes a difference to the end user. Peder Jest explains:

- Seen from a business point of view both the innovation model and the focus on the end user are extremely important as well as the overall business case involving at least 40 new technologies. When we reach 2022 and the new OUH (Odense University Hospital) is opened as Denmark's largest hospital built from scratch on an open field, we hope that many of these new technologies will have been implemented in close collaboration with the project's business partners, Peder Jest says and continues:

- Patient@home provides Danish companies with access to the latest knowledge, laboratories and real-life test facilities. This gives the best starting point for building strong international market positions in terms of innovative and intelligent healthcare technologies and services. This is in Denmark's interest, and in the project's "second half" we are ready to invite new companies to participate in the continued cooperation work. There is still a major technological-commercial uncultivated field here and it should be exploited.

Results must be brought to light and Patient@home will set the agenda

When the Patient@home project assesses current achievements and presents new knowledge and advanced technologies, including this publication, it is also about setting the agenda and influence behaviour. Peder Jest explains:

- A project like Patient@home is really important because doctors and other healthcare personnel can follow the development of our results. It is also important that the staff that will be working at the New OUH have the right competencies. Patient@home can indirectly help to educate people to the future hospital services as the project is basically about three things: To contemplate new ways of cooperation across disciplines in order to reach new targets and new behaviour. And the very ethnology of Patient@home is of great interest to me. For example, when doctors, researchers, software developers, engineers and business people work together to find new ways to organise our society, we actually create something; we build something together. And we are only interested in solutions that solve our problems, and we only benefit from the most beneficial technology, Peder Jest concludes.

"The philosophy of Patient@home is that the patients must take responsibility for their own health. But it does not have to wait till the damage has occurred and the lifestyle diseases have been recognised. As a doctor, I would prefer that people stayed health because of improved self-care.

Peder Jest

Illustration: New Odense University Hospital (OUH)

We must think differently in the future

In relation to the issue of how to influence behaviour, then Patient@home makes high demands on the capability of the technology as well as the cooperation of the individual patient. But Peder Jest would prefer that we went even further:

- Yes, Patient@home focuses primarily on treatment, but we should not forget all the prevention efforts. In addition to the chronic, non-contagious diseases, which can be treated via the Patient@home strategies, I would like far more preventive efforts. The philosophy of

Patient@home is that the patients must take responsibility for their own health. But it does not have to wait till the damage has occurred and the lifestyle diseases have been recognised. As a doctor, I would prefer that people stayed health because of improved self-care. A population that takes care of itself is one of the demographic solutions that have been mentioned so often. It is very a simple way of putting things, yes, but it is true nonetheless. Technology can accomplish much, and we must not be afraid of using it when it can make a difference. In Patient@home we are testing more than 70 new technological solutions, and many of these can also be used in a preventive way. When we as citizens and patients become aware of what technology can do then I think we will take more responsibility for ourselves, because we are using technology to collect data about our physical state. Some would rather live in blissful ignorance, but I am sure that many patients such as those we treat for several chronic conditions would rather have done without these conditions, Peder Jest concludes and continues:

- Patient@home is about technology-assisted treatment, monitoring and rehabilitation in the patient's own home. A future project could be called Citizen@home, and here we could look at how people can be encouraged to take care of themselves and continuously make the best possible decisions about their own lives and health. And the technology must support us and ensure independent living, Peder Jest says.

FUTURE

The Patient@home project will run until the beginning of 2018 and will until then focus on the ongoing research and innovation projects, but will also start up new projects that can benefit from the platform's team of scientists, engineers, doctors and other healthcare and administrative staff. In this way, private companies will get an opportunity to open up new markets and meet new partners from other sectors; hospital partners will get a chance to influence the development of new technology and the future healthcare sector; and the Danish municipalities will get a change to follow the development and maturation of the technologies and services that will be part of tomorrow's healthcare sector at close hand.

INFORMATION AND KNOWLEDGE MANAGEMENT

Information and Knowledge Management (IKM) plays a central role in many Patient@home activities.

By Uffe Kock Wiil
Professor at The Maersk Mc-Kinney Moller Institute, University of Southern Denmark
Project Manager and Research Director in Patient@home and a Board Member of Patient@home

The primary aim of IKM is to make knowledge more accessible to everyone. IKM covers various aspects (including "big data" aspects) in relation to collecting, monitoring, structuring, integrating, interpreting, analysing, and visualising health data.

Patient@home has uncovered a great potential in terms of improving the use of the health data already available at hospitals, municipalities, and general practitioners. We have often heard health professionals say that they believe that they do their job well, but that they could do it even better if they had the opportunity to exploit existing health data more efficiently.

The objective of the IKM area in Patient@home is to work closely with end users (health professionals as well as patients and relatives) with the aim of developing useful software tools such as tools for clinical decision support, which can assist healthcare workers in performing faster and/or more efficiently, and integrated health platforms that enable patients (in interaction with relatives and healthcare staff), to care better for themselves ("patient empowerment").

The IKM area thus contributes with knowledge and competencies in health informatics (especially regarding tools for clinical decision support and integrated health platforms), information and knowledge management (including data mining and machine learning) and software engineering (development of software tools).

The overall philosophy is to work closely with end users and interact with them, in order to identify potential new IKM tools and techniques that can help users by supporting and/or automating different (routine) tasks related to their data, information, and knowledge. Field studies and user studies (user involvement) are important parts of this work.

IKM activities in Patient@home can be divided into two categories: clinical decision support and integrated health platforms.

Clinical decision support focuses e.g. on:
- Identification of high-risk patients
- Early detection of deterioration in patients' conditions
- Analysis and visualisation of data for healthcare professionals

Integrated health platforms focus e.g. on:
- Patient overview of own health
- Motivating patients for rehabilitation
- Sharing information among patients (and relatives) in social networks

PATIENT@HOME ILLUSTRATED

Kirsten (68 years)

Some months ago I was acutely hospitalised with atrial flutter and discharged a few days later – without a clue to what was wrong – the doctors could only tell me to take it easy. Fortunately, I was invited to join a trial with a heart patch that continuously measured my heartbeat and some other things. My heart data was compiled in a box that continuously transferred my data to a computer at the hospital. From this data, doctors found out that I probably had sleep apnoea, which might be one of the causes of atrial flutter, and I am now being treated for that. Had it not been for the new technology and the ability to measure and collect data and have them analysed, I don't think that doctors would have found out yet what was wrong with me.

ACQUIRE-ICD

A telemedicine project that will develop and test the clinical and economic impact of an interactive, integrated, web-based platform that can improve the quality of care of patients with heart disease implanted with an ICD

The incidence of heart failure is increasing, and in Europe and the United States alone more than 26 million are affected annually resulting in over one million admissions. Heart failure is a complex, chronic condition in which the heart muscle is weakened and unable to efficiently pump blood around the body. In order to prevent sudden cardiac death, many patients with heart failure are implanted with an implantable cardioverter defibrillator (ICD). The disorder causes disability, depression, and reduced quality of life due to fatigue, shortness of breath and fluid retention, and the risk of hospitalisation and mortality is high.

The ACQUIRE-ICD project will develop and test an interactive, integrated, web-based platform for facilitating timely detection and treatment of patients with heart disease and an ICD in a multi-centre randomised study.

Professor Susanne S. Pedersen, Project Leader and Initiator of the project, Department of Psychology, University of Southern Denmark, says:
We are faced with the challenge of providing good quality of care to this increasing population of patients, while the healthcare system is challenged on its resources. We know from clinical practice that it is difficult to pinpoint exactly when things start to go wrong for these patients, also since practice has changed and almost all ICD patients are placed on remote monitoring, reducing the number of visits to the outpatient clinic. ACQUIRE-ICD represents a highly innovative and sustainable paradigm shift, as it relies on patient-centered and personalized tools to empower patients, with these tools coupled to a novel web-based and interactive platform that is also available via an app. This approach has not been tried so far, says Susanne S. Pedersen.

Widespread integrated platform to increase 'patient empowerment'

The goal of the ACQUIRE-ICD platform is to make patients with heart disease and an ICD able to routinely monitor their health status and symptoms of anxiety and depression and detect deterioration at an early stage. Via the platform patients will be able to engage in a dialogue with health care professionals, enabling action plans to be set up that are supported with hands-on advice and tools provided via the platform or app. Patients will also have the possibility of engaging with other patients via the platform.

We want to give patients a more active role as advocates of their own health in a medical decision-making process, while enabling treatment recommendations and advice to be tailored to individual patients' needs and preferences. We expect that this will increase patient empowerment, compliance, treatment satisfaction, and quality of life, and may help prevent hospitalisations and overall enable patients to live a better life with their disease and their device, explains Susanne S. Pedersen.

The Livalife platform will be used and adapted to the ACQUIRE-ICD project and can also be used via an app.

- Liva Healthcare ApS is very pleased that the project has chosen to rely technologically on our platform, which is also available as an app. Experiences from the project will significantly contribute to making our product even better, says Kristoffer From, CEO from Liva Healthcare ApS.

Focused design process with the user

The contents for the platform are being developed using a user-centred design involving both patients and health-care professionals. In the fall of 2016, recruitment of patients for the study will commence in order to examine the clinical and economic efficacy of the intervention in a multi-centre randomized controlled trial.

Project partners
The ACQUIRE-ICD team is multi-disciplinary and international and consists of experts from the University of Southern Denmark, Aalborg University Hospital, Odense University Hospital, Aarhus University Hospital, CIMT, Liva Healthcare ApS, and Saint Luke's Mid America Heart Institute, USA.

PATIENT@HOME ILLUSTRERET

Svend (68 years)

I have a bad heart, to put it bluntly. I've visited my own doctor regularly for check-ups and been admitted to the hospital cardiology ward many times. Having the diagnosis I have, one takes one day at a time, trying to make the best of the situation and live a good life. This summer I joined a project that runs over the Internet. It's simply about making me able to keep an eye on my own health and detect deterioration at an early stage. At the same time the system gives me the opportunity to get in contact with a heart-failure healthcare team, if I need advice and feel anxious or afraid, and the system can inform the healthcare team in due time, if something is wrong and I am in need of medical assistance. For me all this means that I've got a swift and flexible tool that helps me in my everyday life. That I am being monitored continuously means that I sometimes can avoid an emergency trip to the hospital because the symptoms are either due to anxiety or false alarm. All in all, my course of treatment has become much more flexible than before, the review is faster and I avoid many hospital admissions.

IDENTIFICATION OF HIGH-RISK PATIENTS

Information and knowledge management in practice at Odense University Hospital

Up to 30% of patients arriving at the emergency department (FAM) at Odense University Hospital (OUH) with vital values in the normal range, experience deterioration within the first 24 hours when values exceed normal limits.

On arrival at FAM the severity of the condition of the patients is assessed and all patients are assigned to one of five colour-coded triage categories red, orange, yellow, green and blue. The challenge with this approach is that a number of patients are unnecessarily assessed as high-risk patients, and that the condition of patients, who basically were not assessed as high-risk patients, suddenly and unexpectedly deteriorates.

Patients with unexpected deterioration in their clinical condition have significantly increased mortality and risk of transfer to the hospital's intensive care unit. This scenario in combination with FAM's general challenges such as varying resource requirements depending on the number of patients and varying severity of their condition, many different categories of patients, who often need to be assessed by a specialist from other hospital departments, and a high volume level from alarms – also sometimes false alarms – results in a situation that highly stresses the personnel and increases the risk of errors occurring.

Attempts have been made, for several years, to develop the optimal tool for healthcare professionals, which they can use to identify patients at risk of deterioration. Many systems have been developed to monitor patients, but it remains uncertain whether a systematic monitoring of emergency patients will be able to contribute sufficiently to reduce the risk of death or transfer to intensive care units. There is, therefore, a need for establishing a better overview of patient characteristics and the development of the different measurements taken over time as well as a need for systematic knowledge of the prognostic value of these measurements and change patterns.

The vision

The project's goal is to provide healthcare professionals at Odense University Hospital with new opportunities to identify FAM patients with deteriorating vital parameters. This is done by identifying risk factors associated with death or transfers to intensive care and developing new technological models that can predict and warn of potential life-threatening complications before they occur. The approach to the project is largely based on the need for interaction between users, patients, and organisation and information technology.

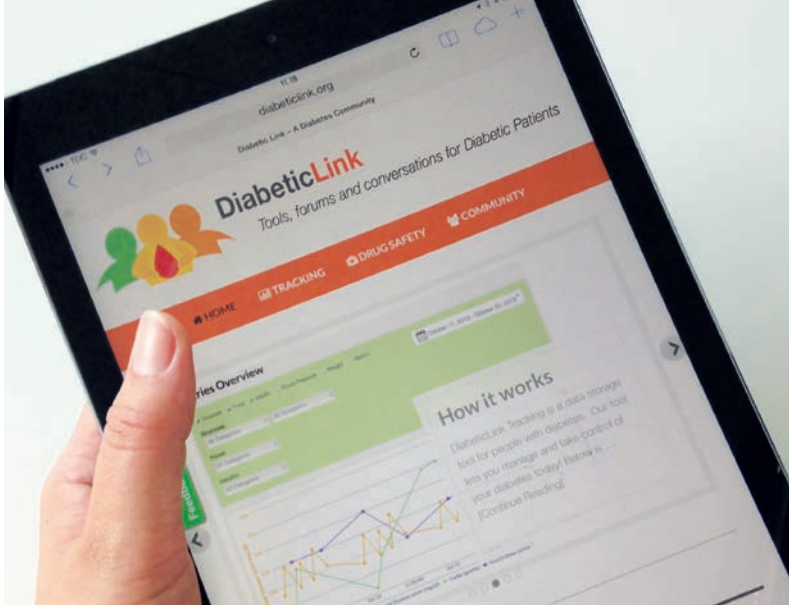
The project's PhD programme is run as a twin project in close collaboration with software engineer Thomas Schmidt and medical consultant Camilla Nørgaard Bech. They cover the clinical and technical angles of the project and are thus a good example of the outcome of building bridges between clinical and technical expertise, which is important for Patient@home.

Camilla and Thomas tell about the status of the project:

- We have at this point in time collected data on all patients during the study period. The material consists of anonymised personal data and data on clinical and developed conditions over a 2½-year period on all emergency patients arriving and admitted to the Emergency Department at OUH. The technical part of the project is structurally spread over the following three items: organisational understanding, modelling of patient care, and design of clinical decision-supportive prototypes. Throughout both the qualitative and quantitative studies, we have defined a number of challenges for both staff and patients, which we are now trying to resolve.

Professor Uffe Kock Wiil, Project Manager and Research Director of Patient@home, talks about the project cooperation:

- There are many exciting prospects in the project. The overall vision of the project is that it can contribute with new knowledge that can form the basis for decisions about the kind of patients that we need to keep better track of. Ultimately, this should result in fewer complications and shorter hospitalisations. The interaction between health science and technical research allows for a more holistic approach to the problem. The interdisciplinary cooperation between Camilla and Thomas is certainly enriching both PhD projects.



DIABETICLINK DENMARK

Development of an online health network for people with diabetes

Diabetes is a chronic and costly disease for the individual as well as for society. According to the WHO, the diabetes treatment costs will rise sharply in the coming years as a result of the demographic and socio-economic development in many parts of the world. In Denmark, the number of diabetics and the costs of diabetes care are also expected to increase steadily. Good diabetes control can save the individual for disease progression and development of complications. Ensuring the right balance between diet, physical activity, medications, and blood glucose value requires knowledge, motivation, and new tools.

DiabeticLink, developed by the company Caduceus Intelligence Corporation (CIC) and Artificial Intelligence Lab at the University of Arizona, is an online health network and tool that help people with type-1 and type-2 diabetes to take responsibility for their own health and disease through new knowledge and communication with other diabetics. The DiabeticLink platform includes easy contact to the doctor's, access to the latest knowledge about diet and nutrition, articles on health, and the opportunity to participate in online support groups. The objective of DiabeticLink is to increase patients' motivation for participating in management of their disease, including the establishment of a strong network around the patient, consisting of family, doctor, and other patients.

The Patient@home project DiabeticLink Denmark (DL-Denmark) is a Danish version of DiabeticLink, the aim of which is to adapt the DiabeticLink platform to a Danish context, based on the needs of Danish patients. A survey of user needs and customisation of the platform was carried out by the Danish Technological Institute.

DiabeticLink covers three areas:

1. Patient support via social media platform – peer-to-peer support, user blogs, and discussion forums
2. Patient education – information on diseases, diabetes knowledge resources (treatment, medication, diet, everyday life, recipes), and the opportunity to see the connection between fitness goals, exercise, and disease development
3. Self-management tools for disease management, knowledge of side effects and risk factors, chat and online communication with health professionals

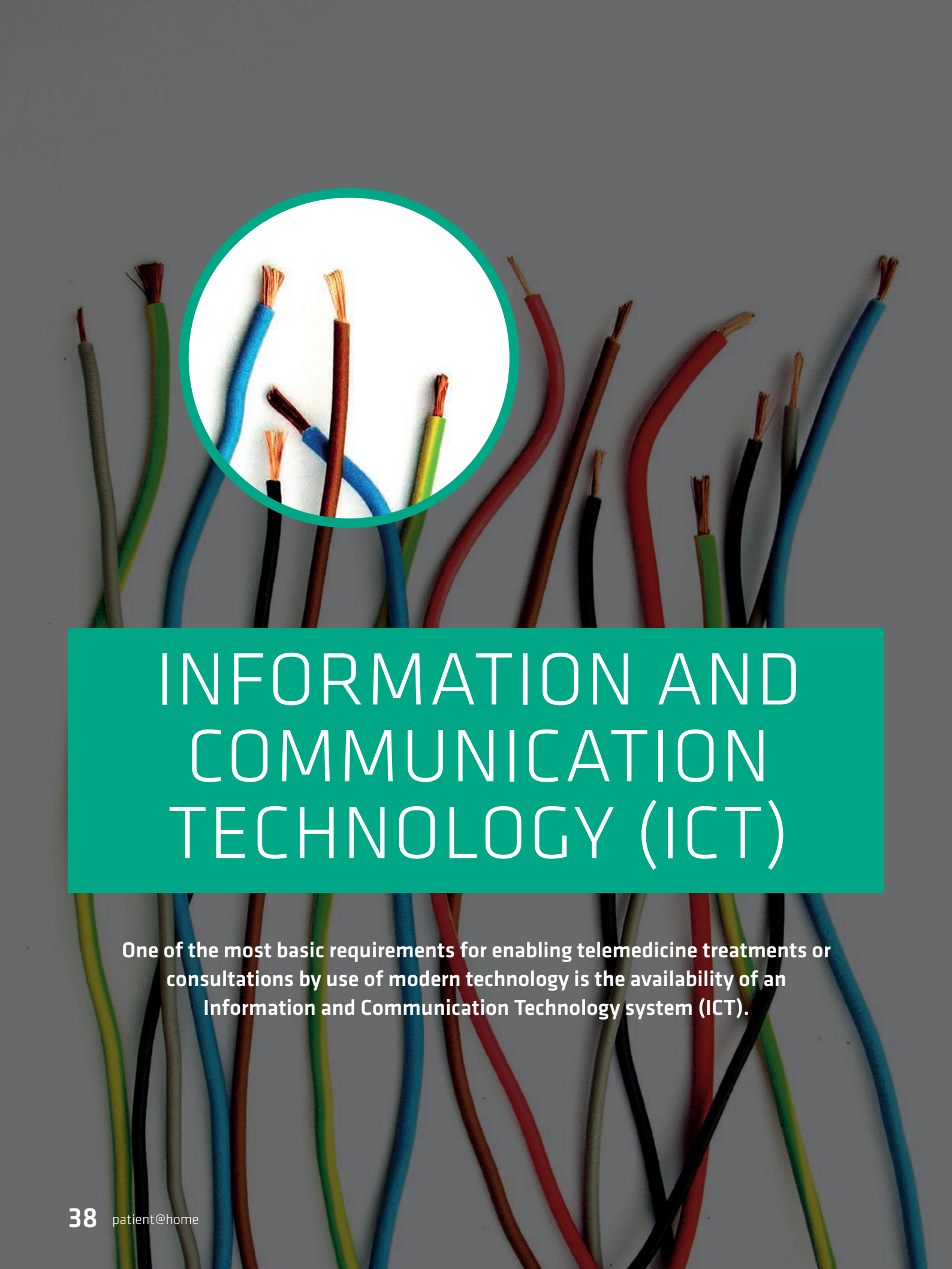
Professor Uffe Kock Wiil, Project Manager and Research Director of Patient@home, talks about the project's international dimension:

- DiabeticLink Denmark is a good example of fruitful international cooperation under the auspices of Patient@home. University of Southern Denmark has had good relations with University of Arizona over the last 5 years. This project will cement this collaboration. It's exciting that we in Denmark can be part of a large international project that includes countries such as USA and Taiwan. DiabeticLink Denmark wants to build bridges between the powerful big data skills of the University of Arizona (and CIC) and the good Danish tradition of involving users in the development and adaptation of systems.

Consultant Ana Maria d'Auchamp, Danish Technological Institute, tells about the project cooperation:

- To investigate how a system developed for other users can be adapted to Danish needs, has been extremely interesting, also how our expert knowledge on Danish users has been successfully combined with the US team's technical knowledge for the development of a new solution. It is a good example of global product development and innovation.

The project partners are:
Danish Technological Institute, Center for Working Life
The Maersk Mc-Kinney Moller Institute, University of Southern Denmark
Artificial Intelligence Lab, University of Arizona
Danish Diabetes Academy – JDRF
Pragmasoft A/S
Steno Health Promotion Center
Region of Southern Denmark, Health Innovation Centre of Southern Denmark
Caduceus Intelligence Corporation (CIC)



INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

One of the most basic requirements for enabling telemedicine treatments or consultations by use of modern technology is the availability of an Information and Communication Technology system (ICT).

By Lars Dittmann
Professor at the Department of Photonics Engineering, Technical University of Denmark
Work Package Leader for the ICT area in Patient@home

The Internet has become widely available and the coverage much better, especially as a result of the expansion of the mobile/cellular networks. But no single technology can support all the requirements expected by an efficient deployment of telemedicine services.

High availability – meaning that the network is always accessible and functioning – and private/secure communication are usually not requirements demanded by users of today's most commonly used Internet applications, but it will be in relation to advanced e-Health applications. And while private users might accept charging their smartphone every day, the power consumption of medical sensors and measuring equipment will play an important role when a new energy-efficient technology solution is to be selected.

Ensuring high availability in relation to maintenance cost/purchase price is a complicated issue. While off-line measurements, for example on weight, blood pressure and lung capacity, can endure some delay (caused by e.g. overloading or poor coverage by the ICT system) before being transferred and registered by the telemedicine health system, real-time monitoring and alarm systems (such as case detection, pain related to heart/vascular diseases) require an ICT system that is available with a minimum probability of typically 99.999%. This is similar to the Internet failing maximum 5 minutes per year ("five-nine" – which is actually 100 times better than required for handling NEM-ID, which is a common log-in solution for Danish Internet banks, government websites and some other private companies).

> **It is important that we continue to develop new and better telemedicine solutions that users are comfortable with (and which they trust will work whenever they need them) without compromising on security**

To create such a degree of accessibility by means of a single technology is generally both difficult and costly, and will also mean higher costs and less usability of applications which do not need these qualities. But that is the reason why we conduct research in telecommunication and information and communication systems.

It is important that we continue to develop new and better telemedicine solutions that users are comfortable with (and which they trust will work whenever they need them) without compromising on security – and simultaneously develop solutions that users find easy to use.

Cost wise, it is also important to base telemedicine solutions on a general system and on standardised principles, in order to avoid development of something that is the target of one patient group or one type of equipment.

And finally, it is important that the user/patient/citizen is involved and committed as much as possible and that use of the patient's own equipment and the data collected through the established health system – for example, when linking self-monitoring equipment with various private gadgets – is secured and applied in compliance with the patient's own wishes. Data that was collected via self-monitoring before the user became a patient may, because of its complexity, prove to be worth its weight in gold in relation to a certain treatment if it is understood and processed correctly.

Believing that such a task can and must be lifted by large international companies only may prove very unfortunate in the long run in terms of patient safety and confidence in the system – and thus the patients' enthusiasm.

In "Patient@home" a number of different solutions are being investigated in relation to secure and user-friendly communication with high availability, with the broader purpose of examining the possibility of making the patient mobile, so that the patient can be monitored and offered assistance outside own home, e.g. in the car, in the garden, when visiting family and friends.

ADAPTIVE SOFTWARE PLATFORM FOR TELEMEDICINE

An innovative Patient@home project focusing on the development of an adaptive software platform for telemedicine will enhance future telemedicine solutions to home monitoring and home care

With new state-of-the-art information and communication-based technologies (ICT), it is possible to optimize treatment in the Danish hospital sector by linking traditional treatment with technology-enhanced home monitoring and home care. However, ensuring a high quality of treatment of patients in own home, still requires solutions to many of the challenges that are related to software systems in telemedicine – both in relation to collection and processing of health data and in relation to exchange of data with other relevant systems in healthcare.

Data collection

Generally speaking, this Patient@home project aims to develop an ICT infrastructure consisting of a number of components that support collection and intelligent use of data. The project is developed as a PhD project with Daniel Bjerring Jørgensen at the helm. Two out of three years of studies have been completed and the foundation for a generic and open software platform developed. The platform consists primarily of three components: Data input layer, ontology and reasoner, of which the first two are fully developed.

PhD Student Daniel Bjerring Jørgensen from the University of Southern Denmark says:

- An overall requirement from Patient@home is that it must be easy for applications and technologies to integrate to the infrastructure/platform developed in this project. When ensuring easy integration, the data input layer comes into play. It is a library developed in Java which has to be included in the systems that want to send data to the platform. The only thing needed to send data to the platform via the library, is a method call with appropriate parameters to an object in the library (a temporary agent is created automatically). Then the underlying infrastructure handles all the necessary technicalities.

- Our platform is a multi-agent system, which is a programming paradigm that was previously known as distributed artificial intelligence. The basis of agents' communications is described in an ontology which is a method to abstractly describe all the knowledge that may be available and exchanged between software components of artificial intelligence systems. The ontology developed in this project describes the example data from measuring equipment (pulse, blood pressure, etc.), smart home (falls, motion sensors, etc.) and data on the citizen's physical activities and daily routines as well as a number of other types of data that relate to "the patient".

Intelligent use of data

The platform's last component is the reasoner that should make it easy for citizens to use the platform. This component is not developed yet, but it is the focus of the remainder of the research project. Daniel Bjerring Jørgensen explains:

- The Reasoner component shall incorporate intelligence into the platform. The starting point is that citizens act differently and that telemedicine systems implemented in their homes must therefore also be able to act differently. To this end, the reasoner will use *user modelling*, to ensure that the platform says the 'right' thing at the 'right' moment and in the 'right' way. The platform will simply be able to adapt to the patient's preferences, habits and physical abilities.

Our work will concentrate on understanding the citizen's habits to ensure that the system does not interfere at inappropriate times. For this purpose, we have obtained a data set from a smart home that for several months continuously collected information about the resident's behaviour. We will then try to develop an algorithm that is able to predict the resident's behaviour the next day so that the platform can schedule reminders etc.

Our models of care must cha – investing in prevention of disease; delaying the point at which disease becomes acute; and transforming hospitals from destinations to become nodes of expertise in a network of care that includes the home and work. The Patient@home programme is very important in providing research and translation of inventions to innovations that can be adopted at scale across health and social care systems in Denmark, Scandinavia and beyond.

#Kevin John Dean (Managing Director, Smart Health Science Ltd., a member of the advisory board of Patient@home)

Expected results

The general objective of the project and the expectations of the new technology are that the developed adaptive software platform will strengthen the future of telemedicine solutions' focus on the individual patient, and thus help to improve the quality of care in general.

The project has been developed at The Maersk Mc-Kinney Moller Institute, University of Southern Denmark.

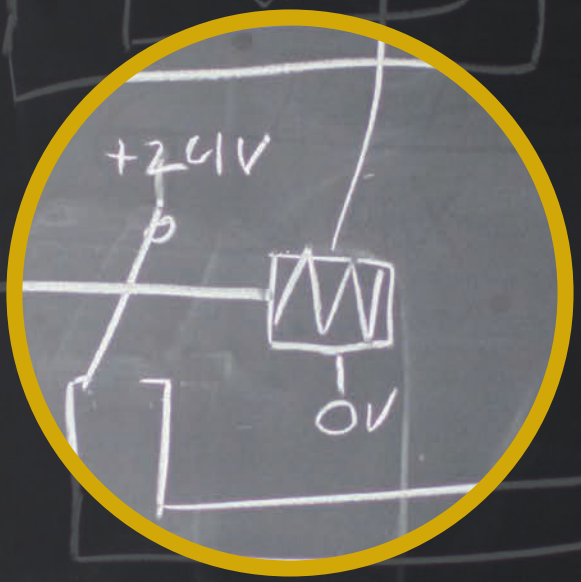
PATIENT@HOME ILLUSTRATED

Jesper – family member of Johannes (81 years)

As a family member, I must say that the new technology gives us a real sense of security in our everyday life. My father has incipient dementia and a genetic predisposition to blood clots. But he is still so fresh that he can take care of himself at home. He is participating in a study that gathers information about his heart-beat rate, blood pressure and place of stay using various technical devices, such as smartphones, motion sensors and intelligent bracelets. This means that doctors, nurses and caregivers can keep track of his well-being. It makes us feel safe and near him, even though we don't constantly drop by his house to see how he is doing. We know that the experts keep an eye on him.

FAST TRACK

Fast-track projects provide special opportunities for faster testing



By Claus Duedal Pedersen
Senior Consultant at
Odense University Hospital (OUH)
Work Package Leader of Fast Track
in Patient@home

Many Patient@home projects require extensive research and close cooperation among several parties e.g. the project Hospital Home. They need several years of planning and execution of tests, before any conclusions can be drawn and concrete solutions made available.

Another group of projects in Patient@home goes under the name of Fast Track. As the name suggests, these projects are characterised by being quickly initiated and implemented. Typically, the entire project period is 3-6 months. Fast Track projects are anchored in CIMT – Centre for Innovative Medical Technology (OUH/SDU) – since OUH has both specific opportunities and interests in using Fast Track projects in relation to testing and evaluating different technologies that can modify and optimise workflows.

The Fast-Track projects do not focus on development of new technology, but on testing the technology in a clinical context, or on implementing a specific technology with proven efficacy in a clinical setting. Activities related to these technologies may have occurred for a long time in another context, such as a long-term research or development project, but now the final push towards actual implementation is needed. In these cases, the possibility of carrying out a Patient@home Fast-Track project means additional resources can be made available for further clinical testing, research and development. It also creates a basis for taking further development or commissioning decisions.

Fast-Track projects can also be built on technologies that have been implemented and tested in one area and then subsequently been deemed beneficial for other areas of the healthcare sector.

The basic concept of Fast Track is that a department finds a new technology that is relevant to the workflow and considered likely to be beneficial on either a clinical, economic or patient-related level.

Finally, there may be completely new technology areas where OUH can carry out fast pilot tests and get an evaluation of the potential of the technology, such as the trial of the Google-Glass technology for visualisation and hands-free communication.

The basic concept of Fast Track is that a department finds a new technology that is relevant to the workflow and considered likely to be beneficial on either a clinical, economic or patient-related level. On that basis, a minor pilot project will be implemented, typically comprising a few members of staff and a small number of patients (20-30). Testing is then carried out in the course of two or three months, followed by a rapid evaluation that covers all domains of the Patient@home innovation model, but has no definite scientific level.

Another special feature of Fast-Track projects is the active participation of the technology supplier. This ensures project implementation with a high degree of support and attention. It also means that it is not possible to get a true picture of the operation of IT systems, but it ensures a test that is "undisturbed" by technical problems and that it is the clinical situation and use that are assessed.

Overall, the Fast-Track concept has proved to be extremely useful. There are solutions that have been rejected and solutions that have been put into operation after a Fast-Track process. It should be stressed, though, that rejected projects are at least as successful as those that have been approved. Being able to quickly reject a solution, which does not provide winnings and are based on practical tests, is of great importance to a large organisation like OUH.

TESTING OF GOOGLE GLASS AT OUH

Project participant Mikkel Scherfig Straarup, nurse at the Emergency Department at OUH

Fast-Track Project on the use of advanced new technologies related to fast patient courses

The purpose of the project was to test Google Glass (GG) as a useful tool in clinical work situations at Odense University Hospital – and to examine whether it is technically possible to use the GG in conjunction with clinical systems used in patient care, and to clarify whether GG, which can be operated hands-free, can be a useful tool in the clinic.

The project ran from 1 May 2014 till 15 January 2015 and was carried out together with the company Accenture, which had an agreement with Google to try out the Google Glass technology in Denmark, and thus made it possible to get hold of the technology before it was released on the market.

GG was tested in two departments at Odense University Hospital: The Emergency Department (FAM) and the Department of Gynaecology Obstetrics D (Gyn. Obs. Div.). GG was used 23 times in the pilot project, 12 of which were without the involvement of patients and 11 with involvement of patients.

At FAM, the spectacles' "see-what-I-see" live streaming function was used to provide doctors or nurses with advice from more experienced colleagues who were not present at FAM. On Gyn. Obs. Div. GG was used to provide operating doctors with a visual input (CTG-curve) as an addition to a verbal description when a midwife had to contact a doctor engaged in an operation for advice regarding a patient at the maternity ward.

Results

The pilot project has found positive indications for the use of GG in clinical settings in terms of observations, user evaluations and verbal feedback by users and project participants.

Project Manager Claus Duedal Pedersen from Odense University Hospital says:
- Google Glass is estimated to provide a quality boost and time savings. At Gyn.

Obs. Div. the participating clinicians all said that the CTG curve shown on the GG was a useful and valuable addition to the description in words and gave a more nuanced basis for decision-taking. In addition, immediate decisions from operating physicians reduce the need for following up on postponed inquiries after surgery. As for the "see-what-I-see" mode on FAM, the clinicians indicated that it is useful and provides clinical value. The use of GG means that decisions can be taken even though the consultative party is not physically present at FAM, and it therefore saves time by not having to wait for their presence.

The project has also met several technical challenges including battery life, using own glasses together with Google Glass, as well as safeguarding the clinical data transmitted via the technology, which prevent immediate implementation of a technology like Google Glass. These reasons are exactly the same as identified by other professionals who have tested GG, and that is also why Google has removed GG from the market – at least for the time being.

There was, however, so much potential in the tested features that OUH will continue to follow the developments of the so-called 'wearables', which allows for hands-free operation and direct connection to networks and clinical systems that can be of great value in the clinical workflow.

Since the pilot test of GG only focused on testing GG as a tool, complex integrations with key clinical systems were not taken into consideration. However, the project's simple tests gave indications that may be followed up by larger tests, including system integrations, if other similar wearable technologies should require testing. Subsequent studies or trials at OUH will also have to gather evidence and greater experience to document positive effects on clinical workflows and parameters.

The project is a collaboration between Center for Innovative Medical Technology, Odense University Hospital's Department of Gynaecology Obstetrics, Innovation Network RoboCluster and the company Accenture.

Project Manager in Innovation Network RoboCluster, Conny Heidtmann, highlights:

- Accenture conducted a workshop at OUH attended by clinical staff from various departments. Accenture gave a presentation and demonstration of GG, and the workshop resulted in a number of scenarios that clinicians had outlined, and in which Google Glass could make a difference in the clinicians' daily work at the hospital. Two of these cases were subsequently selected for the pilot test.

RoboCluster's role in the project has been to invite Accenture to participate in Patient@home, where the pilot test should take place, and to ensure that the results of the pilot test were widely disseminated to relevant players within the healthcare sector and among other stakeholders. It will be interesting to see how and when wearable technologies will make their entry into the healthcare sector for the benefit of both patients and clinicians.

"It is a goal that many more patients will be treated as outpatients in their own homes. Therefore, an innovation model has been established in the auspices of Patient@home which ensures that prototypes and products are based on identified and clearly described needs and challenges among users and customers – at both regional and municipal levels. The model also ensures that the results are validated in clinical and user-close environments, and that new ideas are based on solid research and close involvement of both companies and end users.

 # Jørgen Løkkegaard (Centre Manager, Danish Technological Institute, (Innovation Leader in Patient@home and a Board Member)

PATIENT@HOME ILLUSTRATED

Ruth (61 years):

A few years ago my sister was diagnosed with osteoporosis after she fell and broke her hip. She had always been a heavy smoker and underweight, and the doctor told her that the disease is both hereditary and life-style dependent. One day I pulled myself together and went to the doctor's, who referred me to the hospital for a scan that measured my bones' mineral content and density. The diagnosis was osteoporosis – brittle bones. Fortunately, it was discovered before any fractures occurred, and it doesn't affect my daily living. I have joined an exciting project called Mobile Health Technology for women with osteoporosis. The project helps me understand what the diagnosis means – both in terms of medical treatment and in relation to needed intakes of calcium and vitamin D – and what it takes to live bone-friendly. I have great pleasure in participating in the project, and I suddenly understand what self-care actually means for one's well-being.

patient@home PROJECT PARTNERS

Companies

- Absolute Liquid Solutions ApS
- Accenture
- Access Technology ApS
- Astrid Leisner & søn
- Bandagist-Centret
- Caduceus Intelligence Cooperation
- Cambio Healthcare System A/S
- Capgemini Danmark A/S
- Care Excerciser
- Cekura A/S
- CGI
- CIM Gruppen A/S
- DorsaVi Ltd.
- DoseSystem ApS
- Eglu A/S
- Entertainment Robotics
- Ergolet ApS
- Evidence Profile ApS
- ExorLive A/S
- GN Store Nord A/S
- Hospitalet Valdemar A/S
- IBM
- ICURA
- Induct Software A/S
- Izinga
- KMD
- Life-Partners A/S
- Lindpro A/S
- Medema A/S
- Medicomb A/S
- Medisat A/S
- MedWare ApS
- Mobile Fitness A/S
- Move Innovation ApS
- MV-Nordic
- NETOmsorg ApS
- Nico Design
- OSAA Innovation
- Pacini Medico
- Pallas Informatik A/S
- PlayAlive A/S
- PlayScapes Denmark ApS
- Pragmasoft
- Robotic Ultrasound ApS
- Safecall Denmark ApS
- SENS Innovation ApS
- Sensor Medical A/S
- Systematic A/S
- Teccluster A/S
- Tele Call Danmark
- Ther-Ex
- TriVision A/S
- Tunstall
- Viewcare A/S
- Welfare Denmark ApS
- Yes Group

Universities

- University of Southern Denmark
- Aalborg University
- Technical University of Denmark
- University of Copenhagen
- Aarhus University
- Osaka University
- Advanced Telecommunication Research

Innovation Partners

- Welfare Tech
- Danish Technological Institute
- Health Innovation Centre of Southern Denmark
- DELTARoboCluster
- Idéklinikken

Hospitals/Municipalities

- Glostrup Municipality
- Odense Municipality
- Aarhus Municipality
- Næstved Municipality
- Odense University Hospital

patient@home PROJECT OVERVIEW

Rehabilitative Training

- Home Training of Neck Pain Radiating into the Arm
- Sensors for Neck-Pain Training
- Game Technology for Rehabilitation
- Motivation of COPD-patients
- Digital Support of Clinical Documentation
- Rehabilitation with Industrial Robots – Universal RoboTrainer
- RoboTrainer Light
- Rehabilitation of Brain Damage
- Intelligent Headset for Neck Training
- Efficient home rehabilitation tool SENS motion®

Monitoring

- Evaluation of KMD System
- Innovative Technology Used for Treatment of Wounds
- ACCESS - Coordinated Emergency Efforts for Senior Citizens
- Hospital at Home
- Hospital at Home: Sensor Fusion
- Hospital at Home: Computer-vision for in-home medical diagnosis and monitoring
- Spiromagic - Electronic Spirometer
- D-Time – Safeguarding the Everyday Life of Diabetics
- Pain Management Chair
- Robotic Telemedicine Ultrasound
- Safe-Biopsy: Safe and Efficient Handling of Tissue Samples

Care in Own Home

- Chromalex – The Meditative Image
- Interactive and Socially Assistive Robots
- Exoskeleton for the Arm and Shoulder Region
- Care-O-Bot 3 as a Test Platform and Inspiration
- Technology for Communication and Relationship Building
- Detection of Body Fluid
- Preventing Pressure Ulcers with Patients in Own Homes
- Operating System for People with Reduced Cognitive Functions
- Ecology of Care: Human-centred Care to be Included in the Concept of 'Care'
- Telemedicine for Patients with Hip Fractures
- Digital Help for Citizens with Back Fractures
- Implementation of Electronic Medication Administration in the Citizen's Own Home
- Test and Documentation of a Mechanical IV Bag Pump
- Early Detection and Reduction of Relapse in Social Psychiatry
- Kidney Transplantation, Involvement and mHealth

Information and Communication Technologies (ICT)

- Adaptive Software Platform for Telemedicine
- Secure and Reliable ICT Systems for Telemedicine Applications
- DoloTest® - Helping People with Chronic Pain

Information and Knowledge Management

- Identification of High-risk Patients
- Patient-Centered Tools to Improve Life with Heart Disease
- DiabeticLink
- Mobile Health Technology for Patients with Osteoporosis
- Targeted Drug Information in Community Care
- RELIP: Reading Between the Lines

Fast Track

- COPD Patients at Home
- Monitoring of Cardiac Function
- Wireless Screening in the Home of Patients with Suspected Disturbance of Heart Rhythm
- Baby Briefcase for Maternity Parents
- Telemedicine Discharge Planning Conference
- Videoconferencing in Healthcare
- MAST - Model for Assessment of Telemedicine
- Video Interpretation for Particularly Vulnerable Patients
- Google Glass-testing at OUH
- Telemedicine Rehabilitation of Patients with Severe COPD

Photo: Danish Technological Institute

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