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GE HEALTHCARE SPECIAL SUPPLEMENT

Cover Story:

The Future is Digital

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Point-of-View articles are the sole opinion of the author(s) and they are part of the HealthManagement.org Corporate Engagement or Educational Community Programme.

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Opening a World of POSSIBILITIES

WORKING IN PARTNERSHIP
GE HEALTHCARE AND ESR

EUROPEAN SOCIETY OF RADIOLOGY

GE @ ECR 2020 - Booth 302 - X3

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29TH CONGRESS OF THE EUROPEAN ASSOCIATION OF HOSPITAL MANAGERS

30 SEPTEMBER - 2 OCTOBER 2020
29TH EAHM CONGRESS
BUDAPEST, HUNGARY

Dear Colleagues,

On behalf of the Hungarian Association of Economic Directors of Health (EGVE), we invite you to join us at the 29th congress of the European Association of Hospital Directors (EAHM) in Budapest.
Budapest will be the place for all European hospital directors to come and develop their point of view in relation to their daily work, to achieve excellence, to stay broad-minded, to follow innovation in the sector and to continue to build friendships with colleagues. High quality networking and content will be the pillars of this congress of hospital directors.

We very much hope that you will be with us!

Attila Molnár President of the Congress EAHM 2020	Zsuzsanna Törökné Kaufmann President of EGVE	dr. Lajos Ari President of the Scientific Committee

SAVE THE DATE:
30 September – 2 October 2020

REGISTRATION
Early Bird: until 1 June
Standard: until 25 September
On-site: after 25 September

FURTHER INFORMATION AND PROGRAM
please scan this QR code
or visit the congress website:
https://eahm-budapest2020.com/

DAY 1
WEDNESDAY, 30 SEPTEMBER

09:00-13 :00 HOSPITAL VISITS (transfer by bus)
@ Marriott Hotel Budapest
- Duna Medical Center
- National Institute of Medical Rehabilitation
- Hospital in the Rock
- Premiermed Medical Centre

14:00-18:00 SCIENTIFIC SESSIONS
@ Marriott Hotel Budapest
Opening Ceremony
- Keynote Lecture: Zsuzsanna Jakab, Deputy Director General of the WHO
- Main Topic: Dr. Who - The Future of Health Professional Education, keynote speaker Prof. Béla Merkely, Rector of Semmelweis University Budapest
- Main Topic: Ethics in the 21st Century

19:00 Welcome Party
@ Marriott Hotel Budapest

DAY 2
THURSDAY, 1 OCTOBER

09:00-18:00 SCIENTIFIC SESSIONS
@ Marriott Hotel Budapest
- Introduction To the Hungarian Health Care System, Gyula Kincses, President of the Hungarian Chamber of Medicine
- Main topic: Hospitals Go Green - The Path to Reduce Healthcare's Environmental Footprint, keynote speaker Prof. Diana Ürge-Vorsatz, Central European University
- Main topic: Future Technologies
- Main topic: Innovation in financing, DRG

20:00 Gala Dinner
@ Museum of Fine Arts

DAY 3
FRIDAY, 2 OCTOBER

09:00-15:00 SCIENTIFIC SESSIONS
@ Marriott Hotel Budapest
- Main topic: Big Data and Informatics, keynote speaker Zsolt Kiss, Director General of the Hungarian National Health Insurance Fund
- Best Poster & Innovation Award
- Rectors Summary of the Future of Health Professional Education
- Closing Ceremony

30 SEPTEMBER - 2 OCTOBER 2020
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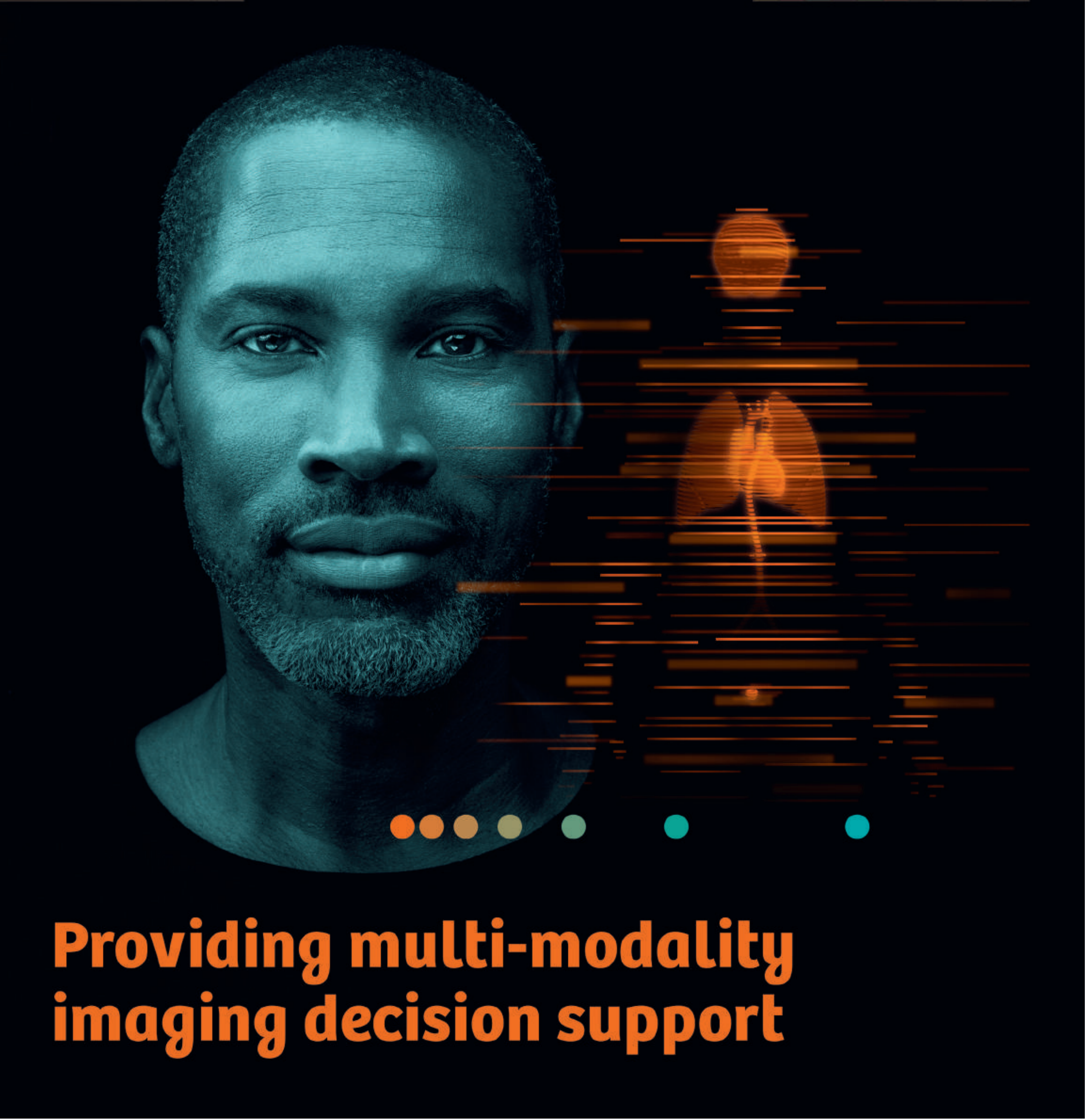
BUDAPEST, HUNGARY


Providing multi-modality
imaging decision support

Contributors

Sophia Arabadjis, USA

Sophia is a PhD Student in Health and Medical Geography at the University of California, Santa Barbara. With a special focus on health and medical geography, she is very interested in disparities of access to care and is passionate about social research in the healthcare space.

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Bettina Baessler, Germany

Bettina is a consultant radiologist with a special focus on quantitative imaging and radiomics at the Department of Diagnostic and Interventional Radiology of the University Hospital Zurich. Her special interest is the application of machine learning algorithms in medical imaging science. She strongly believes that research can only thrive through cross collaboration.

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As an alliance builder and leadership coach, for over 30 years Vonda has guided professionals to succeed. After her husband's death, Vonda decided to contribute to safety in healthcare. She is co-chair of the 2020 March for Patient Safety (PSMF).

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Is a valued member of the Imaging Editorial Board at HealthManagement.org. Prof. Caramella lectures in Radiology at the University of Pisa, is chairman of the Radiotherapy Residency Programme and serves as chairman of the Radiology Unit of the Santa Chiara Hospital in Pisa.

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Prof. Hadjileontiadis received the Diploma degree in Electrical Engineering in 1989 and the Ph.D. degree in Electrical and Computer Engineering in 1997, both from the Aristotle University of Thessaloniki in Greece. His research interests include higher-order statistics, alpha-stable distributions and neuro-fuzzy modelling for medical, mobile and digital signal processing applications. He also holds a Ph.D. degree in music composition from York University in the UK.

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Ismael is the Innovation Director at Bismart, Business Intelligence Specialist Services. With a background in Project Management and special interest in big data, machine learning and business intelligence, Ismael is also an accomplished mountaineer and swimmer.

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Senior Director of Health Information & Innovation at the American Health Information Management Association, previously held positions of CIO and R&D Officer at Badalona Serveis Assistencials. Lecturer and researcher in digital health and integrated care.

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Direction of Innovation and Digital Transformation at Hospital del Mar in Barcelona, Jordi's specialties include integrated services management, integrated care, quality, strategy and health field information systems.

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John Nosta, USA
John Nosta is the founder and President of NostaLab and ranked as the #1 global influencer in digital health. He is a technology theorist, a member of Google Health and a WHO Digital Health Expert. He is regarded as one of the top global strategic and creative thinkers, and is also a popular speaker around the globe.

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Julio Pascual, Spain
Head of the Department of Nephrology at Hospital del Mar, Julio Pascual is also Associate Professor at the Faculty of Medicine of the Autonomous University of Barcelona. During his career, he has carried key activities in the development of new immunosuppressive strategies and was Chairman of the Clinical Research Ethics Committee at Ramón y Cajal Hospital.

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Lecturer and researcher in Information Systems Strategic Planning, Project Management and Business Intelligence at Universitat Oberta de Catalunya. He is also an independent consultant and was CIO of the Barcelona City Council and Basque Health Authority.

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Prof. Luigi Rubino, Italy
Prof. Luigi Rubino is director of Studio Rubino in Genoa, Italy and lecturer in dental radiology at the Universities of Genoa, Pisa and Rome. His interests include how Virtual Reality can be harnessed to fine tune radiology procedures.

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Erin is the research and curriculum director at the Harvard Medical School Center for Primary Care where she studies high performing primary care systems around the globe. Prior to this, Erin was at the Global Health Delivery Project at Harvard University, where she developed a Master's in global health.

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Pol Pérez Sust, Spain
Managing Director – CIO at the Catalan Health Service and the main responsible person of the Digital Health Strategy for Catalonia. He held different positions in the local healthcare system, such as CIO of the Catalan Institute of Health.

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Having worked in a variety of fields in the European Commission, including his position as Director of Digital Society, Trust, and Cybersecurity, Dr Timmers is now involved with the EPC, EIT Health and the University of Oxford.

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Maximilian von Eiff, Germany
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Prof. Wilfried von Eiff, Germany
A professor in hospital management at the University of Münster since 1994, Wilfried is also a EFQM (European Foundation of Quality Management) Assessor focusing on procurement and logistics management, business process management, strategic management and medical cost control among other areas.

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Editorial

The Future is Digital

The debate about Artificial Intelligence (AI) versus healthcare personnel shows no sign of abating. While we can safely say that the role of physicians is not under any serious threat from technology, AI will be critical in managing data for more efficient diagnosis, workflow and patient care.

'The Future is Digital' offers exciting views on data curation and clarifies other 'grey' areas that are a result of healthcare digitalisation.

Erin Sullivan and Sophia Arabadjis from Harvard Medical School and the University of California dive deep into optimal use of data in EHRs while Laia Sans from Hospital del Mar in Barcelona leads a team on Natural Language Processing in data for prevention and cure. A team of authors explain the inception and implementation of Digital Health Strategy for Catalonia (Spain). Jan-Philipp Beck of EIT Health highlights the need to change and adapt to challenges of big data, and Paul Timmers from the University of Oxford expands on the ethical questions raised by AI. Leontios Hadjileontiadis from Aristotle University of Thessaloniki shows us how an ICT-based approach helps detect early signs of Parkinson's Disease while Bettina Baessler from University Hospital Zurich examines the need for standardisation in the growing field of MRI radiomics.

In the spotlight is Prof Boris Brkljačić, President of the European Society of Radiology, who gives us a sneak preview into ECR being held in Vienna in March. John Nosta, a global influencer in digital health, talks about the convergence of technology and health while Prof. Daniel Drucker talks about advancements in the understanding and treatment of Type 2 diabetes.

2020 came in with an alarming bang with COVID-19. Can we emerge wiser in how we deal with epidemics? We look at this in Management Matters, while also examining challenges of transitioning to a culture of safety in healthcare organisations..

In Winning Practices, we see how state-of-the-art Virtual Reality in imaging opens up new possibilities for diagnosis and precisely where digitalisation can improve healthcare. A prominent institution shares its experience of creating a 'Smart Hospital.'

Enjoy this issue and keeps your news and views coming!

Prof. Lluís Donoso-Bach

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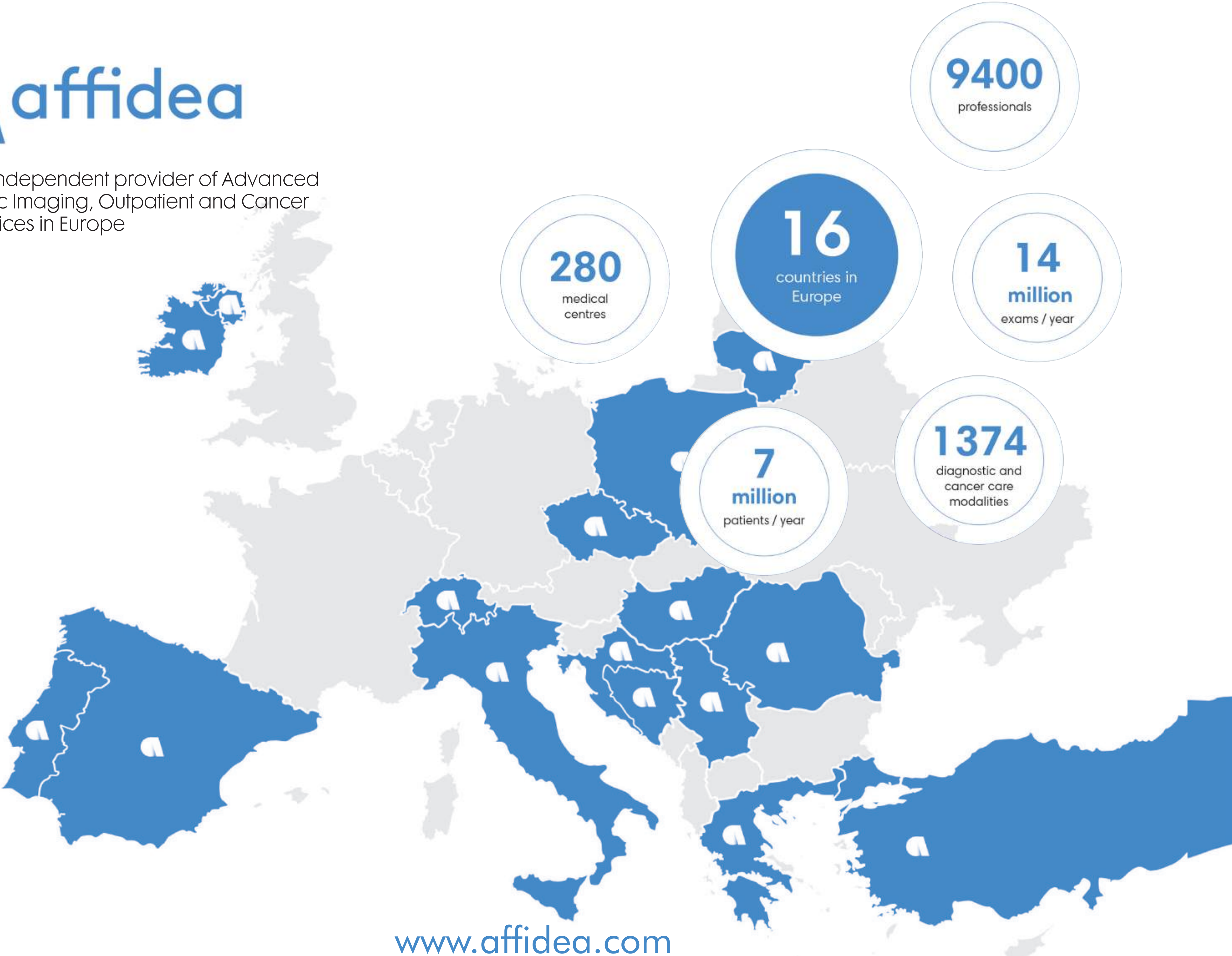

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Editorial Board

Have your say. Engage!

If we were to scrap out traditional ideas about the hospital, what would it look like? What game-changing models already exist? What can we learn from other industries to adapt for better healthcare? We explore this and more.

To contribute, contact us on
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ECR 2020: Leadership and Collaboration

Summary: Leadership, collaboration and insights from nations leading the way in imaging practice are just a few of the features in what promises to be a rich and educational ECR 2020 congress. HealthManagement.org spoke to Prof Boris Brkljačić, President of the European Society of Radiology for the full overview.

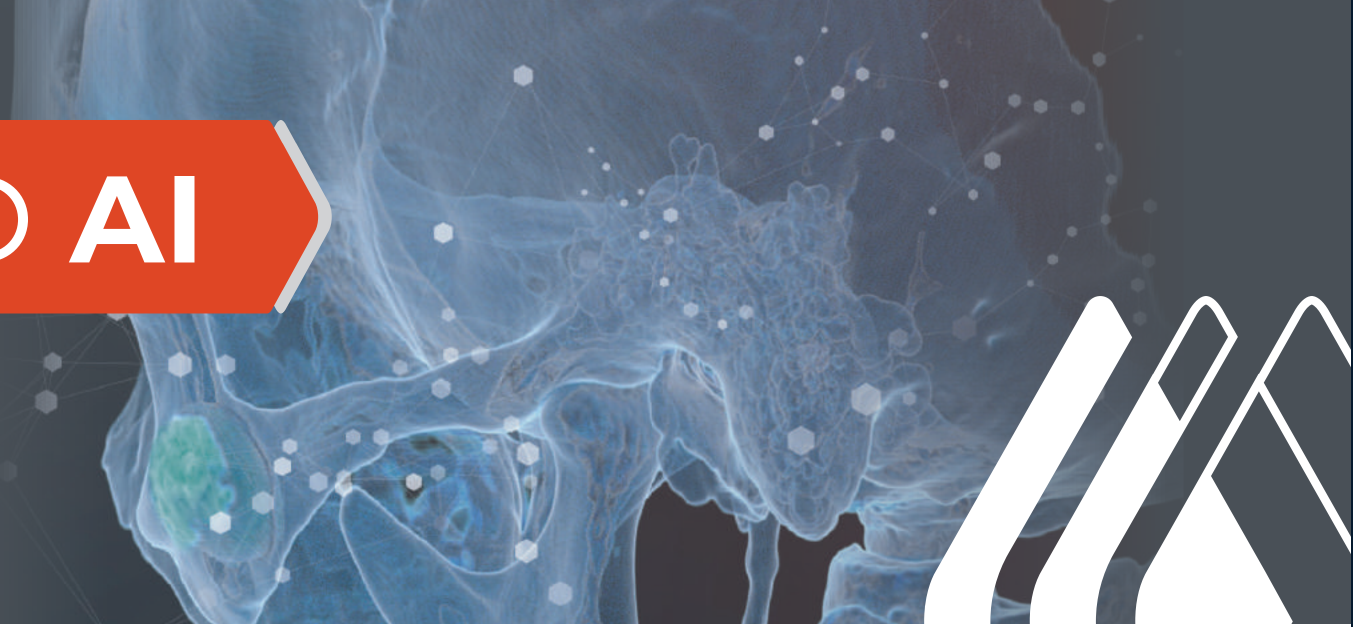
How is ECR supporting 'Management and Leadership' in radiology?

There will be ample focus paid to the topic of 'Management and Leadership' in radiology and this can be seen with the wide variety of sessions that we have prepared at ECR 2020 which concentrate on this subject. The sessions focused on management and leadership look at the topic from various different perspectives, including AI, clinical practice, cross-functional collaboration and so forth. They will take place under the umbrella of various session types including workshops, coffee and talk sessions, research presentation sessions and much more.

With the advent of AI, cross-collaboration is increasingly important in imaging and not just amongst radiology disciplines but across hospital departments. How are ECR and the ESR promoting the important topic of cross-collaboration in radiology? How do you see this area developing in the future and will team leaders need to develop more skills?

Cross-collaboration is an important aspect of modern clinical practice and it's a factor that no radiologist can overlook. This is especially true nowadays with the advent of new technologies, including artificial intelligence. Creating effective cross-collaboration channels not just among radiology disciplines but across hospital departments, presents a clear benefit to all those involved, mainly due to faster and more efficient workflows. Effective

END-TO-END **AI**



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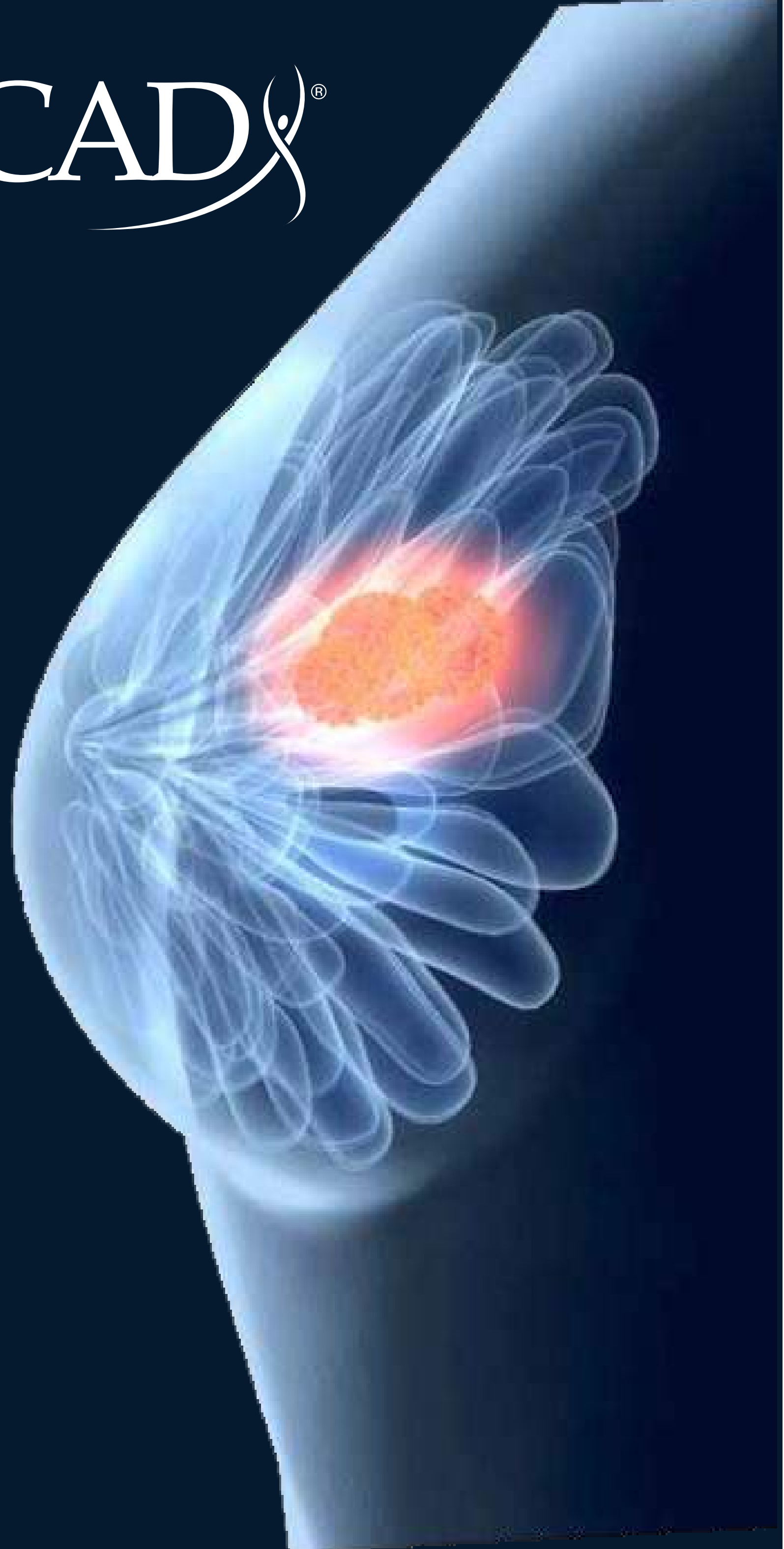

cross-collaboration will also help to maximise the clinical benefit of all the tools that radiologists have at their disposal, namely AI. We are also looking at this topic closely during ECR with sessions that focus on artificial intelligence and translations to clinical practice, AI & clinical decision support and much more, so stay tuned!

How will multi-disciplinary teams in radiology develop in the near-term future?

Looking at the current situation, I think it's accurate to say that multi-disciplinary teams are already developing. I also think that there always has, and always will be opportunity and need for multidisciplinary collaboration between radiologists and their counterparts in other fields of medicine. In particular, I think there will be ample opportunities for the development of multi-disciplinary teams with other specialties such as cardiology, urology, surgery and so forth. Much of this multidisciplinary collaboration stems from the big value that radiologists bring with their highly accurate diagnostic modalities that clearly contribute a huge benefit when it comes to treating patients. In this sense, radiologists will always play a vital role in the treatment of patients. As an additional point, I think that a synergistic and integrated use of different diagnostic pathways is essential in modern healthcare. For many years now, we have organised multidisciplinary sessions at ECR; this year there will be a session on breast cancer (with a radiologist, a pathologist, a surgeon and an oncologist from the same hospital), a session on liver transplantation in HCC patients (with a radiologist, a gastroenterologist, and a surgeon from the same hospital); a session on developmental dysplasia of the hip (with a radiologist, a paediatrician and a paediatric orthopaedist) and a session on epilepsy (with a neuroradiologist, a neurologist and a neurosurgeon).

Which are the 'ESR meets' countries at the 2020 congress sand why did you select them?

One of the big privileges of being the ESR president is that you can choose your 'Meets' Countries. For the first time, Canada will be part of the 'Meets' programme. The country has a very strong and well-organised national radiology society and many excellent radiologists. I know that the programme that the Canadian Association of Radiologists will provide, very diverse with lectures on AI, gender roles, stroke and traumatic bowel injuries, will be very interesting for ECR participants, and we are very happy to host them at ECR.

In addition to this, after twelve years, Israel will once again feature as an 'ESR meets' country. Israel has been somewhat underrepresented so far at the ECR; it is a land of scientific innovations, sometimes referred to as the start-up nation, and many things that we use in everyday radiological and medical practice were invented in Israel. It has a very active and well-organised radiology association who have created a very attractive programme. Both Canadian and Israeli presentations will deal with innovations, technology, and artificial intelligence.

My home country, Croatia, was already an ESR meets country in 2009. To add further perspectives on radiology, I have decided to include other neighbouring Slavic countries, including Slovakia and Slovenia, neither of which have ever been 'Meets' countries at ECR. There are many similarities in the healthcare systems of these three nations, so I am certain that the debate will be very interesting and insightful.

With breast care one of your speciality areas, what diagnostic developments are interesting you most?

The diagnostic developments that attract my attention relate to breast cancer as I believe that we will witness a change in the strategy for breast cancer screening in the future. One big change will come in the form of abbreviated MRI protocols. Regular MRI offers greater sensitivity in comparison to mammography when it comes to breast cancer screenings. However, this imaging modality is currently deployed only in high-risk cases. The issue is, that currently around 20% of breast cancers goes undetected by mammography screening, especially in cases of high breast density.

On a more positive note, abbreviated MRI protocols can radically change the current paradigm as they enable us to perform an examination within 5-10 minutes. The benefits of

Cross-collaboration is an important aspect of modern clinical practice and it's a factor that no radiologist can overlook

this are clear; reduced costs and greater accessibility for all patients. Currently, MRI is showing very promising results in this area and abbreviated MRI protocols will make the whole procedure more cost effective and accessible.

I am personally also very interested in breast ultrasound, and in my department, we run a project called "Sonoelastography and MRI in diagnosis and treatment of breast cancer." Funded by the Croatian Science Foundation, we are investigating the use of sonoelastography in multiple areas.

ECR 2020 features topics like lung cancer screening, AI, interventional radiology, stroke diagnosis and treatment amongst others. What will be new this year and what do you hope the main take-aways will be for delegates in each of these areas?

In true ECR fashion, our scientific programme offers an excellent array of sessions that cover all fields of radiology and in this sense, they are suitable for beginners as well as very advanced professionals. It is true that lung cancer screening, AI, interventional radiology and stroke diagnosis and treatment are currently hot topics which will all receive substantial coverage during the congress.

On top of this, I would like to highlight other developments, such as the return of the 'In Focus' programme, which, this year is all about children and their healthcare needs. Additionally, for the third year in a row, the Cube will present Interventional Radiology in a novel and very exciting way, never seen before at any other meeting.

As every year, the Grand Opening will be a magnificent entrée to the congress, and in 2020 it will have a beautiful equivalent at the end, called 'Grand Finale', on Sunday. This Grand Finale will feature a colourful fusion of inspirational talks, musical performances and visual spectacles with plenty of surprises along the way. The highlights of the session will come from three extraordinary young speakers sharing their thought-provoking personal stories.

Last but definitely not least, I am very proud to announce that we will welcome three extraordinary plenary speakers at ECR, namely Ralph Weissleder, James Thrall Professor of Radiology and Professor of Systems Biology at Harvard Medical School (HMS), Bernd Montag, CEO of Siemens Healthineers and Nenad Šestan who is the Professor of Neuroscience, Genetics, Psychiatry and Comparative Medicine at Yale University, and Executive Director of the Yale Genome Editing Center.

I would like all delegates to feel inspired after ECR 2020, particularly after hearing the stories of the three amazing young speakers and their truly inspiring experiences, going the extra mile to achieve their goals and visions. With the 'In Focus' programme I would like to get participants to think about and discuss important issues related to children and their wellbeing in the context of healthcare provision under challenging circumstances. Above all, I would like all delegates to fully immerse themselves in this year's scientific programme and for ECR 2020 to be remembered as a truly unforgettable experience. ■

Author: **Prof Boris Brkljačić**

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The Convergence of Technology and Health

John Nosta is the founder of NostaLab, a digital health think tank. Ranked as the #1 global influencer in digital health, he is regarded as one of the top global strategic and creative thinkers in this important and expanding area. He is also one of the most popular speakers around the globe presenting his vibrant and insightful perspective on the future of health innovation. His focus is on guiding companies, NGOs, and governments through the dynamics of exponential change in the health/tech marketplaces. HealthManagement.org spoke to him about the future of digital health and how he thinks the convergence of technology and health will play out.

We keep hearing that the future of healthcare is digital. The term digital health is being tossed right, left, and centre. What does it really mean? What does digital health really entail?

Simply put, digital health is the application of technology to health and wellness. Now, if we unpack this a bit, we see this have rather broad implications—from technology itself to consumer empowerment. But the first work of this construct is digital. And that's the domain of science, medicine, and technology. It's been my contention that digital health isn't a social science, but a technological initiative that supports and even transforms some of the aspects of health and wellness.

You've been called many things - an innovator, a top disruptor, a creative thinker, an influencer, a digital health evangelist. What drove you to become all these things? What made you work towards this convergence of technology and health?

I've always enjoyed thinking. Thought experiments were always part of my imagination as both a child and an adult. Perhaps added to that, an intrinsic sense of curiosity makes for a formula of innovation. "What if" is always a key aspect of discovery.

But I don't really see my interests exclusively in the "health tech" area. My curiosity extends to other topics such as art and literature. It's my contention that innovation and creativity borrow from each other. Science, art, mathematics, and many other disciplines can open the door to eclectic thinking that can offer direct solutions or more abstract paths of inquiry. That's part of the magic of digital health. We can have various voices—from patients to engineers—we can look at problems and break free of the "conventional wisdom" of the medical hierarchy.

The World Health Organization has also established a Digital Health Department, which is working towards harnessing the power of digital health technologies. You were named one of WHO's Digital Health Roster of Experts. What does this Department hope to achieve? What will be your part in this?

The WHO has recently made a commitment to drive the role of digital health with a singular focus on improving health. The intent is to drive innovation around the world by fostering a commitment of countries and partners to a unified strategy. Also, the WHO's vision is to catalyse these actions in a collaborative manner that is both monitored and measured to optimise initiatives and outcomes. Perhaps one of the most important points of focus for the WHO is to provide a diverse, yet unified perspective to help digital health evolve in key areas that are focused on improving health. This initial plan, rolling out now, is a 5-year initiative.

You are the founder of NostaLab. What do you envision for this company?

NostaLab is a think tank that focuses on the convergence of technology and medicine. But there's a keen difference in what we do. The mission of the lab is to "drive the diffusion of innovation into the complex healthcare marketplace." For many, the notion of "build it, and they will come" is simply false. The power of an idea is also the ability for it to be assimilated into clinical or social practice. Awareness, engagement and finally, building a habit (for both clinician and consumer) is difficult and encumbered by a host of issues ranging from cost to treatment guidelines. NostaLab helps companies and organisations focus their thinking to optimise market position, brand expression and personality, as well as strategy and tactics. Our unique history and focus add a digital health perspective that many companies just can't match.

You say that the digital health system will be run by citizen scientists and empowered patients. What do you exactly mean by that?

I believe that's part of the emerging equation for healthcare. I don't think that citizens and patients will directly drive all care, but we will see the emergence of a broader collaborative engagement where patients and clinicians will work together to optimise care. This is a fundamental change difference from just a few short years ago. Traditionally, the physician was the gatekeeper. Control was vested to the MD. We now see multiple stakeholders in the care path. These include various healthcare professionals, such as the nurse and various technicians, to patients and caregivers. Putting the complexities of reimbursement aside, we now see a "collaboratory of care" where medicine can be personalised and optimised.

When electronic health record (EHR) was developed and introduced, it was believed to be a time-saving tool for clinicians, and a better way to manage patient records. However, it did not work out that way. Why do you think that is? What could make this concept better?

The path of the EHR and the adoption of many other tech innovations are complicated. On the one hand, we have the habits of clinicians—focused on patient care. On the other, we have the workflow dynamic—focused on optimising time and effort (usually around billing and profit). These are typically antithetical.

But beyond this human/tech conflict is the evolution of technology itself. Connectivity, storage, processing speeds, cybersecurity, and a host of other key considerations were also being developed at the same time as the EHR "intruded" into the clinical space. The resulting battle for care, content, and control resulted in the current problems. Simply put, technology wasn't ready for the doctor, and the doctor wasn't ready for this technology.

It's a bit like the early days of the internet, cell phone, and even Apple's Newton. The technological infrastructure and device hardware were too primitive and required a "human effort" that exceed the practical benefit. I believe that's at the heart of the EHR issues.

Digital health isn't a social science, but a technological initiative that supports and transforms aspects of health and wellness

The solution will be found in the amazing advances we see in technology. The role of AI, voice applications, and the improved user experience will make the EHR more "clinically appropriate" for today's clinician and add such significant value that it will be seen less as an obstacle and more of an imperative. Interestingly, the EHR today is often cited as a driver of diminished patient engagement. Tomorrow's EHR (combined with advanced analytics) will carry some of the cognitive burden of medicine and allow newfound clinician freedom that will drive a superior human experience.

While we keep saying technology will change the face of healthcare, we also see fears within the healthcare community - fears of being replaced, fears of increased workload - an overall fear of change. Do you think this will be a hurdle to the actual realisation of digital health?

Fear is a natural human emotion - fight or flight. It follows innovation like a shadow that never leaves. But let's take a step back and consider mankind's first innovation: fire. Consider the dawn of man as a group of early humans sitting in front of a nurturing fire. It's this very relationship with "technology" that drove humanity's transformation. It wasn't an option; it was a necessity that facilitated everything from travel, safety and cooking. In fact, the simple task of cooking food added the component of enhanced digestion and protein consumption that played a central role in physical strength and brain development.

Today's technology is humanity's fire, empowering a fundamental transformation that will directly impact human evolution. But just as fire is an essential tool of our society, it also represents one of the biggest dangers to life and property. Fire, in the context of its importance, is also one of our biggest fears. Perhaps we can even consider the fundamental value of cars in our society and how we "accept" the tens of thousands of lives lost each year in the USA alone. We've just accommodated and managed those fears - perhaps even rationalised them away. For me, I believe that the power of technology - particularly AI - will always carry with it an intrinsic risk. I guess it comes down to the idea of risk and reward. The potential of technology is vast and dwarfs almost any of mankind's inventions. The risks will always come along. And we have to understand and manage that.

Tomorrow's EHR will carry some of the cognitive burden of medicine and allow newfound clinician freedom that will drive a superior human experience

While we all agree that the future of healthcare is digital, in your opinion, what do healthcare leaders and specialists need to do to successfully embrace the paradigm of digitalisation?

Many of us have learned in biology class the notion of structure and function. In some ways, medicine itself is defined by both structure and function. The hegemony of our hierarchical medical system drives behaviour that creates the system. The chief of medicine, the senior attending, the fellow, the intern, and the medical student all have a place in this structure—this human structure. The question is how to move beyond this paradigm and drive adoption of technology that augments and may even replace the human players in this drama.

Automation, robotics, and cognitive tasks are transforming the workplace as we speak. These changes are also happening in medicine. Beyond the simple adoption of a new amplified stethoscope or advanced imaging technology, the question is more fundamental: How can clinicians establish a new perspective and relationship with technology where it becomes almost a partnership? AI offers the ability for clinicians to assimilate and process information that, in certain instances, the human brain cannot. There's just too much data coming out of the clinical fire hose.

The paradigm of digitalisation is forged out of necessity. Technological adoption is emerging as an imperative that will transform medicine and clinical practice. But as we know, adoption varies with individual and circumstance. To borrow that fearful phrase from the exam room, "this won't hurt a bit." ■

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Advancing the Understanding and Treatment of Type 2 Diabetes

Prof. Daniel Drucker is a clinician-scientist who develops treatments for diabetes, obesity, and intestinal disorders. A pioneer in diabetes treatment, Prof. Drucker's work has provided important insights leading to the development of new drugs for the treatment of Type 2 diabetes. Currently, his laboratory at Lunenfeld-Tanenbaum focuses on understanding the molecular biology and physiology of glucagon-like peptides.

Prof. Drucker has received several awards in recognition for his research including the 2009 Clinical Investigator Award from The Endocrine Society, the 2011 Oon International Award for Preventive Medicine - Cambridge University School of Medicine, the 2014 Banting Medal for Scientific Achievement from the American Diabetes Association, and the 2014 Manpei Suzuki International Prize for Diabetes Research. This year, he has been honoured by the Endocrine Society with the 2020 Baxter Prize. HealthManagement.org spoke to Prof. Drucker about his efforts to understand and treat diabetes and his future research goals.

You have played an active role in discovering and developing new drugs for patients with Type 2 diabetes. Can you tell us a bit about these drugs and the research behind it?

We have studied gut hormones, including GLP-1, for over 35 years. It turns out that GLP-1, or agents that stabilise GLP-1 such as DPP-4 inhibitors, control blood glucose without weight gain, and with a reduced risk of hypoglycaemia. The newer GLP-1R agonists also produce weight loss and reduce the risk of cardiovascular complications. These are very desirable properties for a class of diabetes medications.

Your primary research area is metabolism and nutrition. Specifically, you have had a significant interest in diabetes. What was the reason for your interest in this particular area - why diabetes?

I love all of endocrinology. Diabetes became a focus after I started studying gut hormones, principally GLP-1, and recognised its actions were relevant to diabetes.

Obesity is a major healthcare epidemic. What are your thoughts about this, and how do you think this health issue can be addressed/treated?

We don't fully understand the pathophysiology of human obesity. We need public health programmes directed towards education, including nutrition, exercise, mental health, coupled to elimination of poverty, food insecurity, and related social issues. Obesity is a complex problem not well suited to one-size-fits-all solutions

There are often people who are not overweight but still have type 2 diabetes. What do you think? Is there a relationship between weight/obesity and type 2 diabetes?

Type 2 diabetes clearly has strong underlying genetic components, modified by our environment, activity, diet, and body weight. Some individuals are more susceptible to developing diabetes with weight gain, relative to others.

You are currently involved in the development of new drug classes for obesity. How close are you to achieving this goal?

A GLP-1 Receptor agonist, Liraglutide, has been approved in many countries for the treatment of obesity. Many investigators and companies are studying ways to develop newer more powerful GLP-1-based drugs for the therapy of obesity.

Cardiovascular disease continues to be a leading cause of death worldwide. What strategies does the healthcare community need to implement to address this?

We have made tremendous progress with the reduction of smoking and better control of blood pressure and levels of cholesterol. We need ongoing strategies to tackle the known risk factors to sustain improvements in cardiovascular health. The pharmaceutical industry continues to develop new medications that are also useful for reducing cardiovascular risk in selected appropriate populations.

What are your future goals in diabetes, obesity, and intestinal failure research?

I am fascinated by the underlying mechanisms of action of gut hormone therapies, which remain incompletely understood. Advancing this basic science knowledge may lead to more effective next-generation therapies, based on peptide hormone action, for these and related disorders.

Our cover story for this issue is "The Future is Digital." Do you think digitalisation in healthcare can help improve the prevention, diagnosis, and treatment of cardiovascular disease?

There is great potential in "Digital." Implementation of effective new technologies and therapies, and subsequent demonstration of benefit, is sometimes more challenging than we first realised.

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Where Informatics Meets Medicine

Summary: Medical Informatics Europe (MIE) promises a rich programme covering latest developments in the field from both leading lights and emerging talent. HealthMangement.org speaks to Local Organising Committee Co-chair, Christian Lovis about what to expect.

How have medicine and information technologies changed in the last ten years and how do you see them advancing in the years ahead?

Both medicine and information technologies have had incredible evolution over the last ten years. But, I think that the most impressive evolution is the convergence of these two sciences. Today, it is impressive to see how medicine and information technologies are moving together and helping and benefitting one another. I don't think that medicine is the only winner. At the end of the day, medicine is a huge driver for people, for research and for funding.

How is MIE supporting management and leadership in medical informatics?

MIE is covering the entire field of information technologies and medicine. It provides a very broad vision and understanding of the field. It is not a commercial or hype-driven conference. For more then 30 years, it has driven innovation and brought together experts from around Europe and beyond, about everything that is at the intersection of medicine and digital. It is a unique environment for an immersion in what is happening right now and where the future is moving.

The area of informatics plays a key role in precision medicine. What is the future of this targeted approach to medicine?

I think that many clinicians, physicians and nurses feel unconsidered when researchers who have never left their labs speak about "personalised medicine" rather than "precision medicine." The marriage between the power of digitalisation and medicine is a major revolution in the medical world. It has already brought us major achievements, in diagnostics as well as in therapeutics. If this will be for the benefit of all or only of a few is a matter of societal will.

In my view, it is the responsibility of all of us to make it progress for all.

There will be a focus on standards at the congress. What's the situation with standardisation? Do you think it's possible to have global standards of operation?

I would not say that standardisation is a focus point; I would say that interoperability is a focus point. We are facing global challenges. These global challenges require us to work together, in collaboration rather than in competition. There are many ways to improve interoperability. Standardisation is just one instrument amongst others. It is not enough by itself and sometimes it can be counterproductive. What is necessary is that we work together; it is not necessary that we all speak the same language. But, we have to be able to communicate and share understanding.

What will be new this year at MIE and what do you hope the main take-aways will be for delegates?

Personalised health is at the centre of this conference. Also in the spotlight will be prevention, new tools and translational research, as is shown with the presence of the CERN at the event. CERN will show how fundamental physics can have direct impact on medicine. There will be many sessions on data and knowledge sources, how to build better sources for machine learning and how to share our resources. I am especially excited to hear the keynote of Patti Brennan, the director of the US National Library of Medicine. We also have a lot of young and passionate scientists that have already registered and submitted their work. This is what is the best part of the conference in my opinion: to feel the pulse of the young scientists. They hold the key to our future! ■

BREAKTHROUGH GENOMICS

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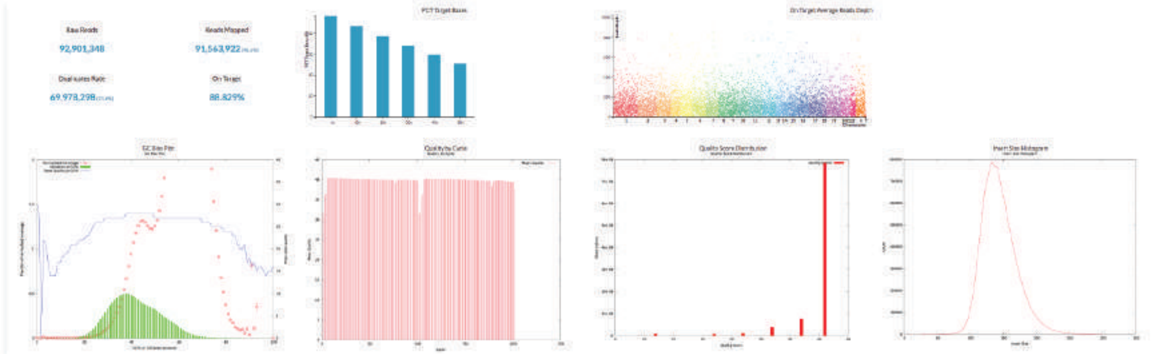

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Bright Ideas

HealthManagement.org rounds up exciting developments that have all the marks of healthcare game changers. What do you think?

Advancements in Cardiac Imaging

Conventional imaging still remains important for the assessment of cardiac structure and function. However, advanced echocardiography with strain imaging techniques, tissue characterisation with cardiovascular magnetic resonance (CMR), and the assessment of biological processes with nuclear imaging techniques have helped clinicians implement early intervention strategies to either prevent or halt the progression of cardiovascular disease.

Echocardiography is also the imaging technique of choice to assess valvular heart disease. Also, the use of transthoracic focused cardiac ultrasound (FoCUS) has gained popularity in emergency departments and intensive care units. In addition, elevated carotid artery wave intensity, as measured on Duplex Doppler ultrasound, was found to be independently associated with faster cognitive decline in the Whitehall II study. These findings highlight the relevance and importance of ultrasound imaging outside the heart.

In recent years, cardiovascular magnetic resonance has made a significant contribution to the diagnosis and management of cardiomyopathies. Similarly, computed tomography has also now evolved into a one-stop-shop imaging tool providing valuable diagnostic and prognostic information in patients with suspected or known coronary artery disease. Coronary artery calcium (CAC) score on CT was also increasingly used to guide statin therapy.

There is no doubt that invasive and non-invasive cardiovascular imaging is developing at a rapid pace. Today, clinicians have access to different imaging modalities, which are now even more effective with fusion imaging as well as the introduction of AI and machine learning. In particular, machine learning has been rapidly adopted and allows automated analysis of electrocardiograms, echocardiography, nuclear perfusion imaging, and CCTA.

Finally, deep learning has also been applied quite effectively to analyse echocardiographic data, including view identification, image segmentation, quantification of structure and function, and disease detection.

PET/MRI Pinpoint Notable Breast Cancer Biomarkers

Researchers have pinpointed breast cancer biomarkers that have the potential to indicate malignancy presence and risk.

A research team from Memorial Sloan Kettering Cancer Center in New York compared healthy contralateral breast tissue of patients with malignant breast tumours and benign breast tumors. They found that PET/MRI imaging could assess multiple biomarker differences that could impact risk-adapted screening and risk-reduction strategies in clinical practice.

Early detection of malignancy is critical in breast cancer for best prognosis and survival. Screening has been successful in decreasing breast cancer patient mortality but is limited for women with dense breast tissue.

The study included 141 patients with imaging abnormalities on mammography or sonography on a tumour. The patients underwent combined PET/MRI of the breast with dynamic contrast-enhanced MRI, diffusion-weighted imaging (DWI) and the radiotracer 18F-FDG.

Several imaging biomarkers were recorded in the tumour-free breast in all patients with differences analysed by two independent readers.

The readers assessed 100 malignant and 41 benign lesions. In the contralateral breast tissue, background parenchymal enhancement and breast parenchymal uptake were decreased and showed significant differences between patients with benign and malignant lesions. The difference in fibroglandular tissue came close but did not reach significance, and the mean apparent diffusion coefficient did not differ between the groups.

As hybrid PET/MRI scanners are increasingly being used in clinical practice, they can simultaneously assess and monitor multiple imaging biomarkers - including breast parenchymal uptake - which could consequently contribute to risk-adapted screening and guide risk-reduction strategies.

Image Quality Means Confidence

Our radiology center has been working with the Planmed Clarity™ 3D digital mammography tomosynthesis unit for the past three years. The center provides full imaging portfolio including MRI, CT, mammography, ultrasound, X-rays, and bone densitometry. Everyone at our center loves working with Planmed Clarity™ 3D system for several reasons.

The intuitive Planmed Clarity™ Flow touchscreen user interface eases the workflow tremendously. Secondly, the MaxView™ breast positioning system has not only helped us to visualize a larger area of the breast and the pectoral muscle, but also contributed to easier, better and reproducible positioning. This is very important – necessary even – when you want to compare the new and the former 3D mammograms of a patient. Furthermore, the Planmed Clarity™ 3D system has significantly increased our image quality and thus our diagnostic accuracy. It has offered us better lesion visibility and conspicuousness, which is essential in a high-quality mammography system.

Naturally, high-quality images with which we can make an uncompromised diagnosis of each case are always our priority. The Continuous Sync-and-Shoot™ method of the Planmed system produces unbelievably clear tomosynthesis images. You even have a great visibility of microcalcifications which helps us to extract all the information we need. The images are not blurry at all and I personally love the image that the Planmed Clarity™ 3D system produces. The images look like real 2D images cut in thin slices and not like computer-produced artificial looking images.

I turned to 3D after having worked with 2D mammography and breast MRI for 10 years. I frequently had to check a woman with a suspicious lesion on both modalities, and sometimes the differences between these two were significant. Using MRI, you realize what you miss on 2D mammography – especially the tissue overlap. That is why I wanted a better mammography system and turned to 3D. With the Planmed Clarity™ 3D system, I see a lot more. I have better lesion visibility and conspicuousness, which has increased my diagnostic accuracy. That has really assisted me in my work environment. ■

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MRI and Radiomics Predict 10-Year Breast Cancer Recurrence

Breast cancer is complex for clinicians to diagnose owing to how greatly cells within one tumour can vary. This complexity and challenge is highlighted by the fact that a biopsy only targets a sample of cells.

A study from Penn Medicine has addressed this. Using MRI and radiomics, clinicians can find it easier to understand a person's individual breast cancer through better clarity on the heterogeneity of cancer cells within a tumour.

As part of the study, the research team wanted to see how a combination of imaging and radiomics could be deployed for personalised tumour characterisation.

With MRI, the team extracted 60 radiomic features (biomarkers) from 95 women with primary invasive breast cancer. Ten years later, the researchers followed up. They found that scans could accurately predict cancer recurrence when high tumour heterogeneity had been detected at the time of diagnosis.

They found that women who had more heterogeneous tumours tended to have a greater risk of tumour recurrence.

Clinical trial scans from 2002-2006 were retrospectively analysed and, for each patient, a "signal enhancement ratio" (SER) map was generated. From this map, researchers extracted a range of imaging features to understand their link with conventional biomarkers (gene mutations or hormone receptor status) and patient outcomes.

The algorithm could successfully predict recurrence-free survival after 10 years.

The team said the findings were interesting because, while imaging would not necessarily replace the need for biopsies, radiologic methods could provide a more individual profile for personalised care.

New Way of Fighting AMR

Discovery of a new group of antibiotics promises to facilitate the fight against antimicrobial resistance.

These antibiotics, corbomycin and complestatin, come from the glycopeptides family produced by soil bacteria. Unlike other antibiotics, such as penicillin, which prevent building of the bacteria cell wall, these have a unique approach to killing bacteria by blocking the function of the wall critical for cell to divide. The new antibiotics are also able to block infections caused by the drug resistant Staphylococcus aureus, as was demonstrated in mice.

The researchers, led by Beth Culp, a PhD candidate in biochemistry and biomedical sciences at McMaster, studied the genes of those members of the glycopeptides, which lacked known resistance mechanisms. Assuming that these might demonstrate a different way to attack bacteria, the group used cell imaging techniques in collaboration with the Université de Montréal to confirm that these new antibiotics acted on the bacterial wall.

According to Culp, this approach can be applied to other antibiotics, which may lead to discoveries of those with different mechanisms of action.

3D Printed Burn Care

A novel approach to treating large burn wounds by using a new handheld 3D printer is being developed by a team of researchers at University of Toronto Engineering and Sunnybrook Hospital.

As reported in the journal Biofabrication, the device can deposit sheets of skin to cover the wounds, while also facilitating the healing process. The printer covers wounds with a uniform sheet of biomaterial composed of mesenchymal stroma cells (MSCs), which promotes skin regeneration and reduces scarring.

Currently, autologous skin grafting is used to care for burns, ie transplantation of healthy skin onto the wound. But with large, full-body burns this can be problematic as there may not be sufficient healthy skin available.

The team presented the first prototype of the skin printer in 2018, which since then has gone through 10 redesigns. Back then the device could form tissue *in situ*, depositing and setting in place in two minutes or less, but now the researchers added evidence of its wound-healing capabilities. In the current prototype a single-use microfluidic printhead ensures sterilisation, and a soft wheel that follows the track of the printhead provides better control for wider wounds. In the future, the researchers aim to also reduce the amount of scarring. They hope to see the handheld skin printer in a clinical setting within the next five years.

Automation of Blood Sampling

A new automated blood drawing and testing device, created by a team at Rutgers University – New Brunswick, performed as well or better than people at blood sampling, the first human clinical trial showed. The results were published in the journal Technology.

In the trial with 31 participants whose blood was drawn, the robot's results were comparable to or exceeded clinical standards, with an overall success rate of 87%. This was even higher for the 25 people whose veins were easy to access: 97%.

The ultrasound image-guided robot is a fully integrated device, with a module that handles samples and a centrifuge-based blood analyser. It could potentially be used at bedsides and in ambulances, emergency rooms, etc.

Venipuncture is the world's most common clinical procedure, but previous studies showed that in 27% of patients without visible veins, 40% of patients without palpable veins and 60% of emaciated patients, clinicians fail to perform it properly. This may lead to a number of negative outcomes and increase overall risk to patient safety.

According to the researchers, procedures such as IV catheterisation, central venous access or dialysis are the prospective areas of the device application. Further adjustments of the robot will focus on improving success rates in patients whose veins are difficult to access.

Heart Failure – Noninvasive Hemodynamic Monitoring on the Rise

Heart Failure (HF) is a major and public health problem as it affects at least 26 million people worldwide and will dramatically increase with an ageing population. Currently 5.7 million people suffer from HF in the US with an expected 46% increase in prevalence by 2030.[1] This is an alarming number especially when accounting for increasing health care cost. In the US around $31 billion, (10% of the total healthcare expenditure for cardiovascular diseases) is related to HF treatment and therapy and is expected to increase 127% by 2030.[1]

The risk factors for Heart Failure are multifactorial and complex[1] and therefore a significant prognosis is essential for an efficient treatment or medication.

Hypertension is reported to be the most prevalent HF risk in the developed world and the ESC guidelines recommend monitoring of continuous blood pressure and heart rate as standard for this patient group.[2,3] Further, decreased cardiac output has been documented as a central problem in HF patients, followed by an increased preload and lower systolic blood pressure.[4]

Standard assessment of heart failure patients is invasive in most cases and the measurement of right ventricular, right atrial, and pulmonary artery pressures and cardiac output determination remains an invasive gold standard in hemodynamic assessment of severe systolic HF during right heart catheterization.[5]

Since technological advances have enabled reliable noninvasive and continuous hemodynamic monitoring devices to become available on the market, the assessment of HF risk factors to support an efficient prognosis has become much easier and less risky.

A study by Fernandes Serôdio et al. with the noninvasive Task Force® Monitor investigated the role of baroreceptor sensitivity (BRS) in HF patients and concluded that baroreflex function is also an independent marker for heart failure prognosis. HF patients show depressed arterial baroreflex function, which correlates closely with other clinical HF parameters.[6]

Related to the medication of the patients, they reported significant evidence that noninvasive methods provide similar results to those obtained through the phenylephrine technique and might even avoid the use of vasoactive drugs.[6]

There are also composite parameters, which are based on noninvasive readings and which "may provide equally accurate prognosis as the invasive examination"[5], as reported by Gilewski et al.

Nygaard et al. confirm "that a set of non-invasively determined parameters provides similar accuracy of prognosis as in the case of invasive parameters".[7]

The assessment of noninvasive hemodynamic parameters in critically ill heart failure, stroke and sepsis patients in the Emergency Department might even help to distinguish one disease state from another.[8]

Another study by Wagner et al. shows that apart from being a helpful tool for diagnostics, noninvasive and continuous BP and CO monitoring is also a benefit for HF patients in the challenging perioperative field.[9]

Noninvasive hemodynamic assessment contributes to decreased cost as well as risk by providing enhanced diagnosis, and enables the development of early and individualized treatment strategies for HF patients in order to avoid heart transplants as the very last consequence.

"If given optimal therapy guided by HD monitoring it might be possible to drive down hospital length of stay and 30-day readmission rates (25%) in this patient population."[8] ■

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Artificial Intelligence-Assisted Care in Medicine: Friend or Foe?

Technical innovation has always been a driver for medical breakthroughs in the field of cardiology. These include the Laennec's stethoscope, the electro- and echocardiogram, percutaneous coronary interventions, transcatheter structural heart interventions, open-heart surgery, ventricular assist, and implantable electronic devices.

However, while we see many examples of such technologies, many have not translated to routine clinical care so far. Artificial Intelligence is one such example. It is important to note that AI is not a specific technology per se and it does not have any artificial features. It is actually machine intelligence (MI) and so far, MI has seen more disappointments than success. The expectations associated with AI/MI seem to over-inflated as far as cardiology is concerned.

There could be multiple reasons for this including a hospital's infrastructure and regulations. Hospitals are still in the process of transitioning to functioning as digitalised units, and data harmonisation is still a challenge for most hospitals. Also, with the introduction of the new EU Medical Device Regulation (MDR) in 2017, which is to become effective in 2020, several software are now considered medical products and have time-consuming and costly requirements for certification.

Machine intelligence is here to stay, but its application still poses a challenge for most hospitals. These can be overcome by using statistical models and by combining knowledge-based approaches with deep learning. MI has the potential to disrupt healthcare systems and clinical care. Computers can process large quantities of data and structured representation of knowledge in just a short time without loss of information. Both digitisation and desire for personalised medicine are likely to establish new clinical domains that will focus on computer-assisted medicine. It's just that both hospital management and clinicians have to keep up with this rapidly developing technology.

German Doctors to Prescribe Health Apps in 'World First'

The German healthcare system is undergoing several digital upgrades in 2020 in order to improve the service.

One of the key features of the plan is that, for the first time, doctors will be able to prescribe healthcare apps to patients.

Expected to pass into law this year, the policy means that health insurance companies will provide health services digitally on tablets, computers and smartphones. An example of such an app would be one specially designed for diabetes monitoring and care.

German Federal Minister of Health, Jens Spahn described the move as a "world first."

There have been some reservations however. The Green Party has criticised the government for implementing new procedures with apps having proven their benefit.

Addressing this, the Federal Institute for Drugs and Medical Devices is set to examine app quality and safety, after which the developer must prove that the product better scare.

Other digital upgrades to the German healthcare service this year include provision of online doctor consultations, digital prescriptions and digital sick notes.

Promising Technology for Managing Pulmonary Diseases

A new non-invasive technology developed by Monash University (Australia) researchers can be used to diagnose, treat and manage respiratory lung diseases, such as cystic fibrosis, asthma and lung cancer.

Existing technology, eg 3D CT scans, cannot capture the spatial distribution of lung function in a breathing lung, which hampers early diagnosis and monitoring. New four-dimensional X-ray velocity (XV Technology) imaging provides high-definition images at 30 frames per second, allowing to see the movement of air in real-time and assess functional airflow in healthy and diseased lungs in live organisms, as was demonstrated by the research on mice. A comparison of a cystic fibrosis mouse model against a healthy control mouse allowed researchers to pinpoint localised areas of deficiency in a lung.

The study led by Dr Rhiannon Murrie from the Department of Mechanical and Aerospace Engineering at Monash University and published in Scientific Reports in January 2020, shows the potential application of this technology in respiratory disease detection, monitoring and treatment through non-invasive and non-terminal means. Another promising direction is assessment of how effective early interventions may be for respiratory illnesses.

The technology, commercialised by an Australian med-tech company 4Dx Limited, is being tested in human clinical trials in the USA, with Phase I already completed successfully.

ACC, HeartHero to Advance Out-of-Hospital Cardiac Arrest Treatment

The American College of Cardiology (ACC) has partnered up with HeartHero to form an alliance to combat sudden cardiac death (SCD) and improve survival rates. For many years, the ACC has been on a mission to improve cardiac care. Now it aims to improve survival with the help of HeartHero's portable defibrillator.

SCD is a leading cause of mortality in the USA, claiming about 360,000 lives every year. A large majority of these patients die before they reach a healthcare facility. Also, a significant number of sudden cardiac death episodes occur in the home (65%), followed by a public setting (21%) and nursing homes (11%). About 37% of cardiac arrest is witnessed by a bystander and 12% by an EMS provider. Among the patients managed by EMS, about 20% have an initial rhythm (ventricular tachycardia or ventricular fibrillation) that is shockable by an external defibrillator. Today, external defibrillators can be found in most public places including airports, hotels, government buildings, airplanes, cinemas, etc.

HeartHero's AED was the recipient of the Innovative Challenge award in New Orleans. It is small, portable, and user-friendly. The miniature size means that individuals at risk for sudden cardiac death can now store the device in their car, carry it home, and even have it in the office, ensuring instant access. The HeartHero AED has a visual indicator that guides the user through the resuscitation process. It also has auditory and visual aids that guide the user through the resuscitation process.

World Economic Forum Promotes AI Toolkit

While about 29 countries have established national AI policies to address potential risks, very few companies have followed suit.

To address this challenge, the World Economic Forum (WEF) has worked with more than 100 companies in six countries and experts in the field of technology to develop the Empowering AI Toolkit.

The kit has been designed with the structure of a board meeting in mind. It aligns 12 learning modules with traditional board committees and working groups. The objective is to support companies in making informed decisions on AI solutions for protection of customers and shareholders.

WEF said that AI was a tool in a corporate board's toolkit and that boards need to know when to deploy it and how it aligns with a company's overall strategy.

The Empowering AI Toolkit was created by the World Economic Forum with Centre for the Fourth Industrial Revolution Network Fellows from Accenture, BBVA, IBM and Suntory Holdings. Among the many others who contributed to its development were AI4All, Australian Institute of Company Directors, Best Practice AI, Latham & Watkins, Saudi Aramco and Splunk.

Machine Learning and Early Diagnosis of CVD

Despite significant advances in the diagnosis and management of cardiac disease, cardiovascular disease continues to have high morbidity and mortality. In some cases, the diagnosis is delayed, while in others, the diagnosis is mistaken for another disorder. Advanced technology and machine learning have opened up new opportunities to evaluate image-based data.

Currently, image analysis is completely reliant on observer visual assessment and using crude quantitative measures to assess cardiac function and structure. Clinicians agree that there is a need for more advanced analytical techniques that can allow for more refined quantification of imaging phenotypes. That is why machine learning is slowly creeping into mainstream medicine, especially cardiology. Machine learning approaches to image-based analysis/diagnosis rely on models/algorithms that learn from past clinical cases through the identification of complex and hidden imaging patterns.

Preliminary data show the superiority of image-based cardiovascular diagnosis with machine learning for cardiac disorders like heart failure and coronary artery disease. The vastly superior diagnostic performance of artificial intelligence-based image analysis may help lower the burden of certain cardiac disorders by facilitating earlier and more accurate diagnostic decision making.

However, we are still in the early stage of machine learning, and researchers have systematically started to add the different case scenarios for each cardiac disorder with all the possible permutations and combinations. The more data is entered into the system, the more likely it is that the performance of the model will improve. Also, machine learning requires accurate output diagnostic labels and a suitable application to predict the right cardiac diagnosis based on the imaging data. But in any case, it is an effective tool and can help improve early diagnosis of cardiovascular disease.

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Going from a Culture of Blame and Denial to a Culture of Safety

Summary: Many healthcare organisations face difficulties while managing transition from a culture of blame and denial to a culture of safety. To succeed, leaders should identify obstacles, create an environment of trust and set an example with their own actions.

Healthcare holds traditions in high esteem. The white coat and nursing pin ceremonies to symbolise the transition from student to provider continue through the centuries. These are patterns of behaviours that are upheld even in the face of a changing world.

Sadly, one pattern that also continues is a culture of blame and denial (CoBD). Culture is what you say and do on a daily basis. How errors are analysed, discussed and acted upon influences the culture of an organisation.

The power structure leaves the top individual in the role of needing to be perfect in decision-making, execution and communication. We all know that is impossible

Human error factors can cause negative patient outcomes, but they are not isolated as a cause of harm. Processes, policies and system failures have greater influence over patient outcomes than individuals. Leaders who focus solely on the individual human errors reinforce a CoBD, in which employees tend to not want to be singled out or disciplined. This creates a cycle of employee unwillingness to elevate issues or failures that need addressing.

Prerequisites

The prerequisites for a CoBD have been rooted deeply within healthcare for centuries: shifting blame to others, not reporting or identifying errors for fear of retaliation, a lack of accountability due to power structures, etc. Incivility in the workplace and a lack of response to behaviours further reinforce cultural influencers of blame and denial. Errors within healthcare have been seen through the lens of individual actions and the need for disciplinary action to correct behaviours. Leaders who promote a CoBD look for and reinforce individual failures, but do not deal with high-power individuals. Analysis of an error will only consider the surface facts and draw conclusions without deep examination of underlying influencers and contributors. Employees learn to keep their head down, 'just do their job' and not speak up in a CoBD.

In contrast, leaders who are consciously promoting a culture of safety (CoS) understand that organisations are dynamic and complex. Leaders look for failures within systems and processes, not individuals. They utilise tools to analyse both upstream and downstream for the cause and effect of changes. They understand what culture is and that actions are being evaluated to the stated standards of performance and behaviours. All individuals are accountable for improving quality, safety and the culture of the organisation. As outlined in the Patient Safety Movement Foundation's Actionable Patient Safety Solutions (APSS) #1, 'Culture of Safety,' creating such a culture entails fostering a safe and reliable environment of transparency, safety, trust and accountability (PSMF 2018).

Importance of Team Roles

In understanding a CoBD and why it is difficult to move to a CoS, you have to be willing to examine and understand the current culture within an organisation. Typically, organisations have looked at physicians as captains of the ship, giving the orders with everyone rowing even when it is in the wrong direction. The brave ones who speak up are dealt with swiftly. Soon it becomes well understood to not stand out, not speak up and do what you are told. That power structure, however, leaves the top individual in the role of needing to be perfect in decision-making, execution and communication. We all know that is impossible; humans make errors, especially in complex environments.

In contrast, a CoS understands that everyone has a role that is also mutually respected. The physician's role is thus similar to that of a quarterback in a football game. An important role, but one that is dependent upon others. If you analyse successful teams, you see commonalities – clear communication, accountability among team members, role clarity, and agreement on goals and metrics. Team members listen and feel part of a greater whole, not just an individual doing a job. Leaders foster an environment that promotes mutual respect, to keep precision focus on patient safety being the top priority over competing priorities, such as financial and growth goals.

Additionally, a prioritisation of learning is found in a CoS and conversely, mistakes are repeated in a CoBD due to denial. This has a significant impact on patient safety.

This dynamic must also be addressed alongside managerial prioritisation of fostering a CoS. It is not enough to support a culture of learning, which in turn supports a CoS. The individuals must develop trust in themselves as they develop trust in each other. Shifting from a CoBD to a CoS must be staffed by people who are both willing to face errors and competent at reversing lifelong mental patterns that not only tend towards blame and denial but also interpret through a lens of shame. This course correction takes more than simply saying 'it's okay to fail' or 'learn from your mistakes.'

listening to truly understand rather than checking boxes, and making commitments that recall and align with the professed CoS values.

When walking the talk becomes predictable, team members begin to rely on each other in ways that increase transparency and learning. The trust derived from this environment sets the context for respect, and an environment of positive intent evolves. Put another way, when there is trust and respect, there is a presumption of goodwill, which goes a long way in making it easier to speak up when near-misses happen or errors occur.

Training to manage one's own response to error-making and take responsibility is critically missing from medical curricula

Obstacles

Cultural transformation is loaded with complexity, barriers and doubters who do not believe that you can achieve zero harm. Bias creates invisible barriers that influence human behaviours. Bias such as some medical errors cannot be prevented, or the severity of illness influences outcomes more than safety actions. The business of healthcare creates conflicting priorities and confusion within the workforce on what is the top priority today. Layer upon an organisational change, such as a key leader leaving, and it is easy for the organisation to move from true transformation to patient safety as another programme that will fade away with the new leader.

One obstacle we cannot underestimate is the tendency for individuals to be defensive under stress. Currently, preparations for clinical professionals concentrate on medical skills and omit skills to handle high risk/consequence environments. Training to manage one's own response to error-making and to take responsibility is critically missing from medical curricula.

Mindset of Trust

Leaders must have a preoccupation with system and process failures, looking to create safety nets to assure that individuals can perform with safety in mind. This mindset change must be one of the top priorities for leaders. Starting with a baseline survey analysing the level of trust and truth-telling, leaders then develop strategic action steps to advance their culture from blame to safety. When errors occur, leaders must assure that there is transparency in analysis and reporting. They know that developing trust within an organisation is an outcome based on actions seen by employees, taken by leaders.

Building trust as a team is a significant contributor to a CoS. Trust begins with creating opportunities to have clear thinking. This is often challenging in the unpredictable, time-constrained healthcare environment. So, a commitment to designing the system in alignment with human capacity is paramount to forming a successful CoS. Straight thinking lends liberties to straight talk,

Necessary System Changes

The first action to achieve change is an articulation of what the vision for patient safety is and why there is a need to achieve that vision. Telling the stories of where safety failed and the impact to those involved helps to gain understanding of the 'why' behind the needed changes. Utilising methodology to engage employees in developing the vision will accelerate ownership throughout the organisation. Develop communication mapping to assure that all employees feel that they are knowledgeable of the vision and the process of development.

Once the vision for safety is established, analyse the systems and processes that need to be revised to assure that the vision can be transformative and sustained. How are safety issues communicated? Is it a form online that goes into a database, but employees feel it is a black hole? Do employees know how to call out a safety issue to bring immediate attention to it? How are safety issues reviewed and addressed? Do you conduct safety huddles that are effective in escalating issues? Safety huddles

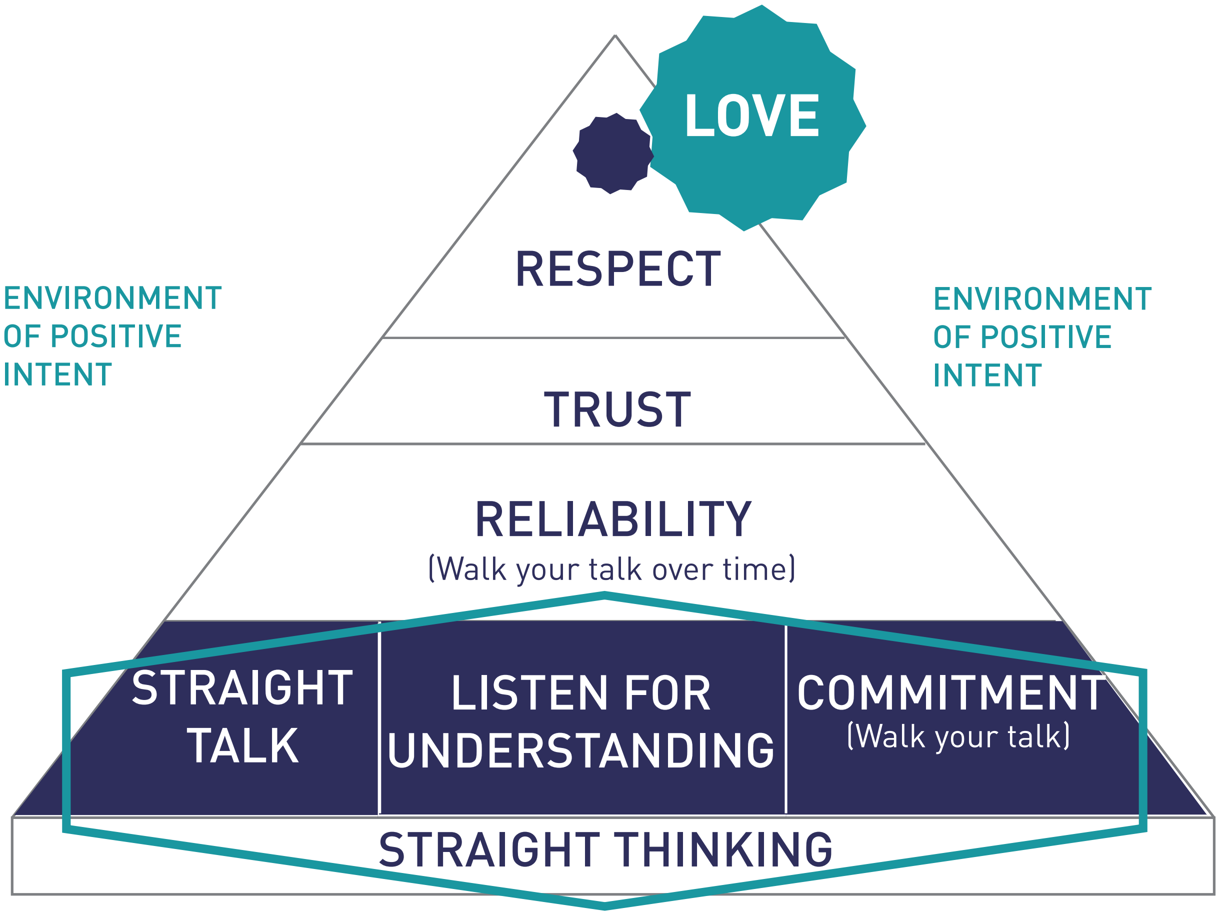

Figure 1. Howard Jackson Trust Model, Modified by Yogiraj Charles Bates.

– brief, routine meetings to share information – can be used as a deflection from change when they become routine. In essence, they become another meeting instead of a powerful tool to advance safety. Listen for truth-telling and willingness to discuss difficult issues in huddles. Look for listening and follow up not from the usual volunteers, but all participants.

Use stories to communicate why safety is important. Storytelling helps employees to identify, feel empathy and understand why changes are needed. Employees become engaged and more willing to give discretionary energy to advance patient safety.

Personal Experience

Vonda Vaden Bates' husband, Yogiraj Charles Bates, died in a Minnesota hospital following brain surgery in 2012. Many people have contacted her to say that hearing his story influences their actions on behalf of patient safety. She believes that one reason people are impacted by their experience is that a CoBD was a factor in his death. This became evident as she approached the hospital with questions about the shocking outcome; an overlooked blood clot, which resulted in a fatal pulmonary embolism. It's estimated that over 45,000 people die from hospital-associated blood clots in the U.S. each year. Reports suggest that as many as 70% of cases of HA-VTE in patients could be prevented (Centers for Disease Control and Prevention 2019).

Like many others, Vonda walked back into the hospital where Yogiraj Charles died assuming that the administration and clinicians would be interested in thoroughly reviewing his care with her 24/7 experience to identify what happened. She presumed that the priority would be to ensure lessons were learned so others would not suffer the same fate. She was horrified to find a CoBD. It began to be apparent that denial and defensiveness contributed to his death by neglecting to educate everyone in the hospital about how to address one of the most common preventable hospital-acquired conditions in the U.S.

Organisational Experience

As one organisation Martie worked with started to understand what a CoS truly meant, small tests were made to see if leadership was sincere about this body of work and change. Tests such as bringing up a small issue to see if there would be a response. The toughest test was dealing with disruptive behaviour of top volume producing physicians and employees with seniority whose behaviours had been normalised. Knowing that negative disruptive behaviour causes harm and hurt to patients, they had addressed what was to be the standard of expected behaviours and dealt with individuals when they did not meet those expectations and values.

One of the top volume producing physicians informed the employees that a culture of safety did not apply to him. The line in the sand was drawn. Employees would trade shifts, pay each other and call in sick to avoid working with him in the operating room. The less senior employees were routinely assigned his room and would leave the cases crying or so upset that they could not think clearly. His rooms had more errors than others, yet it had been tolerated and discounted as individual performance of the staff – not a systemic issue of safety.

His behaviour and others' were dealt with in a fair but clear manner. Expectations of behaviours and why those expectations were being enforced were clearly articulated. He continued in his behaviour feeling that he did not have to comply with the expected performance and behavioural standards. Each time, each instance they had to address it. It was a defining moment for the organisation. Evidently the physician made the decision to take his cases to the competitive hospital. It impacted them financially, but in the long run was the defining moment within the organisation that communicated loudly the commitment to assuring the safest care possible for the patients.

Leadership Behaviour

Leadership behaviour will make or break cultural transformation within an organisation. Employees many times play the game of Clue (a popular murder-mystery board game) when it comes to watching leaders and looking for what is happening next or what is expected of them. That is why it is imperative for a leader to pause and self-reflect on their own values, beliefs and motives. This can be extremely difficult to do as a leader. Reflection opens up the mind's ability to understand the cost to humanity, the degree of moral and ethical distress felt and faced when safety fails. It feels overwhelming, and many times leaders will deal with the significance by making safety a tactical action only.

Safety needs to be both. Tactical actions need to occur to assure the organisation self-examines and pushes to perform at higher standards. Yet, the leader cannot devoid themselves of the deeper calling of patient safety. It is the countless faces of individuals who trust, rely and depend upon their leadership and commitment to being relentless in elevating patient safety throughout their organisation. It is that behaviour that is the most important of a leader. When a leader feels passionate about their work, others will follow living the same passion through their actions. ■

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Key Points

- A culture of blame and denial is a continuing pattern.
- Instead of focusing solely on the individual human errors, leaders look for failures within systems and processes. Safety nets should be created to assure that individuals can perform with safety in mind.
- Obstacles to cultural transformation are many, including complexity, doubters, various biases and the tendency for individuals to be defensive under stress.
- For culture of safety, examining the current culture is needed as well as understanding that everyone has a role that is also mutually respected.
- Building trust is an important element of a culture of safety. It fosters respect and positive intent.
- Articulate the vision for patient safety and the ways to achieve it. Develop communication mapping. Conduct safety huddles that are effective. Storytelling can help staff to identify, feel empathy and understand why changes need to occur.

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COVID-19: What Can Healthcare Learn?

Summary: A new decade is normally a time for optimism and fresh starts but what 2020 ushered in was a new coronavirus. Named by WHO as COVID-19, the virus causes severe acute respiratory problems. It is thought to have emerged at a live animal market in the Chinese city of Wuhan at the end of 2019 with an initial trickle of reports soon turning into a deluge as it spread across borders. At the time of going to print, more than 75,000 cases are known while in excess of 2,000 people, mostly in China, have died from contagion.

COVID-19 has put the matter of response into sharp focus and nowhere has this been more significant than in healthcare. There are as many questions as answers, but at least they're been asked. HealthManagement.org takes a look.

Hype vs. Facts

The WHO has warned the world against 'infodemic' and urged caution when interpreting new information on cases of COVID-19 as the data currently available is insufficient for a proper understanding of how the virus works and acts in humans.

The organisation has a point. The attention COVID-19 is getting from the mass media can be explained by the novelty of the disease, but the numbers do not correlate with the hype. For instance, since the beginning of winter in the U.S. alone, the seasonal flu has taken over 10,000 lives – far more than the new virus – and the global annual toll is usually between 290,000 and 650,000 (Centers for Disease Control and Prevention 2020). During the H1N1 outbreak in 2009–2010, at least 150,000 people died in the first year, with some estimates going as high as 500,000 (Dawood et al. 2012).

In relative numbers, global pandemics usually take lives of 0.01–0.02% of the infected population. For SARS this number was around 10%, for MERS and Ebola – around 40% (Fan et al. 2018). Among people with confirmed COVID-19 infections, 4.7% were classified as critical, 13.8% as severe and 80.9% as mild. The coronavirus's fatality rate is estimated to be in the range of 0.5–4%, ie similar to that of seasonal flu (Yanping 2020). The latter is rarely diagnosed in a laboratory setting, and many people with COVID-19 could have also abstained from visiting a doctor, which means that the official mortality rate might be inflated – as happened, for example, in the beginning of the H1N1 outbreak (Baumgaertner 2020).

On the other hand, only 18% of those with COVID-19 have recovered while 82% are still ill (WHO 2020). Of the 2% who died, most were elderly and already had underlying health issues. In other words, it is not yet clear how the ultimate picture on recovery and mortality rates will look. At this point, COVID-19 seems to have more in common with the regular flu than with Ebola or MERS. “We need to be very careful with throwing around figures, speculating or scaring people,” said Dr Michael Ryan, head of the WHO’s Health Emergencies Programme, on Twitter (twitter.com/GHS).

Since the beginning of winter in the U.S. alone the seasonal flu has taken over 10,000 lives – far more than the new virus

Healthcare Technology Coming to the Fore

If there is anything positive to come out of the emergence of COVID-19, it is how technology has played a prominent role in information, prevention and treatment.

A Toronto-based health-monitoring platform beat both the Chinese authorities and WHO to officially going public in early January on the virus when it notified its customers about the outbreak on December 31.

BlueDot uses AI-driven algorithms to predict the spread of diseases through searching news reports and airline ticketing data (Niiler 2020). Further data and information from international news reports in 65 languages, official announcements and animal and plant disease networks give clients advance notice of danger areas.

Public information was also central in a mapping project at Johns Hopkins Whiting School of Engineering. In response to the public health emergency, the faculty devised an online dashboard for tracking and visualising of daily reported cases (systems.jhu.edu). With data collected from official healthcare sites and sources, the aim of the dashboard was to provide transparent information about the situation as it unfolded. How else could healthcare use such technology for protection of public health?

Additionally, robotics and telemedicine have shone during the virus spread as doctors in facilities around the world have resorted to using robots in isolation units for treatment of COVID-19 cases. In the U.S., at the Providence Regional Medical Centre in Washington, a robot equipped with a stethoscope, assisted doctors with vitals and communication via a screen (Staines 2020). The deployment of the robot reduced staff contact with a male patient, allowing medics to observe him as they moved the robot around the isolation area.

In Israel, the Sheba Medical Centre launched a telemedicine programme in a bid to control virus spread. As well as being able to monitor patients in isolation rooms, it can be used to observe those who are less ill from the comfort of their own homes (Hoffman-Jaffe 2020). While the aim of the former is obviously to reduce disease spread, the latter serves to create an alternative to short-supply isolation rooms.

Panic-Built Hospitals

In Wuhan, reports persist of overcrowded hospitals, lack of medical personnel, poor working conditions and a shortage of test kits, protective gear, etc. In January, China announced (People’s Daily 2020) the construction of two emergency hospitals there. They are located about 40km apart and have a total of 2,600 beds for patients in serious condition. Each was completed in 10 days, with the initial plan being 6 days.

Huoshenshan Hospital opened on February 3, with an area of 25,000 square metres and 1,000 beds. It has been staffed with 1,400 military medics of the Chinese People’s Liberation Army. The other one, the 1,300-bed Leishenshan Hospital, started operations on February 5.

On February 16, Qiboshan Hospital in Zhengzhou, Henan Province, began to admit COVID-19 patients. It has 800 beds and is staffed with over 200 medical workers (Ecns 2020). Two days later, a city in Hubei Province, Huanggang, added another 400-bed makeshift facility, rebuilt from the maternity and childcare hospital, for treating COVID-19 patients. 150 doctors and nurses have been dispatched there (Xinhua 2020a).

With no time for planning or consultations, Chinese officials have used blueprints from the Xiaotangshan Hospital in Beijing (Holland and Lin 2020). This 1,000-bed facility was built in seven days during the SARS epidemic in 2003. The hospital admitted one-seventh of the SARS patients in the country within two months, an unprecedented event in the history of medicine. After the epidemic ended, the hospital was abandoned, but has been renovated and put in use for the current outbreak (Wen 2020).

In all the cases, these are not typical, permanent medical facilities, more of disease management centres to be used for a limited period of time. They were built using prefabricated units – fully-assembled, factory-made rooms. Such modular construction has been applied in emergency scenarios in other parts of the world, to assemble a rapid-response medical facility, and it is widely used in China, eg for high-rise buildings (Quito 2020).

These massive facility additions are still not enough, however. Wuhan has been turning its sports centres, exhibition halls and other venues into makeshift coronavirus hospitals with the overall capacity of 10,000 beds. These shelter facilities are used to provide emergency aid, treatment and clinical examination services for individuals with mild coronavirus symptoms (Xinhua 2020b).

Some point that such rapid actions would have never been possible in a privately-financed healthcare system (Baker 2020). China was capable of expanding its facility base because on a state level it has fewer bureaucratic restrictions for urgent and massive projects like these, and can allocate resources in a centralised way.

If there is anything positive to come out of the emergence of COVID-19, it is how technology has played a prominent role

The Rise of the Remote Healthcare Congress

Scores of healthcare meetings around the globe already offer the opportunity for delegates to attend remotely. All you need is a good Internet connection and a quiet place to watch and you're set.

The reasons for the rise in provision of remote congress attendance range from reducing the global carbon footprint to time restrictions for busy professionals. Surmounting the challenge of travelling in the face of a coronavirus hasn't been a typical reason for attending congresses via tele-commute. However, the threat of spread of COVID-19 and restrictions on travel in some cases have highlighted the advantages of remote congress.

For example, while announcing that it had received no cancellations for its March event in Vienna, the European Society of Radiology (ESR) pointed to the option of attending its congress online as concerns about the spread of the Wuhan Coronavirus grew (myesr.org). For delegates thinking about refraining from travelling because of the virus and for colleagues in China, ESR issued reassurance that the meeting would be available online.

"The ESR is well-prepared and pleased to offer everybody everywhere to be part of the ECR online, regardless of any restrictions," it said. "The ECR is a fully digital online congress and can be attended from anywhere in the world via our platform ECR Live on ESR Connect."

Attending a congress in person or remotely depends on what you want to get out of it. For some, networking face-to face is an essential part of an annual meeting; for others, being able to watch sessions and presentations is sufficient.

Whatever the reason, could COVID-19 force congress delegates to think again and take advantage of the feasible and convenient opportunities presented by virtual congresses?

Drone Surveillance and Tech Detection for Spread Prevention

In healthcare, drones to date have traditionally been used to deliver supplies to remote or inaccessible areas. In the face of the COVID-19, they have been deployed in China to press people into donning protective facemasks as part of multiple measures to control the virus.

Several online videos depict urban scenes where drones shame offenders for failing to wear masks. Authorities in rural China were also using drones to keep an eye on citizens out and about without facemasks (rte.ie).

Drones have also been pressed into action to spray disinfectant against virus spread in key public potential contagion areas like train stations.

Elsewhere, thermal imaging has been deployed in busy hubs such as public transport networks to detect if someone has a higher then normal temperature, indicating they may have the virus. China also launched an app that allows people to check if they have been in close contact with anyone with the virus. The 'close contact detector,' allows the population to track possible contact with infected people through input and cross-referencing of phone data.

While the benefits of such actions are clear (live and remote monitoring of the population to ensure adherence to anti-disease spreading measures, sanitation), critics have commented on the ease with which China has integrated such monitoring tech, saying the methods have a hint of the Orwellian.

While such surveillance and prevention technology could prove its worth again in other healthcare scenarios, the authorities would have to be very cautious that such monitoring did not cross over into intrusion. This is a question for ethics and standards.

What About Healthcare Workers?

Li Wenliang, the Wuhan physician who was among the first ones to issue a warning about the Coronavirus, and who wasn't taken seriously at the time, recently died after being infected with the virus. There are now 1700 confirmed cases of healthcare workers who have been infected; six have died at the time of reporting this piece.

These healthcare workers are the frontline warriors in the battle against COVID-19 coronavirus. While everyone is focused on how to contain the virus - through border closures, quarantines, strict airport screen etc, the issue of safeguarding healthcare workers has taken a backseat, which is unfortunate since these are the people who are there putting their lives on the line treating infected patients.

According to findings published in the Journal of the American Medical Association, 40 of the first 138 patients diagnosed at the Wuhan University Hospital were healthcare workers (Wang and Hu 2020). "Health workers are the glue that holds the health system and the outbreak response together," says WHO's Director-General, Dr. Tedros Adhanom Ghebreyesus. "We need to know more about these figures, including the time period and circumstances in which the health workers became sick." According to Tedros, WHO had already disseminated guidelines for protecting healthcare workers but the primary issue seems to be obtaining protective gear (Boseley 2020).

The seriousness of this problem needs to be understood. If healthcare workers are not protected, they will soon become patients instead of providers. It has already been difficult to manage, contain, and treat the increasing number of infected patients. If healthcare workers themselves are not safe, who will be the patient and who will be the doctor?

Without equipment such as gloves, respirators, disposable suits, etc, how can we expect healthcare workers to survive the virus? Because of the coronavirus, global demand for respirators and masks is now 100 times higher, and prices are 20 times higher (Branswell 2020). In such a scenario, what is the system really doing for the frontline warriors? How are they being protected?

The safety and protection of healthcare workers should be a top priority. Protective gear should be provided to healthcare workers immediately because, in the end, these are the people who will play the most important role in minimising the level of illness and the number of deaths. No matter how many borders you close or how many patients you put in quarantine, if your providers are sick, there is really nothing more that could go wrong. ■

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Get Data on Board: Incorporating Health Information Technology in Care Delivery

Summary: How can healthcare practitioners at all levels contribute for optimal integration and use of data and HIT for best care delivery?

If you were to poll clinicians from every practice across the United States about the state of their electronic health record system (EHR), we would wager $100 that you would find at least one dissatisfied person from every practice. "Cumbersome," "difficult," "time-suck," "aggravating," are all common descriptors that we've heard from clinicians across a variety of settings when talking about notes or orders or even logging in. Yet, in the same breath, we've heard these same clinicians wax poetic about a new integrated tracking system or health exchange that helps them better care for their patients, whether it's notifications of hospital visits or insights from medication adherence technology. The irony, of course, is that the data that fuels these helpful technologies largely stems from (or funnels through) clinician entries into the EHR.

In our work researching exemplary healthcare organisations, we have talked to a lot of people. We've talked to C-suite executives about tough leadership decisions and financial growth opportunities, we've talked to mid-level clinical managers about department performance and accountability, and we've talked to frontline clinicians about their patient panels and challenges. Across all of these groups, across all of these topics, we consistently heard that data and technology formed the backbone for decision-making at all levels within the organisation, from the C-suite to the exam room.

"But, how?" In other words, given the volume of data, extensive analyses, and complexity of healthcare organisations, how did data and technology get so integrated into all of these levels of care delivery? Well, we wondered the same thing. Here are the three main lessons we learned about integrating data, technology, and decisions.

Audience: The Right Data for the Right People

Not everyone was looking at all the data all the time, and in fact, we learned that different subsets of people were looking at different subsets of data; we call these different subsets "data audiences." Across all of the organisations we visited, big or small, we identified four common data audiences, each with their own datasets.

We consistently heard that data and technology formed the backbone for decision-making at all levels within the organisation

The first was the clinician audience, which required data that was useful and actionable for practicing clinicians, such as the percentage of total patient panel vaccinated against the flu, reminders for patients overdue for preventative care screenings, or simply time-to-last hospital visit. This data is useful for care delivery, and valuable in guiding clinical care.

The second audience was the managerial audience, who needed data to support administrative and operational decisions within specific units or departments. This data might include clinician performance metrics, equipment use (such as percentage of patients requiring x-rays or MRIs), or department performance relative to benchmarks and internal goals. This audience wanted data to guide mid-level decision-making and as evidence to create accountability across clinical teams and departments.

In the same vein, the third audience was the C-suite, or executive group. Their data focused on costs and utilisation aggregated at the highest level. This data, too, guided overall organisational trajectories and decisions – to build another ambulatory clinic, to expand services to a new region, to switch electronic health systems. The data for this audience was largely current performance data and informed high-level forecasting specifically curated to speak to the organisation's stated goals.

The final common audience was the data team audience, the folks that made all of the data systems "speak" to each other. We think of this audience as the data tailors, the ones who sew the data sets, who pry open the EHR to extract the data and format it for the needs of each audience. Yet they, too, had their own data needs, if slightly more operational: workflow, resource management, and research protocol adherence.

But it's not just audience; having the right audience sitting in front of the right data was not what drove investment in EHRs, health information technology (HIT) or, ultimately, data-based decisions. There was another piece of the puzzle: purpose.

Purpose: Make Your Point

What was truly striking, especially from a research perspective, about the 130+ interviews we conducted was the frequency with which people were able to articulate the purpose of the data being presented to them. At every level (frontline to C-suite) it was clear that "this graph indicates this and that number means we need to do better at that." Everyone knew what they were looking at, where that data came from, and, more importantly, why they needed to look at it.

At one organisation we visited, the patient population was particularly high-need, high-cost, and high-risk. To manage their population, this organisation's care model depended on regular (weekly) contact with patients to mitigate avoidable emergency room visits and hospitalisations. A key tool for the frontline staff (clinician audience) was a specific data visual (box and whisker plots) that displayed time-since-last-contact for all patients. Every frontline huddle area we visited had a screen with the most recent iteration of this visual for daily review, specifically displayed to help maintain a cadence of regular patient contact.

At another organisation, department heads (managerial audience) had charts for each physician in their department, and tracked each one individually in terms of department and national benchmarks for preventative care measures achieved in their patient panel. While the department head was the only individual with data for the entire department, each physician could access their own scoring and identify actionable steps (and patients) that may benefit from more preventative care.

These data (and – dare we say it – data mechanisms) were integrated into the fabric of the organisations, into their culture. Data use was both encouraged and expected, but not without guidance. The purpose of the data was always made clear. It was as if someone was saying, "Here, take this data, collected just for you, and read it this way. Now what will you do with it?" And the results were, well, exemplary.

Building an Integration Loop

Will electronic health systems remain difficult, cumbersome, aggravating and time-sucking for the foreseeable future? All signs point to yes. However, building a feedback loop may go a long way in achieving more of the amazing stories of data and technology integration, and less of the aggravating sort. Like it or not, clinicians are the source of much of the data that makes all of the fancy wheels whir, the charts fly, and the decisions data-driven. At some point, patients themselves will likely also become data enterers, especially with the rise of companies like Fitbit, Withings, and Apple Health, but not yet, or at least, not reliably yet. So, the task falls on our clinician scientists and their EHRs. But, if we can draw a circle from data entry, to useful data and back again; if we can show the integral nature of EHRs and clinician autonomy in all levels of care delivery; if we can loop data to audience to purpose and in so doing inspire action and understanding -- then we can make strides in integrating data and HIT into care delivery. ■

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Key Points

- Generally, physicians are dissatisfied with the amount of time and focus EHRs consume.
- When healthcare staff are clear about how to interpret data and how to use it, data-driven decisions permeate all levels of care delivery.
- Clear audience and purpose support the integration of data in care delivery.
- Data is increasingly the lifeblood of modern healthcare and its potential will grow as patients begin to contribute more personal data in the future.

Supporting Diagnostic and Therapeutic Decision-Making Along the Patient Pathway

Making the right decisions, patient by patient, day by day is at the core of what every healthcare provider must do. These decisions often have to be made fast, under the pressure of extremely high workload, complex bureaucracy and long working hours.

Quick and easy access to information is critical here, and digitalization can contribute significantly to improving decision-making along the whole patient pathway. With modern and connected healthcare solutions, the complete patient history and previous tests become available anytime to be able to decide on the right next steps.

This kind of data-based clinical decision support is predicted to have substantial impact as we move towards value-based care that focuses on improving outcomes, increasing efficiency and reducing costs. In the U.S., the Centers for Medicare & Medicaid Services (CMS) are increasing their emphasis on the use of clinical decision support (CDS) tools, recognizing their role in reducing care costs and improving care quality.

- Clinicians who have already adopted CDS systems report these tools can help significantly in diagnostic and therapeutic decision-making by: Providing access to relevant patient information and to diagnosis-specific order sets, increasing diagnostic support
- Enabling adherence to evidence-based guidelines, risk stratification, and treatment options
- Stimulating provider-patient discussions about appropriate care

Siemens Healthineers offers a variety of products in its portfolio to support clinical experts in regards to diagnostic and therapeutic decision-making. For instance, the AI-Rad Companion, a family of AI-based reading assistants, supports radiologists in routine tasks. The first application of this tool targeted Computed Tomography examinations, supporting the thoracic examination comprehensively by addressing lung parenchyma and lung nodules, the heart, the aorta, and vertebras[1]. The semi-automation of these reading processes with repetitive tasks and high case volumes helps to ease the daily workflow – so that experts can focus on more critical issues.

Now, the portfolio expands into the field of Magnetic Resonance Imaging with solutions for morphometry analysis and prostate biopsy support[2]. AI-Rad Companion Brain MR can perform a volumetric analysis of the brain and generates a result table where deviations compared to a normative database are marked.

With AI-Rad Companion Prostate MR[3], the outer contour of the gland in an MRI scan can be automatically segmented for the radiologist to subsequently mark suspected areas. When the scan is transferred to the urologist, the annotated MR images may be fused with the ultrasound images for guidance during the biopsy. In 2020 more new extensions of the AI-Rad Companion will be launched to free radiologists from the burden of performing routine activities.

Siemens Healthineers solutions not only help to ease routine activities, but also support decision-making in multidisciplinary teams so they can find the best individual treatment options.

The AI-Pathway Companion[4] uses Artificial Intelligence, including Natural Language Processing, to bring together data on a patient's disease and treatment status and present it via an intuitive graphical user interface. The digital assistant also draws the physicians' attention to the appropriate guideline-based recommendations to provide treatment in accordance with medical evidence.

The first application of the AI-Pathway Companion called prostate cancer is designed for oncology and prostate treatment. Further applications for lung cancer and cardiovascular are currently in development and will follow. The AI-Pathway Companion applications helps to match the data available for the individual patient with the guidelines to identify the possible treatment approach and facilitate the appropriate disease management.

We at Siemens Healthineers know that digitalization can make lives of caregivers and patients easier. However, it is neither efficient nor sufficient to add one isolated solution to the other. Healthcare providers can benefit even more if they use a platform that inherits the global expertise of a reliable partner with healthcare domain know-how based on a large installed base and long-term experience.

The teamplay digital health platform of Siemens Healthineers is bound to act as a scalable backbone giving a kickstart into digitalization, improving operational efficiency and reducing costs by providing the right data at the right time.

Moreover, caregivers become future-ready by getting the chance to apply latest innovations like AI to support decision-making and better care along the entire patient pathway. ■

Learn more about innovative digital health solutions and the possibilities of AI at https://www.siemens-healthineers.com/digital-health-solutions

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1.The AI-Rad Companion Chest CT (MSK) is pending 510(k) clearance, and is not yet commercially available in the United States. Its future availability cannot be ensured

2 AI-Rad Companion Brain MR is pending 510(k) clearance, and is not yet commercially available in the United States. This product does not fulfill all the essential requirements according to the European Medical Device Directive (93/42/EEC) and its national implementations. It is not commercially available in the European Union. Its future availability cannot be ensured.

3.AI-Rad Companion Prostate MR is pending 510(k) clearance, and is not yet commercially available in the United States. This product does not fulfill all the essential requirements according to the European Medical Device Directive (93/42/EEC) and its national implementations. It is not commercially available in the European Union. Its future availability cannot be ensured.

4.The AI-Pathway Companion products are not commercially available in all countries. Their future availability cannot be guaranteed.

Big Data: Application of Folksonomy for Clinical Nephrology Research

Summary: Nephrology researchers show how natural language processing can enable a more efficient and effective use of the vast amount of healthcare big data.

The daily activity in the medical field generates a multitude of data from clinical records and reports, collected from anamnesis and physical examination, laboratory and other tests, diagnosis and treatment. At present in our environment, most patient medical information is collected in the electronic health record.

The analysis of data from the clinical records allows for quality control of medical actions, to obtain observational and prospective data to generate scientific evidence and to select patients with certain characteristics in order to propose their participation in clinical trials.

Classically, obtaining this data requires a great load of work consisting of the manual revision of the reports to obtain data of interest, to set up and feed databases (collection of data from quantitative variables and transforming the information expressed in written language into numerical variables) and its subsequent analysis. This is a time-consuming process, and usually does not allow the real time reanalysis of parameters not considered of interest in the initial project. Any reconsideration involves redoing the entire manual process.

The term big data, increasingly used in our daily lives, implies an amount of data in which the volume, variability and speed of processing required makes it very complex to analyse using manual systems or standard software for handling them (Palanisamy and Thirunavukarasu 2019; Escarvage et al. 2019).

Most systems that perform natural language understanding (NLU) or natural language processing (NLP) require an ontology or master entity to later analyse the documents (El Wazir 2019). In these types of systems, the categories or labels are established by the master entity - top down distribution - so they do not discover anything that is not already considered in the ontology.

Furthermore, it should be taken into consideration that, on many occasions, creating an ontology in the medical field can become a bigger project than the analysis of some tens of thousands of documents (as can be seen with the Snomed project (snomed.org) that has been developing for a long time).

The concept of folksonomy comes from two terms: "folk" and "taxonomy." Taxonomy is the art of labelling documents, and "folk" refers "popular."

Therefore, this term refers to a taxonomy defined by the data contained in the documents, without the previous need to generate an ontology or master entity on terms of interest. Folksonomy allows concept tags to be automatically highlighted in natural language to reveal the internal content. This advanced analytics solution transforms unstructured text documents into structured text documents and discovers information. Folksonomy is a real-time classification system that is automatic, based on the labels and the frequency with which they appear, and is the only viable way to be able to work with huge amounts of documents. The way this system works is known as bottom up and the Bismart Folksonomy solution is the first software that can manage this type of classification (bismart.com).

The application of folksonomy and artificial intelligence techniques such as NLP has made it possible to reduce the time taken to extract information from data

Figure 1. The solution proposed by Bismart is based on a data flow that begins with the incorporation of the PDF documents provided by Hospital del Mar into the knowledge database. OCR processes and the definition of the fields we want to import from each document are applied to these documents. Once the fields are stored in the database and identified, the system starts the folksonomy process, detecting important words or groups of words in the set of documents. Once the Folksonomy tool has extracted the information needed to work, it is presented on a website so that it can be consulted, modified or to run the process again on demand.

The use of NLP algorithms together with folksonomy in the medical field would allow the investment of just as much time in the generation of databases as that required by the usual care activity and the real time analysis of the new data collected. Thus, big data would bring significant benefits to the medical sector (Dong et al. 2017).

In this paper, we report on the first pilot experience in the use of folksonomy together with artificial intelligence in NLP to analyse clinical data from hospital discharge reports of the Nephrology Department of the Hospital del Mar in Barcelona.

Methodology

Data

The research team collected 1,631 hospitalisation discharge reports from the Nephrology Department of the Hospital del Mar between 2016 and 2018. The documents were written in two languages: Catalan and Spanish.

These reports, which were in PDF format, were scanned using Optical Character Recognition systems and the different fields in the documents were separated using algorithms based on pattern detection, while each document was anonymised and saved in the cloud. Then, data normalisation processes and lemmatisation were carried out, algorithms were applied, and folksonomy was executed. The Bismart Folksonomy web portal was installed so that the addition of synonyms and/or implications could be carried out (Figure 1). This process allowed the anonymisation of each medical discharge, and the identification of the relevant information collected in each section of the discharge reports: diagnosis, reason for consultation, personal medical history, usual treatment, complementary tests, evolution and treatment at discharge.

Medical terms and acronyms specific to the specialty appeared in the documents. This added further complexity for data extraction. Since folksonomy does not work with languages but with terms, the problem was solved by using synonyms.

The use of NLP algorithms with folksonomy in the medical field would allow the real time analysis of the new data collected

Chronic Kidney Disease Stages

In nephrology, the classification of the chronic kidney disease (CKD) stage (Astor et al. 2011) is of great importance since it has prognostic and therapeutic implications. The review of the disease stage or renal situation according to the information collected in the “diagnoses” section in the discharge reports only allowed the identification of the CKD stage in some 300 reports. Thanks to the tool's ability to add synonyms, the words "grau," "estadio" and "estadi" were assigned to the word "grado" ("grade"), making it possible to find the CKD stage in 768 reports.

In order to classify the CKD stage of the rest of the reports, algorithms were generated with heuristic rules for their correct identification based on: (a) the presence of the words 'acute kidney failure' and synonyms in the diagnostic section implied the label of acute kidney failure, (b) the presence of the words 'kidney transplant recipient' and synonyms in the reason for consultation section implied the label stage 5 CKD, c) the identification of the words "chronic kidney disease stage X" and synonyms among personal medical history allowed the labeling of reports as CKD stages 1 to 5, d) the use of creatinine in the entry laboratory tests together with age and gender (data collected among anthropometric variables) allowed the estimation of glomerular filtration rate (eGFR) by entering the formula of CKD-EPI (Castro et al. 2009) in the software. Despite this, 79 documents were left unclassified in terms of renal situation, so a manual review and assignment of the renal situation was carried out. Thus, all reports were classified as: acute kidney failure, CKD stages 1- 5 or no renal disease.

Pilot Test Questions

As a pilot test, 3 questions were raised:

- What percentage of admissions to nephrology are diabetic and receive treatment with metformin associated or not with another hypoglycaemic drug? What is the CKD stage of patients admitted and treated with metformin? How many and what is the renal situation of patients treated with metformin and diagnosed with lactic acidosis related with the drug?
- What is the attitude of the nephrologists in the Nephrology Department of Hospital del Mar in relation to the withdrawal or maintenance of inhibitors of the renin-angiotensin system of the patients admitted?
- Emotional health in CKD patients. What is the percentage of admissions to nephrology who receive some hypnotic/sedative/antidepressant treatment even though there is no diagnosis related to this pathology included in the patient's medical history?

Results

Metformin

Metformin remains the most widely used hypoglycaemic drug to treat type 2 diabetes. The benefits of metformin in terms of morbi-mortality even in moderate CKD stages (up to 45ml/min/1.73m2 eGFR) have been clearly demonstrated (Cameron et al. 2017). However, in moderate CKD stages the dose should be adjusted, and its use is contraindicated in advanced CKD, its administration being associated to the presence of lactic acidosis especially in patients with eGFR below 30ml/min/1.73m2 (Alexander et al. 2018).

Diabetic patients were identified based on the presence of this diagnosis in the "diagnoses" section of the discharge reports. Thus, a lower than expected percentage of diabetic patients were identified, so the search was extended with new heuristic rules, assigning the diagnosis of diabetes to those reports in which a hypoglycaemic drug was among the usual treatment. Given the high number of hypoglycaemics available on the market, the inclusion of each one of them individually in the searches generated a greater complexity to the project. Thus, it was decided to join the different hypoglycaemics into groups, and the use of the ATC (anatomical therapeutic chemical classification system (WHO, EMA)) was chosen. This classification categorises drugs into groups and subgroups. This process involves detecting the trade names of drugs and active principles separately and applying graph analysis algorithms to obtain these ATC groups. In discharge reports both trade names and active principles can be found, so the detection of ATC groups is not a trivial exercise. In the case of hypoglycaemics, these correspond to Group A, sub-group A10 of the ATC classification.

Finally, 651 of 1631 reports were identified as having a diagnosis of diabetes (39.91% of reports), 85 of which were treated with metformin (subgroup A10BA of the ATC active ingredient classification).

The classification of these patients in relation to their CKD stage is shown in Table 1.

Renal status (n= 85)	n
Acute kidney failure	17
Stage 1 chronic kidney disease	10
Stage 2 chronic kidney disease	21
Stage 3 chronic kidney disease	31
Stage 4 chronic kidney disease	6
Stage 5 chronic kidney disease	

Table 1. Patient's renal status of medical reports containing metformin on admission.

In addition, five cases of metformin related lactic acidosis (four episodes in the context of acute kidney failure and 1 in a patient with stage 4 CKD) were identified by searching in the diagnostic section the term “lactic” and synonyms.

Renin Angiotensin System Inhibitors

The renal and cardiovascular benefits of angiotensin system inhibitors (RAS inhibitors) in patients with CKD have been widely demonstrated (Hou 2016). However, in situations of acute decompensation of kidney function, they are usually removed. The delay in their reintroduction once the decompensatory episode is resolved could imply a worsening in the prognosis of our patients (Bhandari et al. 2016).

In 509 reports of the 1631 available (31.2%), a drug belonging to the C09 group according to the ATC classification (RAS inhibitors) was identified among the usual treatment. The renal status of patients treated with this group of drugs on admission is shown in Table 2 (column 2). The same table (column 3) shows the number of reports that were still receiving RAS inhibitors at discharge.

Since the percentage of reports maintaining treatment with RAS inhibitors at discharge seemed subjectively high, we proceeded to a manual review of these reports (specifically those classified as acute kidney failure). Manual review allowed words such as “stop” or “modify” to be detected in front of RAS inhibitor drugs, so that in the acute kidney failure group only 14 reports actually kept treatment at discharge, with nine reports being erroneously detected as false positives.

Total patient reports containing RAS inhibitors (n=509)	n (on admission)	n (to the discharge)
Acute kidney failure	30	23
Stage 1 chronic kidney disease	19	15
Stage 2 chronic kidney disease	43	35
Stage 3 chronic kidney disease	108	80
Stage 4 chronic kidney disease	84	61
Stage 5 chronic kidney disease	221	93
No chronic kidney disease	4	4

Table 2. Renal status and number of patient reports receiving at admission (column 2) and discharge (column 3) treatment with RAS inhibitors

** admission for adrenal catheterisation as a study of primary hyperaldosteronism*

Emotional Health

Previous studies report a high prevalence of depressive symptoms among CKD patients, and psychosocial variables play an important role in the perception of the quality of life of renal patients (Cangini et al. 2019; Wang et al. 2019). However, in the nephrology services daily work, the patient’s psychological field is still relegated to a secondary position.

Reports containing any drug from the N05 or N06 group according to the ATC classification (psycholeptic and psychoanalytic drugs) among the usual treatment on admission were searched. We identified 402 reports containing any of these drugs (24.6% of reports). On the other hand, only 45 (2.75%) and 192 (11.77%) of the reports did mention any diagnosis related to the emotional health either in the “diagnoses” or “personal medical history” sections. These data support the poor awareness of the prevalence of anxiety-depressive disorders among CKD patients despite a high prescription of drugs to treat their symptoms.

The Road Ahead

The application of folksonomy and artificial intelligence techniques such as NLP for the analysis of data from discharge reports of the Nephrology Department has made it possible to significantly reduce the time taken to extract information. Only on the basis of the usual structure of the reports and their writing in natural language, has it been possible to extract relevant information which, if the tool had not been available, would have required the manual revision of these reports and the generation of databases. One of the lessons learned from this pilot project is that clear writing of relevant medical information in the field of nephrology (such as classification of kidney disease) would have made it easier and faster to obtain data.

Despite the non-uniform and structured wording of hospital discharge reports, often with a lack of relevant information in the field of nephrology (such as the appropriate classification of the patient's renal status), the tool has made it possible to include algorithms and heuristic rules to solve these initial difficulties.

The work carried out in this pilot project could be applied automatically to the new hospital discharges being incorporated into the system, allowing, therefore, a real-time analysis of any issue to be explored, as well as creating alarms that would allow us to detect and/or select patients with certain characteristics of interest. This tool could also be used in other care settings, such as outpatient consultations or the day care hospital, where a significant volume of information is generated in natural language. In addition, obtaining and cross-referencing data from reports with laboratory results or other complementary tests not included in medical reports, would exponentially increase the information extracted with the application of folksonomy.

We do not intend to analyse or discuss the findings associated with the research questions posed. We simply note that it is possible to ask oneself clinical questions of interest and that the applied tool based on folksonomy allows to extract data of interest automatically and quickly.

However, some aspects should be improved. Misclassification of reports attributed to false positives has required a manual review exercise. In view of this, the possibility of applying a negation detection would allow the automatic identification of these cases and avoid manual tasks. Moreover, the search tool of the Bismart Folksonomy portal (easy query section) allows the addition of word searches (using "and") but currently does not allow the search for one term or another (using "or"), which represents a certain limitation in obtaining information.

In conclusion, the use of big data in the medical field, in this specific case of folksonomy and NLP, can allow a significant saving of time without detriment to the quality and veracity of the information obtained for research purposes and quality management of the care activity carried out. ■

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Key Points

- There are unwieldy quantities of data in the healthcare space.
- Analysis of data from the clinical records allows for quality control, observation and generation of scientific evidence among other uses.
- The concept of folksonomy comes from "folk" (popular) and "taxonomy" (labelling).
- NLP and folksonomy can reduce the time spent on targeted data extraction and therefore efficient use for better care.

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Reimagining Healthcare: A Story of Growth, Innovation and Transformation

With ageing populations on the rise and healthcare funding increasingly strained, the capability to enhance patient experience and improve clinical outcomes while also driving efficiencies will make the difference in the healthcare battleground. According to the latest data provided by the World Economic Forum, the global population will rise from 7.6 billion to 9.7 billion by 2050, and the number of people over age 60 will reach around 2 billion[1].

In order to meet the new medical demands, healthcare systems will need to undergo a transformation, taking advantage of the power of big data and the AI seduction. This will require from healthcare providers more efficient integration of relevant patient data, leading to precise diagnostics. By tailoring therapy on the basis of the disease and specific patient characteristics, healthcare providers can give the right treatment to the right patients at the right time. The more precise the treatment, the better patient outcomes.

All the major initiatives we implemented so far on our growth journey were aimed to create value for patients and doctors by making our services leaner, faster, more integrated, and putting them on the cutting edge of the digital age

However, a change in the healthcare industry is nothing to be feared. At Affidea, we treat it as a great opportunity to shuffle the deck and lead the transformation pathway for the benefit of our patients and doctors. We started two years ago this exciting journey when we had to rewire our brain, thinking that the role of the innovators and the leaders is granted to the ones who anticipate and lead the change. We never stepped back from setting big ambitions to create long-term value. So, we embarked on a bold journey, having in mind that growth and transformation is in our DNA and it is in our mission to lead the change in healthcare and solve tomorrow's challenges.

Driving change at scale takes time and resiliency. So we acted with patient care and their needs in mind.

Looking back in the past year, I am proud to see what we accomplished so far.

Expansion at Scale

Since the beginning of 2019, we expanded in 8 countries, adding 40 new centres to our network and reaching now 280 centres at European level with an enlarged portfolio of outpatient care services and subspecialties:

- Ireland, with the opening of three new ExpressCare centres
- Italy with the acquisition of Medicenter and NSL clinics
- Lithuania where the company added MPG centres - doubling its presence in the country - and the private healthcare clinic Ventures, at the beginning of this year
- Spain where we added Manchon Group, a reputed DI provider in Cataluna region
- Hungary, adding the private outpatient provider MSB, located in the biggest shopping malls of Budapest
- Portugal, adding Medicir healthcare provider
- Greece, with the addition of the dermatology chain Athens City Med, opening a new pathway for Affidea in the outpatient area
- Romania, by adding CT Clinic Cluj, a reputed PET/CT provider, expanding our presence in cancer care.

We have a long track record in integrating new centres, organically or through acquisitions. While increasing by 60% the number of our centres only in the last 5 years, we also made great strides in revamping our strategy, portfolio and European footprint.

These latest investments are an important proof of the successful business model expansion, in which we decided to broaden our core operation model based on diagnostic imaging and cancer care to private outpatient care services. With each new investment we make, we look for a proposition that adds

value to our patients, providing high quality medical care, as well as the ability to integrate with our current medical services. Adding these new centres to our network will result in best-in-class access for our customers to a wider range of medical services which will enable us to serve them on a much more integrated level.

A Deep-Dive into AI and Sub-Specialty Expertise

Adding centres to our map is core to our success, but so is the development of a strategic position in each country to offer a premium medical service for patients, doctors, PHIs, national health systems and our employees.

2019 was the year when we developed our internal sub-specialty expertise in different areas to address patients needs in a personalised way and we also made the first steps in AI, proving our digital and data-driven capabilities. We have launched and integrated in our operations 5 AI clinical products in 8 different countries:

- Affidea neuroInsight|MS for patients with multiple sclerosis,
- Affidea breastInsight|Mammography for breast cancer screening,
- Affidea lungInsight for lung cancer diagnosis,
- Affidea PETInsight for improving patients experience during PET/CT scans and the latest one
- Affidea LiverInsight for liver diseases.

These advancements were brought to provide our radiologists with greater insight and increase the speed in which they can make accurate diagnoses — effectively giving them superpowers. In the same time, this will help clinicians to better understand the disease development and in turn, optimise patients treatment.

Digitisation for an Improved Patient Experience

Another theme on our growth journey was to implement new digital tools that can help us continuously improve our daily operations, enhancing patient safety and delivering faster, better and more efficient care every step along the patient's pathway.

We see more than 7 million patients every year in our network of 280 centres, and we always think about their expectations. That's why, we have introduced KPI dashboards which are meant to offer our teams better insight around our operations, resulting in continuous quality improvement actions and overall improved patient experience.

All the major initiatives we implemented so far on our journey were aimed to create value for patients and doctors by making our services leaner, faster, more integrated, and putting them on the cutting edge of the digital age. All these advancements have positioned the company to be preferred over time for patients, doctors, payors, employees and more valuable for our shareholders.

Moreover, the knowledge that our work improves millions of lives every year is a powerful reward for all of us.

We understood that transformation requires that we stay true to our values and follow our vision in every step of the journey so that our actions can change healthcare for the better for patients and medical professionals in a time when they need it most. ■

Author: **Giuseppe Recchi**
Affidea CEO

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SPECIAL SUPPLEMENT ABOUT EFFICIENCY WITH GREAT QUALITY CARE

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Opening a World of POSSIBILITIES

Special supplement from GE Healthcare in collaboration with HealthManagement.org

Contents

Improving Efficiency While Providing the Best Care

Catherine Estrampes

President & CEO
GE Healthcare Europe

The growth and aging of global populations, the rising levels of chronic disease coupled with escalating costs, growing complexity and inadequate infrastructure is forcing a fundamental re-think of every aspect of healthcare.

Swedish doctors spend on average one working day a week on administrative tasks. The British National Health System estimates that an extra 291,327 operations could be completed every year by improving operating room management. The proportion of inefficient or wasteful public spending in Italy was estimated to be around 19% in 2017.

Finding smarter ways to reduce waste and increase efficiency across healthcare is today's challenge. The good news is that there is tremendous opportunity to ease the burden of administrative tasks, improve processes and support faster decision-making across Europe.

Take for example X-Ray - the most common method of imaging and the first way of detecting a collapsed lung. It can take radiologists anywhere between two to eight hours to review the scans. But with Critical Care Suite™, a new algorithm built into the X-Ray device, clinicians can be alerted of a potential collapsed lung at the point of care, telling them to urgently review and prioritize the patient.

In MR, the MR Excellence program combines applied intelligence and data-fueled analytics with MR technology to increase productivity and quality in imaging. As a result, a practice in Germany saw up to 30% increase in productivity and increased MR scans from about 120 per week to about 170 per week. Patient wait times for an exam dropped from 6-8 weeks to just 1-2 weeks.

At the hospital level, traffic-control-style Command Centers help address capacity, safety, quality, and wait-time. By constantly pulling in streams of data from multiple hospital systems and using simulation and AI, the Command Center generates predictive analytics to help staff recognize patterns in real-time and predict what will happen in the next 24-48 hours. The first of its kind in Europe was launched in September 2019 in Bradford, UK.

Too often though, important patient data is siloed in different departments, devices, medical records or even hospitals. Storage, access, and use of data are key to unlock the potential in healthcare. National governments are showing the way with encouraging examples: in Germany, the new Digital Supply Act foresees that doctors will soon be able to prescribe digital health apps to patients. In Finland, the Findata initiative is already considered an exemplar for health data governance in Europe with anonymized data and a dedicated clearing authority handling access requests in a GDPR-compliant manner.

I am excited to see the impact that this digital transformation will have. The increased use of advanced data analytics, connected devices, genomics and AI is ushering in a new era with the potential for real breakthroughs in patient outcomes and operational efficiencies across every facet of care. Never before has innovation in healthcare been more digital. ■

Artificial Intelligence - Putting Patients First

A recent MIT Technology Review Insights survey looked at the current and potential future applications of artificial intelligence (AI) in the healthcare environment. This article discusses the survey's findings, and looks at how these technologies are 're-humanizing' healthcare, by aiding the transition from target- to value-based care models.

Not long ago, no one would have dreamed that a machine could be a partner in guiding a medical procedure, but recent advancements have transformed AI technologies into powerful tools for enhancing clinical and operational efficiency.

Today, AI is allowing everyone involved in the healthcare ecosystem—doctors, nurses, administrators, and patients—to benefit from enhanced efficiency and better diagnoses. It extends and augments professional capabilities and provides the foundation for better, more cost-effective outcomes. Crucially, it is an enabling technology for a more personalized approach to patient care, focusing on patient outcomes rather than just system efficiency.

During the next 10 years, AI is expected to radically streamline healthcare delivery by providing immensely powerful insights to enhance the patient management pathway, yet there are hurdles to overcome before AI transforms healthcare provision. For example, at present, too much patient consultation time is spent entering data, rather than drawing inferences from it. However, these transitional issues should quickly be resolved as AI is more broadly adopted across the sector, and the outlook among healthcare professionals is positive; almost half of medical staff expect AI will enable more robust diagnoses, and 57% believe its improved predictive capabilities will allow them to focus more on preventive medicine. Rather than eliminating the human element from the system, AI allows those individuals to make smarter decisions, with fewer errors.

AI is already here

Numerous technologies are in play today to allow healthcare professionals to deliver the best care, increasingly customized to patients, and at lower costs. For instance, in medical imaging analysis applications, the combination of AI-based imaging technologies and radiologists has been shown to outperform either AI or the radiologist in isolation. So, far from replacing radiologists, the technology supports decisions and amplifies the performance of existing staff.

Radiologists don't just look at images. That would be a complete misunderstanding of what radiologists do. In my view, AI will enhance the value radiologists provide to patients, not replace them. While AI has been shown to augment the care radiologists provide, AI does not yet have the capacity to do what radiologists accomplish every day. It does, however, offer the tremendous opportunity to bring radiologists back into daylight by empowering them to become more 'doctor' than ever before. AI will help to re-establish the human connection between the radiologist and the patient. As such, I'm not the least worried that radiology as a medical specialty might eventually be at risk if we responsibly embrace AI.

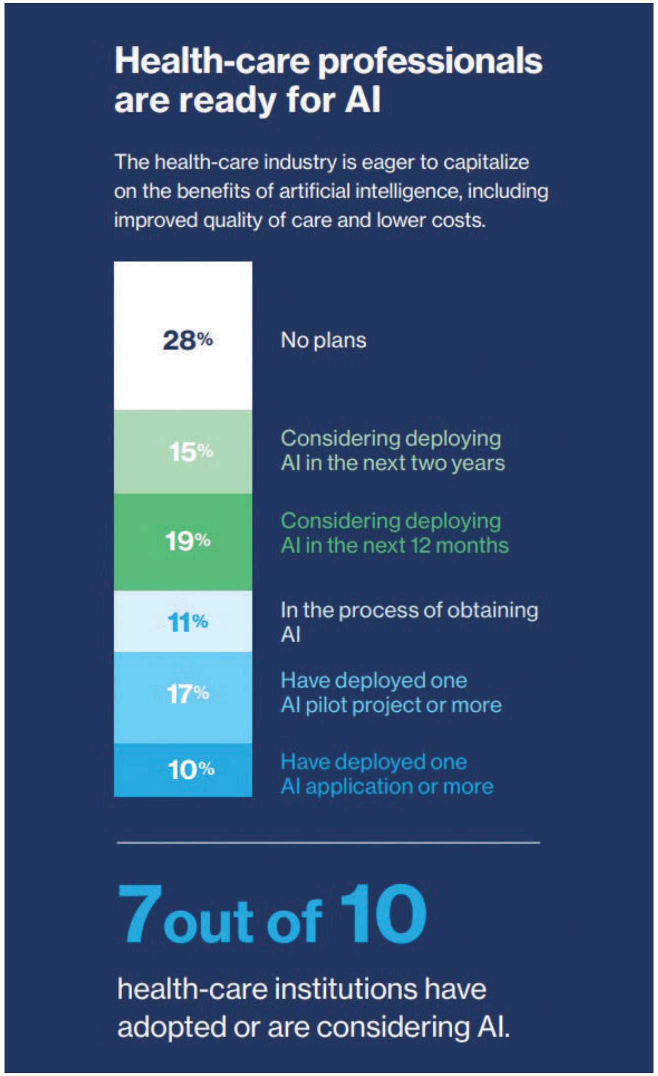
To give just one example—GE Healthcare recently gained FDA clearance for first AI algorithms embedded on-device to prioritize critical chest X-ray review. These help radiologists prioritize critical cases with a suspected pneumothorax—a type of collapsed lung—by immediately flagging critical cases to radiologists for triage, which could drastically cut the average review time from up to eight hours[1]. They offer the first-of-its-kind automated AI quality check features that detect acquisition errors, flagging images for technologist review and allowing them to make corrections before they go to radiologists for review, and were built in collaboration with UC San Francisco (UCSF), using GE Healthcare's Edison platform. It's just one example of how an AI algorithm can help busy practitioners—reducing the turnaround time it can take for radiologists to review a suspected pneumothorax.

The industry is slowly realizing that AI is an enabling tool that represents the extension, not extinction, of professional capabilities. The survey found that seven out of 10 healthcare institutions have either adopted or are considering AI, with 10% using it for one or more applications, 17% conducting pilot projects, 11% in the process of acquiring at least one AI application, and more than a third planning to increase their spending on AI in the next two years. For those institutions that have already adopted AI, 86% of respondents believe that it has helped them analyse and make better use of data, while 79% indicate that it has helped avert healthcare worker burnout. Healthcare administrators and leaders also see AI as an agent for positive change, with 80% of business-facing and administrative healthcare workers expecting it to help them improve revenue opportunities, and 81% believing it will make them more competitive healthcare providers. In addition, more than 82% of healthcare business leaders report that adoption of AI has led to workflow improvements in both their operational and administrative activities, with nearly three out of four institutions planning to develop their own AI algorithms in the next two years.

Untangling complexity

Across the entire healthcare ecosystem—from patient management, operations and administration to diagnosis and treatment—medical professionals are confronted with growing complexity. Regulatory concerns, expanding treatment alternatives, and the onslaught of data and information are all exceedingly challenging to navigate.

The true value of AI is in reducing this complexity, automating and streamlining workflows to allow healthcare professionals to harness the insights available, without being overwhelmed by the sheer volume of data. Handling growing workload volumes—and managing the backlog and staff fatigue that accompanies it—was cited as the top challenge that they were looking to mitigate through the use of AI. These technologies can be used to assume many of a physician's more mundane administrative responsibilities, such as taking notes or



Infographic from the MIT Technology Review Insights report: The AI effect: How artificial intelligence is making health care more human

updating electronic health records, which can take up to 10% of a typical medical professional's working week. Almost 80% of AI adopters surveyed indicate that AI has already automated many of these time-consuming tasks, and 45% believe this frees up additional time for patient consultations, procedures and other higher value tasks.

Expect the unexpected

Integrating AI applications into existing systems is obviously a major challenge for any healthcare system, with 60% of respondents concerned about the disruptive impact on established processes. Interestingly, there are four issues that less than half of current AI adopters consider obstacles to more widespread adoption: cybersecurity; lack of compelling adoption rationale; reluctance of staff to adopt the new technology; and lack of senior leadership support. Despite this, overcoming these 'traditional' adoption difficulties isn't easily done for most institutions, as a willingness to change and adopt AI is a perpetual challenge for even the most tech-forward organizations. The key to success is for medical professionals to see these technologies as something positive, rather than a threat, and evolve their practices to embrace these developments. AI can extend the resources and capabilities of overworked healthcare professionals and vastly improve processes, leading to better patient outcomes.

Conclusion

AI needs to work for healthcare professionals as part of a robust, integrated ecosystem, and success relies on more than simply deploying a new technology. The more 'humanized' the application of AI is, the faster and more widely it will be adopted, and the better the return on the initial investment. Ultimately, this will improve results and patient care and, in healthcare, the priority should always be the patient.

About the survey

In October 2019, MIT Technology Review Insights surveyed 908 healthcare professionals involved in the purchase or selection of AI, big data analytics, or medical technologies. With respondents from both sides of the Atlantic - 70% USA and 30% UK - this mixed cohort included:

- 17% medical doctors and specialists
- 5% nurses or nurse practitioners
- 26% senior managers
- 16% information technology professionals
- 16% research and development staff
- 9% legal or regulatory professionals
- 9% finance or accounting personnel
- 2% other healthcare workers ■

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Leveraging the Power of AI on Smart Devices

The results of the MIT Technology Review survey, in partnership with GE Healthcare, emphasize AI's potential and ensure that the technology is here to stay, but its ability to overcome potential disruption must be addressed.

GE Healthcare believes the solution is in packaging. By unlocking data, breaking it out of silos, and deploying it on the right platform, AI can seamlessly integrate into existing workflow, thereby making it easier for providers to adopt these algorithms.

To do this, GE Healthcare recently introduced the Edison Developer Program to help healthcare providers gain easier access to market-ready AI algorithms and applications by directly integrating these technologies into existing workflows.

"Edison works to meet clinicians where they are and provide the intelligent solutions they need, when they need them," explains Karley Yoder, Vice President, Artificial Intelligence, at GE Healthcare. "It combines diverse data sets from across modalities, vendors, healthcare networks and life sciences settings to enable quick development of advanced intelligent applications and reduce barriers for developers to create intelligent solutions."

These solutions can be deployed on medical devices, via the cloud or on the edge, a computing technology that sits close to the physical device.

"The platform selected for the deployment of each application is a strategic one, since each offering provides unique benefits to radiologists and technologists," continues Yoder. "That said, many of our product launches this year are on-device AI solutions, which offer unique opportunities to increase clinical and workflow efficiency at the point of care."

"It also offers a lower barrier to entry for hospital systems that are interested in adopting and testing AI but are hesitant to make additional IT investments," adds Katelyn Nye, General Manager, Mobile Radiography and Artificial Intelligence, GE Healthcare. "On-device AI does not require infrastructure investments, security assessments, or IT configurations – offering a faster and more accessible way for hospital systems to test algorithms quickly and benefit from several unique on-device AI benefits."

After consulting customers throughout the world and evaluating their healthcare needs, GE Healthcare announced several unique on-device solutions across its portfolio, each offering a different benefit to customers:

On-device AI can improve efficiency by automating steps in the workflow and expediting exams

"Automation and smart technologies are not only the future of medical imaging but are essential as departments look to transform workflows and the patient experience," said Dr. Vincent Lombard, the first clinical adopter of Revolution™ Maxima with AI-based Auto Positioning, and a radiologist at Centre Imagery Jacques Callot. "By integrating artificial intelligence into existing workflows we've been able to not only improve scan quality and reduce steps, but we've also been able to spend more time caring for patients."

Revolution™ Maxima with AI-Based Auto Positioning uses real-time depth sensing technology to generate a 3D model of a patient's body to pinpoint the center of the scan range and automatically align it to the isocenter of the bore. Altogether, it is designed to simplify, streamline and automate the entire CT experience for one click, hands-free patient positioning.

Automatic quality checks catch errors at point of care, enabling technologists to retake images and fix protocol labels before uploading the exam results to PACs

"Automatically running quality AI algorithms – like Intelligent Field of View and Intelligent Protocol Check – on-device increases efficiency and integrates them into the technologist's standard workflow, enabling technologist actions – such as rejections or reprocessing – to occur at the patient's bedside and before the images are sent to PACS," explains Katelyn Nye, General Manager, Mobile Radiography and Artificial Intelligence, at GE Healthcare.

Intelligent Field of View and Intelligent Protocol Check help detect acquisition errors on GE Healthcare's Optima™ XR240amx mobile x-ray system, flagging images on-device for technologist review and allowing them to make corrections before the images are sent to the radiologist.

Embedding AI into the image processing chain enables the use of raw data to help improve image quality and presentation consistency

"I do not have to choose between improving the quality of the exam and shortening the exam time," says Dr. Pascal Roux, a radiologist at Centre Cardiologique du Nord (CCN), one of the first global clinical sites to evaluate a prototype version of AIR™ Recon DL. "I can have the best of both worlds. [We] can demonstrate high-resolution images with no truncation artifact, imperceptible noise and depiction of sharp structure."

AIR™ Recon DL*, an Edison application providing TrueFidelity™, is a GE-first, deep-learning MRI reconstruction technology application designed to simplify this choice by improving signal-to-noise and image sharpness and enable shorter scan times. Clinicians and technologists would no longer have to compromise between image quality and scan time with AIR™ Recon DL. This application was developed using a neural network trained on tens of thousands of images using GE's Edison AI Platform.

Embedding AI onto the device can help provide clinical information at the point of care and to the radiologist to assist with diagnosis and enable triage

"This project validates the focus of the industry in pushing research & development in deep learning algorithms," claims Dr. Bharat Aggarwal, Director of Radiology and Principal Investigator at MAX Hospital, one of the first global clinical sites to evaluate Critical Care Suite™. "We clearly saw advantages of the system in the sensitivity of detecting small pneumothorax in some patients, enhancing the speed of alerting the treating teams regarding development of PTX in their patients."

Critical Care Suite™ is an industry-first collection of AI algorithms embedded on the company's Optima™ XR240amx mobile x-ray device for triage. Recently cleared by the FDA, the embedded AI automatically analyzes images on-device and immediately flags cases with suspected pneumothoraxes to ensure a fast and reliable way of delivering AI results that are generated within seconds of image acquisition. All this is done without any dependency on connectivity or transfer speeds to produce the AI results, which are sent to the radiologist while the device simultaneously shares the original diagnostic image, ensuring no additional processing delay.

To further assist technologists and radiologists, three additional features are also available in Europe, including:

- **AI Score**** from 0 to 100 is presented in which the higher the score, the more confident the algorithm is that a pneumothorax is detected;
- **Image Overlay**** can be seen on-device (as well as on the Secondary Capture image sent to PACS) and accurately localized 96% of positive pneumothorax findings; and
- **Customization of preferences**** allows users to set an AI operating point (5 setting options) in order to tune the performance of the system to preferred sensitivity or specificity.

"At the end of the day, we believe widespread AI adoption will be determined by its integration into existing workflows and accessibility to hospital systems," concludes Yoder. "All our Edison platforms – on-device, cloud and edge – are designed to deploy the latest AI solutions to healthcare professionals where they need them most." ■

*Not available in the United States and Europe.
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The English Patients: This UK Hospital Is Harnessing AI To Deliver Slicker Service

At Bradford Royal Infirmary, about 20 staff members work out of a centrally located room called the command center, monitoring a "wall of analytics" that helps them manage patient flow and make decisions quickly.

If you watched the opening ceremony of the London Olympic Games in 2012, you will know that British people love their National Health Service (NHS) as much as they cherish Peter Pan, The Beatles and James Bond. The ceremony's climax was an eccentric and poignant dance routine that celebrated the NHS's special place in the nation's heart. At one point, dancers bounced on trampolines made up to look like hospital beds.

Artificial intelligence (AI) is now helping ensure that the NHS gets the best out of those world-famous hospital beds. Hospital staff in the fast-growing northern city of Bradford are using cutting-edge software that generates real-time, 24/7 insights about the hundreds of beds and patients on their wards. Those insights allow them to help prioritize the city's hospital beds for the neediest patients, make faster decisions about care, identify and prioritize the sickest patients, and allocate resources more efficiently. Managing patient flow and care is a vital mission, because 96% of bed capacity at Bradford Royal Infirmary (BRI), the city's main hospital, is used regularly.

Patients at BRI may well catch a glimpse of the system in action. Around 20 staff members work from a new, centrally located room in the hospital called a command center, which officially opened Nov. 12. They monitor a 'wall of analytics:' Eight high-definition TV screens which constantly update with real-time data about the 800 beds across the hospitals that are part of the Bradford Teaching

Hospitals NHS Foundation Trust. BRI alone sees around 125,000 emergency department (A&E) attendances per year, but the trust

serves approximately 1.1 million people in the West Yorkshire region.

If you think a command center sounds like those banks of desks that manage moon missions and airport runways, you are on the right track. "It's the same concept of mission control at NASA or air traffic control, but applied to hospitals," says Gerald Dunstan, partner, GE Healthcare Partners, which designs, builds and activates the command centers. "Bradford is getting real-time insight on patient flow and can make better decisions over what actions need to be taken."

Dunstan explains what is going on behind the scenes. Like any large healthcare operation, there are multiple streams of real-time data from the various departments and wards within the Bradford trust. At any one time, this might include paramedics alerting the site team from inbound ambulances, a general practitioner referring a patient to BRI's nephrology department, or the hospital's hematology ward relaying updates about the availability of en suite rooms.

These data streams used to live in not-so-splendid isolation from each other, making it difficult for hospital staff to get an overview of their patient population together with a snapshot of bed availability. It prevented them from allocating beds efficiently and identifying which patients need extra attention based on clinical need. In the past, staff would phone around wards to find out about patient comings and goings, and then produce a rough estimate of bed availability. "It was a manual effort that needed lots of calls," says Dunstan. Very often, bed allocation was a case of first come, first served, says Dr. Brad Wilson, the command center's medical director. "We didn't have the visibility to improve overall patient flow."

Those days of hanging on the telephone are over, because command centers consolidate those disparate data streams, offering staff an overview of bed supply and demand just by glimpsing at the screens. "The command center gives us cross-system visibility to make smarter decisions," says Wilson. The system, which can also be displayed on staff's tablets and mobile phones, allow users to quickly drill down to obtain more information about bed supply and demand. For example, the bed might be set up for a male patient in a negative pressure room, which lowers the risk of cross-contamination. Staff could quickly earmark that bed for an incoming cardiac patient, who is at high risk of infection.

The software is not just a hyper-efficient ward organizer and bed allocator. It also avoids potential bottlenecks, helps caregivers prioritize and focus on the sickest patients in the Trust right now, and preserves scarce hospital resources by using predictive analytics to generate insights from the mountains of data, or as Dunstan puts it, "add actionable intelligence." For example, it could predict that special handling is required for incoming patients based on an analysis of their symptoms, which would allow nurses on the ward to make up an appropriate bed. The software could also alert staff to patients who haven't filled out a consent form for surgery, thus averting the wasted time of a cancelled operation. Whatever the case, staff can get ahead of the game in terms of patient flow and resource allocation. Dunstan says greater situational awareness and slicker patient flow are boons for the hospital's A&E ward, which sees up to 400 patients per day.

The NASA-style command center is one small step on NHS's digital journey, but one giant leap for Bradford. It is the first hospital outside North America to receive such a nerve center. In 2016, the Johns Hopkins Hospital in Baltimore, Maryland, launched

GE Healthcare's first center, and over the next 18 months it improved access for very sick patients by 78% and reduced emergency department patient waiting by 35%, even as inpatient occupancy grew by 8%. Humber River Hospital in Toronto, Canada and OHSU Health in Portland, Oregon, have also opened command centers and seen similar results.

It is early days for Bradford's own command center, but BRI is already seeing faster ambulance transfer times, fewer delays to patient consultations, patients returning home quicker, and fewer cancelled operations. Dunstan and Wilson are hoping to see an especially steep reduction in the time that medically fit patients spend in hospital. This would be good news, since this time is a huge strain on any hospital's administrative capacity and resources, says Wilson. "It's actually bad to have people in hospital who don't need to be there — they are at greater risk of all kinds of things: infection, delirium or malnutrition."

Wilson, an American who moved to northern England 22 years ago, is proud of reducing the number of patients that stay 21 days or longer at Bradford's hospitals by 40% in recent years. "It used to be in the hundreds," he says. "But right now [early November], we've only got 54 such patients." He is looking forward to Bradford's AI-enhanced future. "We had been on this digital journey for years and not understanding our own data," he explains. "Now it's finally pulled together in a meaningful and actionable way." ■

*Article previously published on GE reports by Chris Noon

Children in the Spotlight: When Every Second Counts

The University Hospital of the Free University of Brussels (UZ Brussel) in Belgium is pioneering the use of real-time deep learning-based image reconstruction (DLIR) on CT scan, exploring the benefits it offers for rapid pediatric evaluation, including lower dose and enhanced efficiency.

In healthcare, it is acknowledged that the sooner a patient receives the right diagnosis and the right care in the right place with the right resources, the better the chance of a positive outcome. Time is of the essence. Every second counts, and reacting in a timely manner can make all the difference, especially when the patient is as vulnerable and delicate as a newborn baby. It's all about caring for tomorrow, today.

In Belgium, doctors were working against the clock when a critically ill 18-day-old baby was admitted to the UZ Brussel emergency ward, having already collapsed twice. A correct diagnosis was needed immediately, and the medical team reacted swiftly after a positive thransthoracic ultrasound exam, by performing a CT scan. Using a system incorporating a DLIR application, they were able to obtain high quality images with a reduced radiation dose.

This combination of rapid action and advanced technology was the key to saving the newborn's life. In a few minutes, the high quality images enabled the medical staff to identify a rare congenital cardiac condition and arrange transfer to a specialist facility. UZ Brussel's rapid diagnosis and decision-making were acclaimed by the receiving hospital, highlighting the importance of having access to such high quality imaging, allowing the team to find an answer in record time.

> "We were able to perform a very, very low dose CT scan and generate excellent quality 3D images with realistic texture to diagnose an extremely rare cardiac condition"

Dr. Koenraad Nieboer, a specialist in emergency radiology at UZ Brussel, led the team behind the newborn's case. He said: "We were able to perform a very, very low dose CT scan and generate excellent quality 3D images with realistic texture to diagnose an extremely rare cardiac condition. The images were straightforward to interpret, giving us confidence in our diagnosis, and the child was transferred to a specialist cardiac hospital for surgery."

After the CT scan, the patient's cardiovascular system was reformatted, creating nearly noiseless 3D volume rendered images in a time-efficient manner. This data was sent to the specialist cardiac surgeons prior to the child's admission to their hospital, allowing them to visualise the pathology, plan their approach to surgery and prepare in advance. Dr. Koenraad Nieboer added: "The technology allowed us to diagnose the condition accurately and with the minimum of tests, using procedures that asked less of the patient. The surgeons really appreciated the quality of the images we generated; they had never received such good 3D images of a baby before. Consequently, they were able to do what they do best, care for their patient."

Achieving a balance between efficiency and lower dose

A couple of decades ago, the emphasis for radiology exams was purely on image quality, with little concern about the radiation dose. With the realization that the dose levels used with filtered back-projection (FBP) were very high, the focus switched to developing alternative iterative reconstruction methods. The difficulty was that noise increased as the dose was reduced. A balance had to be struck, using the lowest radiation dose possible without compromising image quality.

Attention turned to model-based iterative reconstruction, where parameters are manually designed and optimized by human experts, which proved an effective means of reducing both the dose and noise while continuing to generate good quality images. However, the process takes around 30 minutes and image texture can be compromised. Several generations of iterative reconstruction later, users began to request a faster solution that delivered a more natural looking texture. By then, artificial intelligence (AI) had come to the fore, enabling the development of an algorithm – TrueFidelity™ – capable of generating the same image quality as FBP at a low dose, with minimal noise and in real time. This DLIR technique contributes to increase the speed and efficiency of imaging, producing intelligent image noise reduction and restoring the preferred noise texture. This leads to improved objective and subjective image quality compared to FBP and iterative reconstruction.

Dr. Koenraad Nieboer said: "We are in an era of deep learning, where artificial intelligence has made it possible to train an engine to recognise and adjust for noise, and to produce the same high quality images as FBP, but at a much lower dose and in real time."

The need to lower the radiation dose without compromising on image quality and, at the same time, improve efficiency, has been an ongoing challenge for radiologists everywhere. DLIR is the future, allowing the dose to be further reduced compared to previous techniques, and enabling high quality, real-time imaging to help increase the speed of patient assessment and streamline the treatment pathway. ■

From Breast Cancer Diagnosis to Treatment Plan in the Same Place, Same Team, Same Day

The time between a suspicious screening mammogram and a diagnosis and treatment plan can be weeks, leading to stress and anxiety for women. A hospital in France developed a unique one-stop breast cancer clinic that can confirm a positive finding, including biopsy, and provide a treatment plan, in one day, in one place, for most women with suspicious scans. The concept is now being exported to other countries.

Gustave Roussy is a cancer-research institute and European Cancer Centre. It is the first dedicated One-Stop Clinic for Breast Cancer in France

Approximately half of all women receiving screening mammograms over 10 years will have a false positive result, which can cause considerable anxiety.[1] Understandably, then, women want to confirm the diagnosis (or negative findings) and obtain a treatment plan as soon as possible. But this requires meeting with a variety of clinicians for tests and consultations, a process that could take four weeks,. up to seven if a biopsy or other exams are required.[2] Such delays lead to considerable stress and anxiety and may even affect prognosis.[3]

In a world in which a click of the button can bring a package to your door within a few hours, in which nearly everything we need to know resides in a device smaller than a purse, such delays may seem archaic. However, it is possible to offer a much faster option to the traditional pathway.

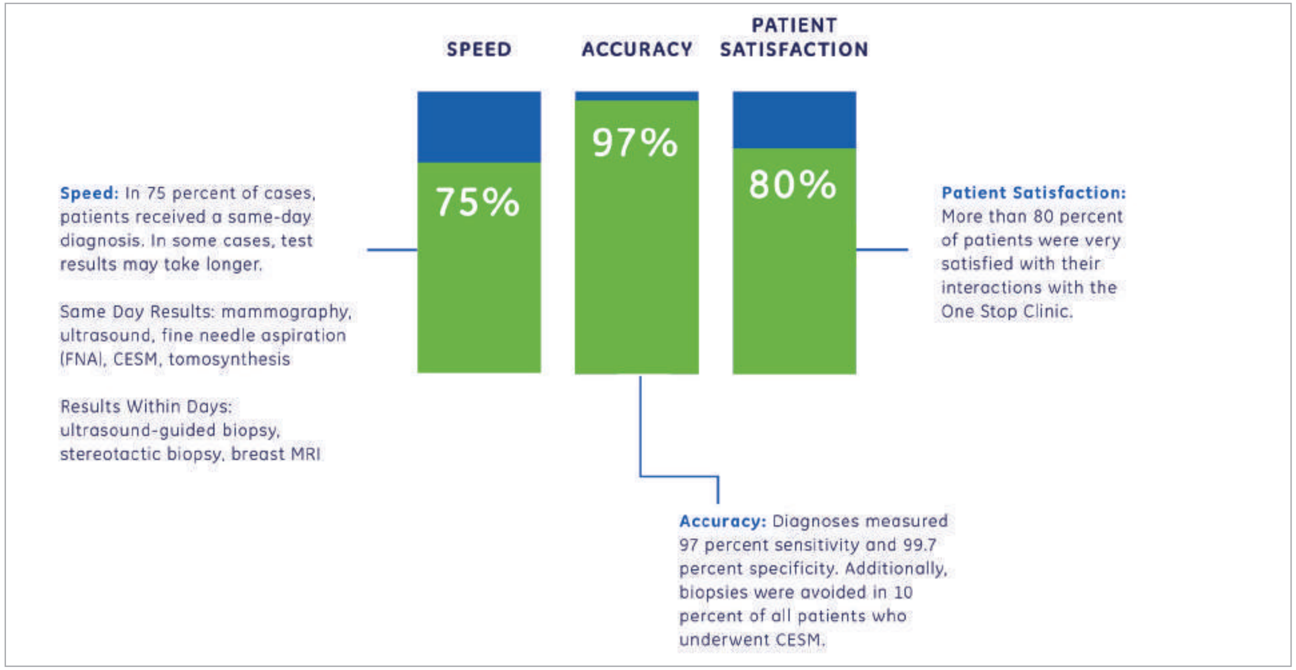
The proof lies in one of Europe's top cancer center, which decided to tackle this challenge more than a decade ago after realizing its patients had to wait up to two months to confirm a questionable scan. "Sometimes there are images that are hard to read, and these women do not know whether they have cancer or not," said Dr. Corinne Balleyguier, radiologist and head of the imaging department at Gustave Roussy Cancer Center in Villejuif, France. “This is too long. The clock is ticking, and we have to move as quickly as possible and start treatment early.” Otherwise, she said, “the uncertainty can be nerve-wracking, and we want to reduce it as much as possible.”

> “The clock is ticking, and we have to move as quickly as possible and start treatment early”

“We started seeing younger patients with dense breasts and more complex lesions,” Dr. Balleyguier said. “We wanted to develop a multidisciplinary approach that would deliver high-quality care and reduce the time between screenings, primary evaluations deemed positive, and diagnosis.” The concept was revolutionary at the time, said Dr. Suzette Delaloge, associate professor of medical oncology, founder of the One-Stop Clinic and head of the breast cancer department at Gustave Roussy, “at least on a scale as large as we were planning.”

From Screening to Treatment Plan in 1 Day

Today, the One-Stop Clinic Delaloge developed enables women with abnormal or unclear findings to go from screening to confirmed diagnosis and treatment plan or confirmed negative result in just one day. The clinic operates with a multidisciplinary team including surgeons,



With Gustave Roussy Cancer Campus, a study was per formed with ~11,000 women over 8 years and proved One Stop Clinic provides unprecedented patient benefits.

radiologists, oncologists, pathologists, nurses, patient navigators, and social workers; a comprehensive suite of mammography equipment and applications; and clinical pathways designed to speed diagnosis and treatment planning.

The team is a critical component, with evidence that such a multidisciplinary approach may improve outcomes in patients with breast cancer.[4] Communication between the team members, and the ability for a patient to interact with the team in a single day or two rather than having to return for multiple appointments, speeds diagnosis and treatment planning and, overall, may result in a better outcome.

The women start arriving at Gustave Roussy around 8 am every Monday. A coordinating nurse divides them into three groups based on their referrals and schedules them to see one of three specialists for examination and screening. Women with unclear scans see a radiologist for consultation; those with suspicious lesions smaller than 10 mm visit a surgeon for a biopsy; and those with confirmed cancers see an oncologist to discuss a treatment plan. "The majority of patients who come to our facility don't have to worry about false positives or callbacks which, as you know, are an issue in breast cancer diagnostics," Delaloge said.

At the end of the day, patients have a final consultation to discuss the diagnosis and plan their treatment. "The results are remarkable and truly unlike anything we've seen happening anywhere else in the world," said Dr. Delaloge.

To date, more than 20,000 women have passed through the clinic.

Study Results Demonstrate Success

An independent analysis of 11,000 patients seen at Gustave Roussy over eight-and-a-half years found that that 75 percent with suspicious breast findings received an exact diagnosis (97 percent sensitivity and 99.7 percent specificity) and treatment plan the same day. Overall, 80 percent said they were "highly satisfied" with the process and the care they received. Ten percent evaluated with GE Healthcare's Contrast-Enhanced Spectral Mammography (CESM) were able to avoid biopsies.

Replicating the One-Stop Clinic Around the World

The One-Stop Clinic model is easily replicable, said

Delaloge. "When you combine the right people, process, and technology, you can deliver excellent clinical, operational, and financial outcomes with increased value."

Thus, Gustave Roussy and GE Healthcare are now internationalizing the concept with the first One-Stop Clinic open in Medellin, Colombia. Representatives from Dynamica Medellin spent two years working with the team at Gustave Roussy to develop its clinic. Today, the Colombian clinic sees about 17 women a day, five days a week.

In the United States, Premier Inc. is working with GE Healthcare to develop the model for the One-Stop breast cancer diagnostic centers to give US women the same-day results. To support the effort, Premier conducted a Rapid Evidence Review, one of the first comprehensive evaluations of expedited diagnosis for patients with breast cancer. Based on the results of the first phase of the collaboration, GE Healthcare and Premier will next evaluate the potential and merits associated with adopting the One-Stop Clinic model in the US.

The companies have also convened an advisory board to provide insight on the One-Stop Clinic model, as well as guidance and counsel on best approaches to redesign it for the U.S. market. Such clinics, said Annemijn Eschauzier, Chief Marketing Officer, Women's Health at GE Healthcare "would set a facility apart from other clinics in the region by enabling the clinical team to provide a higher, more cost-effective, less stressful level of care for patients." ■

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New Catalonian Digital Health Strategy: A Presentation

Summary: The Digital Health Strategy for Catalonia (Spain) is one of the current few ambitious initiatives of health information systems' transformation in Europe.

Similar to other developed countries around the world, the public health system of Catalonia is subject to tensions, challenges and opportunities that mainly result from an ageing population, rising operational costs, incorporation of new technologies and medical treatments, labour supply changes, the ever-increasing demand for high quality patient care, as well as a higher level of knowledge and demand on the part of citizens (Rossini and Marra 2014; Majchrzak et al. 2016). Within this scenario, a topic that emerges strongly is the transforming role of data management and information technologies (IT) for the empowerment of the patient, improved healthcare practice and management, and better allocation of resources (Kudyba 2010).

Healthcare has been identified as one of the sectors with the greatest potential for the intelligent use of data. At the operational level, it allows clinicians to share patient health information throughout different healthcare stances. At the management level, it facilitates transparency and comparability reducing the variability of healthcare practice and increasing the quality and security of care, and enables regulators, insurance companies and service buyers to establish contracts and economic conditions. At the analytical level, it is an opportunity to research new treatments, services and products that fulfil the promise of personalised and predictive medicine. In all cases, it provides patients with access to their data and information and modifies their relationship with professionals and health system (Davenport and McNeill 2013). Healthcare is an information industry where information and knowledge play a key role (Kothari et al. 2011).

Locally, the Health Plan is the strategic, interdisciplinary and collaborative framework that guides the actions of all stakeholders within the Catalonian healthcare system in order to improve the quality of life and the wellbeing of the population, the access to and resolution of health services, and the efficiency and sustainability of the system as a whole.

The Digital Health Strategy for Catalonia (Departament de Salut 2017) is designed to achieve the goals as defined by the Health Plan (Directorate General for Health Planning 2016). As a matter of fact, it is not just a technology update, but a framework for the management of the data and for architecture of the information systems that corresponds to and, in some cases, anticipates the changes taking place in the care model with regard to citizen relations with the health system, in the work processes and in the relationships between professionals. Hence, its approach is systemic, meaning it covers the exchange of data among the various healthcare services and even with other areas, such as social services, and consequently affects the tools used by the care providers. Also, for this reason it provides instruments to intensify collaboration between different actors, define semantic and technical standards and share and take advantage of technological innovation.

The current model has generated great diversity of systems that results in high maintenance, licencing and evolution costs, which impacts both transactional and departmental solutions

The design of the Digital Health Strategy for Catalonia, now being executed, was developed in the course of one year (March 2017 – February 2018) by executives and IT managers of the Catalonian Ministry of Health and care providers, as well as clinicians and experts in health and care management and planning. The Digital Health Strategy was conceived as a comprehensive exercise with the aim of taking into account the opinions of all the stakeholders who form the Catalonian healthcare system. It was also enriched with an analysis of experiences from the international landscape. In total, almost 300 people took part in the project through different mechanisms.

Current Situation

Spain has a statutory national health system (Beveridge model), which is characterised by universal coverage and funded by the government through tax payments. Services are largely provided free of charge at the point of care whereas most pharmaceuticals prescribed require a co-payment. There are 17 regional health ministries across Spain, each having political control and jurisdiction over the organisation and delivery of health services within their respective regions.

In Catalonia, the Department of Health is the ultimate authority for the definition and planning of healthcare services in Catalonia. The Catalan Service of Health acts as the purchaser of services and guarantees quality control. At the supply side, the Catalan healthcare system is ensured by an integrated multi-provider public network. Currently, this network comprises 71 hospitals, 369 primary care centres, 96 intermediate care centres, 41 mental health facilities

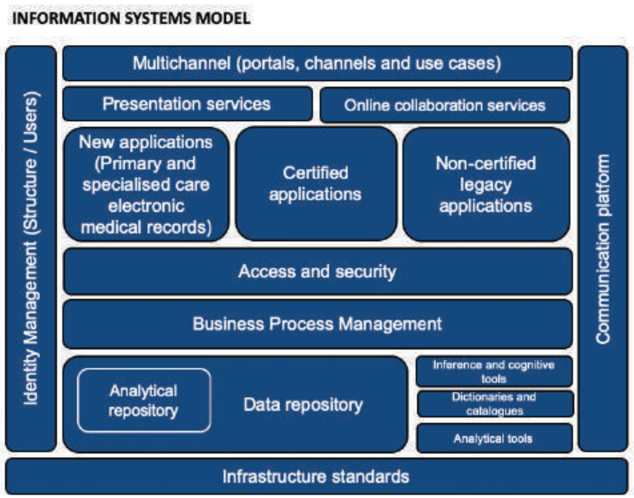

Figure 1. A Simplified View of the Electronic Health Record Model as Defined in the Digital Health Strategy for Catalonia.

and 422 resources of emergency transportation and other services (rehabilitation, community mental health centres, etc).

Even though healthcare providers are free to select their information systems and interoperability among different software, 98% of the primary care centres rely on the same system. Unfortunately, there are also some drawbacks such as the high heterogeneity of information systems in specialised care where 29 different systems coexist, which means substantial technical complexity is needed to achieve interoperability among them

The Catalan healthcare system, from an IT point of view, successfully completed what could be considered as the first wave of digitalisation. This initial phase consisted of incorporating IT within the care providers with the aim of supporting the work of professionals, namely in clinical workstations and, in large part, nursing, both in primary care and in hospitals, some departmental systems and enterprise infrastructure systems (ERP).

From an economic point of view, the current model has generated great diversity of systems that results in high maintenance, licencing and evolution costs, which impacts both transactional and departmental solutions. Local capacities of providers, especially during the recent economic recession, have also been seriously limited..

Therefore, it was necessary for the Catalonian healthcare system to urgently advance its information services and technologies, both quantitatively and qualitatively, in order to build a person-centred information system. Such a system would facilitate the continuous tracking of citizens and patients and be compatible with the professional or the provider dealing with them at a specific time. This new model should offer all the actors common and meaningful information that is relevant and of quality, and easy to record, access and analyse if needed. The management of the data and the proposed technological scheme should make possible the extension of new care models, allow the automation of bureaucratic tasks, and facilitate patients' access to their information and interaction with the system.

Key Features of the New information System Model

The longitudinal Electronic Health Record (EHR) is the main feature of the Digital Health Strategy. It represents the functional and technical repository of all the relevant information on a certain citizen that must be recorded and shared throughout the healthcare system. It is a conceptual and technological evolution of the medical records that are currently used in the systems of different service providers. A common health record scheme must take into account and align process components (how to make and register events and the route of a citizen through the health system), data components (a shared structure and nomenclature) and a technological model (how data are recorded, stored and transmitted).

Sharing more and more quality data will make it possible to interrogate and analyse large volumes of information, compare risk factors and different practices and treatments, return the results to patients, professionals and healthcare managers, improve decision-making and further move towards predictive and personalised medicine. The strategic plan foresees the construction of an advanced analytical repository for the treatment of structured and unstructured data (text, image, electromedicine devices and wearables).

The EHR also has the potential to become an integral information system that may provide value-added services to the care providers that need or wish to evolve or transform their current systems. Some of the existing systems, such as the main primary care medical record, deserve a profound technological update exercise. This update is also a good opportunity to create an integrated citizen data model that considers the vision of the individual health status together

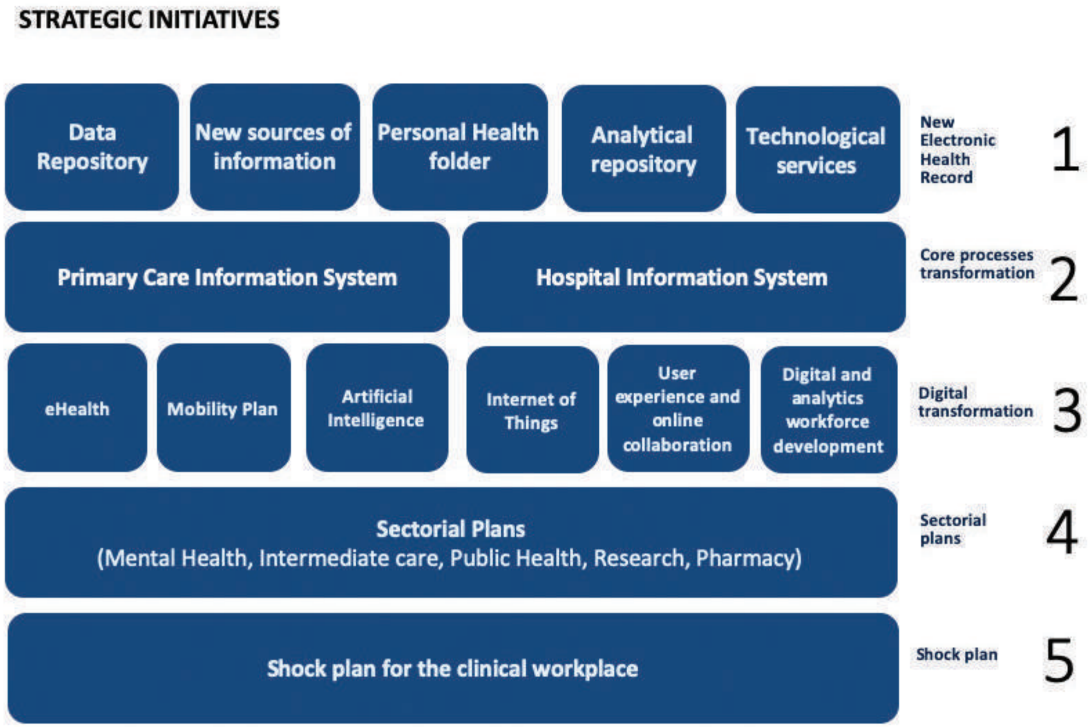

Figure 2. The 15 Strategic Initiatives of the Digital Health Strategy for Catalonia Grouped in 5 Key Dimensions.

with the logic of acute episodes, regardless of where they occur. In this way, the primary care database will become the nucleus of the central data repository, with which it will be integrated naturally.

This model ('coordinated' technologically and 'participated' in its governance) (Weill and Ross 2004) is well aligned with a health model that needs to share information and is integrating healthcare services in a region, while maintaining the institutional autonomy of service providers to design their organisational processes and structures. The new technological solutions present in the market, more modular and uncoupled and easier to integrate, facilitate these design options.

The introduction of the longitudinal EHR can be considered the second wave of digitalisation, similar to those being recently tackled by other international health systems, both vertically integrated (ie where the regulator and planner is also the owner of the service provider entities) and those where different types of providers coexist. In many cases, diversified systems facilitate greater adaptation to the way each entity works and encourage localinnovation. The healthcare sector, including the one of Catalonia, has been a pioneer in creation and application of digital transformation technologies, particularly in the field of telemedicine. Despite that, a set of factors have hampered the extension and generalisation of many valuable projects.

The strategic plan faces this status and facilitates a cooperative environment in order to foster, evaluate and extend innovation. The main objective is to provide the critical mass and the necessary economic dimension to allow the growth and use of innovation throughout the system, especially those technologies that help to redesign care processes, deploy new ones and develop the new EHR. This is the case with the Big Data initiatives, eHealth and mobility, the Internet of Things and Artificial Intelligence.

Governance

To guarantee the success of the Digital Health Strategy, a governance model of information systems is being implemented combining both executive and regulatory leadership with the participation and advice of the supplier entities, as well as the creation of communities of practice for the development of innovation.

The governance model is designed with ambition to position the Catalan health system at the level of the most advanced organisations in terms of management of data and technologies. These organisations acknowledge the strategic role of information systems in supporting and transforming their work processes and rely on data to make decisions all along the care continuum. Normally, this recognition is associated with a corporate governance of information systems, a stable and recognised management body, a top-level management role of its managers and adequate allocation of economic, technical and human resources.

In order for the strategic plan to be effective and credible, a specific funding mechanism is being processed now at the government level. The financing of investments in technology will have to be sufficient to achieve the objectives of the plan, sustainable over time and include incentives that favour the renovation of the technology park and its alignment with the proposed information model.

For the implementation of the strategy, an ambitious, but flexible and realistic executive programme has been established with the aim to simultaneously work on strategic projects that leverage change and improvements in projects and current services to make them converge with the future model, and in immediate actions and decisions, including the removal of services and circuits that do not provide value. In the short term, the aim of construction and initial launch of the central data repository is to make the information from different sources, currently stored in the system, available to the community.

Conclusion

Today, more than ever, the so-called 'digital transformation' (Bharadwaj et al. 2013) means convergence between business and organisational strategies and technology strategy, where the contribution of information technology is clearer for the creation of value.

Information technologies enable different actors in the system to optimise processes and provide much more personalised and effective care. The fusion between healthcare and information technology is transforming the quality of the patient experience at a rate previously unthinkable.

Health systems are undergoing unprecedented changes that seek to improve quality of care and maintain costs while addressing the challenges of the ageing population and the subsequent increase in chronic diseases, global financial crises, the reduction in public spending and the increase in operational costs. In this environment, digital tools and services can help to solve these problems by offering more sustainable, patient-centred solutions. Changes are massive, and the only way to success is proper information systems' strategic planning and governance.

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Key Points

- Strategic planning in the public sector is always complex. In the highly fragmented and politicised Catalonian landscape the effort is enormous.
- Multiple stakeholders (more than 300 managers, IT specialists and clinicians) took part in the design, through different mechanisms.
- Unlike other information systems' strategic plans, which are based on the automation of processes, this plan is fully data centric.
- The strategic plan aims to syntactically, semantically and technically unify the data model by building a single longitudinal Electronic Health Record.
- The plan aims to develop a common data repository and analytical services following a 'data lakehouse' approach.
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- Governance is crucial: find a balance between executive direction and industry involvement and participation.

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Novel Interventions for Early Parkinson Detection

Summary: An award-winning ICT-based early detection of Parkinson's Disease aims to support healthcare sustainability and more personalised care for at-risk adults.

Population ageing, which entails an increasing share of older persons in the population, is a major global demographic trend, which will intensify during the twenty-first century (United Nations 2013). Increasing life expectancy raises the question of whether longer life spans result in more years of life in good health (expressed via the quality-adjusted life years [QALYs]), or whether it is associated with increased morbidity and more years spent in prolonged disability and dependency (expressed via the disability-adjusted life years [DALYs] (Ezzati et al. 2006).

The main aim of i-PROGNOSIS is to create an ICT-based behavioural analysis approach for capturing the appearance of PD symptoms as early as possible

Parkinson's Disease (PD) is one of the commonest neurodegenerative diseases, affecting approximately 1% of individuals older than 60 years and 2-4% over than 75 years, causing progressive disability that results in a burden of about 2.2 million DALYs, exhibiting the greatest loss of QALYs among 29 major chronic conditions (Dorsey et al. 2007; Tanner et al. 2008). For patients with PD, there is a reduction in the brain dopamine, which controls movement and mood, so simple activities like walking, talking and writing, along with emotional stability can be negatively impacted. PD is a progressive and chronic neurological disease that often begins with mild symptoms that advance gradually over time. Symptoms can be so subtle in the early stages that they go unnoticed, as there are no PD-related biomarkers (eg blood tests) and findings on routine magnetic resonance imaging and computed tomography scans are unremarkable, leaving the disease undiagnosed for years.

Motivated by the aforementioned, i-PROGNOSIS (i-prognosis.eu) proposes an intelligent ICT-based approach for early PD symptoms detection and early intervention in older adults' everyday lives, promoting active and healthy ageing, by introducing new ways of health self-managing tools, set within a collaborative care context with health professionals. The main aim of i-PROGNOSIS is to create an ICT-based behavioural analysis approach for capturing the appearance of PD symptoms as early as possible, and to apply ICT-based interventions countering identified risks based on early PD detection, relating to progressive frailty, falls and emotional shift towards depression.

Regarding early PD detection, i-PROGNOSIS proposes a radically novel approach to capture the risk of transition from healthy status towards PD, by unobtrusive behavioural sensing and large-scale collection of seniors' data, acquired from their use of smartphones (with their permission) via a corresponding mobile application, namely iPrognosis App. This data (GData) is drawn from the population of older adults (55-60 plus years) and refers to voice/motion/typing-handwriting patterns, socialisation/life-style behaviour and selfies.

Selected seniors who, according to noticeable changes in their GData patterns, exhibit initial indications towards PD, follow more guided and controlled testing scenarios, producing additional data (SData), acquired from their interaction with the everyday Internet-of-Things (IoT) through mHealth. These include ECG/gate patterns change, bowel immobility related to increased constipation identification, food-intake curve alterations related to depression identification, and daily/nocturnal health status alterations. GData/SData-based features, ensuring users' privacy protection, are anonymised and securely stored in the Cloud for processing by advanced big data analytics and machine learning techniques in a distributed and privacy aware manner, so as to produce reliable early PD symptoms detection alarms.

Three large European PD clinics (KCL, TUD, AUTH), and Age Platform Europe (AGE) representing more than 40 million older people in Europe have so far engaged more than 2,000 individuals that are offering their GData for system development and validation purposes. This campaign is actively supported and channelled by the three participating companies with high a societal footprint (MICROSOFT, COSMOTE, PLUX). A selected subset will offer SData.

The core pipeline of i-PROGNOSIS applies novel information processing algorithms on all GData and SData cues in order to extract PD indicators that are used to instantiate our PD Behavioural Model. The latter encapsulates all the available evidence for PD prediction by means of machine learning algorithms.

Regarding the PD-related risks interventions, i-PROGNOSIS proposes a series of innovative ICT-based interventions applied to those identified by the analysis of GData/SData and confirmed by clinical data as potential or early stage PD patients according to the related PD scores (eg MDS-UPDRS, PIF, 10MW, GAS, PDQ39, GDS, BDI) (Kadastik-Eerme et al. 2015). The objective is to target as early as possible the elimination of their risks for frailty, falls and depression, as it has been proven from epidemiological studies that early intervention could have an inverse relation with the PD-related risks.

The Components

Personalised Game Suite (PGS): i) ExerGames for muscle tension reinforcement, walking pattern/posture reestablishment, ii) DietaryGames for dietary habits adaptation for reduction of constipation/depression, towards the increase of quality of life, iii) EmoGames for expressive face encouragement, natural blinking reestablishment and depression/anxiety treatment, and iv) H/VGames for handwriting pattern correction/reestablishment and hypophonia reduction.

The i-PROGNOSIS Platform is realised as an Internet-enabled sensor-based home game platform that allows remote users' participation in all aforementioned PGS programmes at any time, from the comfort of their own living room. The proposed platform includes peer mentoring and supports real-time analysis and positive feedback on the employed interaction using MentorAge sensor. Sensed data (ie GData and SData) are continuously aggregated and used as the basis for analysis to adapt and personalise the patient's PGS programme over time, with abstracted summaries provided as feedback to both the older adult and his/her attending clinician. This serves as a motivation to the older adult and helps the clinician to make more informed decisions.

Assistive interventions referring to voice enhancement and gate rhythm guidance (via vibration/metronome cueing) mobile applications that facilitate their interaction with others and foster their socialisation, as reflected to the relevant acquired daily data. In general, i-PROGNOSIS interventions assist older adults with PD to better understand and deal with their own health status in a more effective way, by reducing as early as possible the PD-related risks and increasing their QALYs. The aforementioned PD Behavioural Models are used for monitoring the effectiveness of intervention leading to possible readjustments.

The i-PROGNOSIS project undertakes initiatives that increase the awareness for the PD-related risks in a social scale, through social interventions (via the mobile phone/Internet users) for raising awareness for active and healthy ageing, fostering: a) the participation of as many as possible to volunteer as i-PROGNOSIS app users to participate in the "early PD detection initiative," further enriching the GData, and b) the construction of behavioural and socio-economic models for new cost-effective ICT-based early PD detection and intervention practices and policies, establishing appropriate recommendations to all engaged stakeholders.

In summary, the main innovative elements of i-PROGNOSIS are: i) the introduction of new early diagnostic tests for PD symptoms based on features extracted from securely Cloud-stored behavioural and sensorial data, collected by smart devices (eg smartphone, smartwatch), wearable biosensors and IoT-based everyday living sensorial artefacts, and processed by advanced big data analytics and machine learning techniques, ii) design and implementation of novel ICT-based adaptive, gamified, and personalised interventions, along with assistive interventions, taking into account older adults' physical and psychological

i-PROGNOSIS interventions assist older adults with PD to better understand and deal with their own health status in a more effective way

status, promoting his/her health self-management at the family setting by providing dynamic feedback towards the improvement of older adults' skills and functionalities for reduction of the PD-related risks of frailty, depression and falls, and iii) fostering of social awareness for volunteerism in early PD detection and construction of socio-economic and informed behavioural models for new cost-effective ICT-based PD early detection and related risks-reduction intervention practices and policies for the sustainability of health and care systems and the benefit of the older adults.

i-PROGNOSIS leverages and extends state-of-the-art technology in a number of different areas, such as behavioural, physiological and lifestyle monitoring, motion capture, physical activity evaluation, personalised gaming, home-based human computer interfaces, multi-parametric data modelling and decision support systems.

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A Winning Consortium

i-PROGNOSIS won the innovation pitch for "digital solutions" at the commercial senior health congress AgeingFit held in Nice, France in January.

The project is the result of a consortium of individuals and organisations as listed below:

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Key Points

- Population ageing and related pressure on healthcare systems is a major global trend.
- Parkinson's Disease (PD) is one of the most common neurodegenerative diseases in seniors.
- An ICT-based approach can assist with early PD symptoms detection and early intervention.
- i-PROGNOSIS deploys state-of-the-art technology in PD behavioural, physiological and lifestyle monitoring and decision support systems for improved care and use of healthcare resources.

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How Healthcare Can Unlock the Promise of Big Data

Summary: The healthcare space will not only need to change its systems, operations and infrastructure, but also healthcare professionals may have to adopt an innovative mindset to embrace the changes and challenges brought to their working lives by implementing big data.

I believe that big data present enormous opportunities in the healthcare space to improve the quality of life for patients and drive efficiencies for professionals charged with their care. With the vast quantities of data generated in the last decade, we have more insights than ever before into the best patient management and outcomes.

Somewhere in all these data are, in my view, opportunities to note trends in best practice healthcare delivery, predict epidemics and avoid preventable deaths, particularly from chronic diseases. All of this points to a more personalised level of care for each patient, with the capacity for healthcare professionals to make increasingly tailored diagnoses, thereby improving efficiency.

However, from what I've seen, there are sizable barriers to overcome in ensuring the promise of big data is brought to market to truly benefit patients, rather than remains unrealised. These barriers include the challenges of combining and analysing the vast range of different data sources across regional and national boundaries to ensure that we can make like-for-like comparisons and draw meaningful conclusions.

Big Data Present Enormous Opportunities

National health systems and databases in Europe are diverse and fragmented, and need a common data format. There are also organisational, legal and ethical issues associated with data sharing, including the General Data Protection Regulation.

Against the promise of bringing vast improvements to patients' lives, we also need to come up with solutions that address concerns of privacy and autonomy of Europe's citizens. Privacy is a very real issue, as improving patients' lives doesn't just begin and end with their health.

How do we assure ordinary citizens that their data – and in particular their medical records – are going to be used beneficially? Recent events, such as the Facebook backlash over privacy, are causing a general sense of unease. Both healthcare systems and citizens are opting out of sharing their data, suspecting they may be used for commercial purposes.

As a network, we will need to explain the opportunities that exist and then win the support of Europe's citizens. That is not a task for the innovators alone, it is a task for the industry. We need a new deal where people get not only better health for their data, but also the assurance that those will not be misused.

Privacy is a very real issue, as improving patients' lives doesn't just begin and end with their health

Last but by no means least, in my view, are the perceptions by often overstretched healthcare professionals that implementing big data will only add extra information and a cognitive burden, or even eradicate their jobs.

Initiatives Harnessing Real-World Data

EIT Health is dedicated to finding solutions that both strengthen healthcare systems and improve the lives of citizens and as such, one of our core focuses is supporting organisations and initiatives that are considering these challenges seriously and harnessing real-world data for the benefit of society. For instance, in 2018, the EIT Health Think Tank brought together more than 100 experts and key stakeholders in big data and healthcare to discuss and plan how to accelerate innovation in this area in the future.

One initiative that EIT Health has implemented as a result of Think Tank is RABBIT (Registries and BioBanks in Transition). Access to qualitative sample and data collections from registries and biobanks can give unparalleled insights, paving the way for new medicines and treatments. Discussions at Think Tank, however, highlighted that there were different rules in different countries for how they could be managed and used, resulting in hard-to-access, fragmented information. EIT Health therefore launched RABBIT to simplify this access and improve knowledge sharing.

We have also created a website, which acts as a portal holding transparent information on all biobanks and registries across Sweden, Estonia and Denmark. The goal is to eventually expand the reach across Europe. The website increases exposure for biobanks, but also improves entrepreneurs' access to big data to ultimately deliver enhanced solutions for patients.

Another initiative that EIT Health supports is 'Data Saves Lives.' It aims to raise wider patient and public awareness about the importance of health data, and improve understanding of how they are used across the continent. This initiative establishes a trusted, multi-stakeholder environment to promote responsible data use and good practices across Europe. It empowers both patients and healthcare professionals to experience how big data can

underpin the health interventions that make the most difference to the end-user.

Using AI to Fight Antimicrobial Resistance

Among other innovative projects we're bringing to market is Abtrace, which harnesses Artificial Intelligence (AI) to fight the threat of antimicrobial resistance (AMR). As certain bacteria become resistant to the most powerful antibiotics available, due to overuse and misuse, healthcare professionals are finding that infected patients are becoming harder to treat. AMR is expected to kill more people than diabetes and cancer combined (House of Commons Health and Social Care Committee 2018). The statistics are sobering: antibiotic resistance causes 25,000 deaths per year in Europe and 2.5 million extra hospital days (World Health Organization 2018). Equally alarming is the fact that 30% of all antibiotic prescriptions are inappropriate, meaning the patient will not benefit from or does not meet the clinical criteria for the treatment (Dyer 2016).

Abtrace uses AI to quickly analyse and aggregate vast sets of global antibiotic prescription data in a software tool. Clinicians can make more informed prescribing decisions, so that patients receive the most appropriate antibiotic for their particular condition.

Impact on Healthcare Professionals

I'm of the view that all of this digital technology promises to deliver significant improvements to patient outcomes. But as we've already identified, what about the healthcare professionals tasked with using the software? Are they ready for this brave new world? If not, what changes need to happen?

Lina Mosch, Director of Policy at the European Medical Students' Association (EMSA), sees a clear appetite for training in data science amongst medical students. A recent EMSA survey (2019) found that more than half of medical students consider their eHealth literacy either 'very poor,' 'poor' or 'acceptable.' Ms Mosch talks about a gap between the lack of awareness of these technologies, and the willingness of tomorrow's clinicians to be key players in big data.

To help to meet this gap, EIT Health has introduced a number of educational initiatives. One of these, Pathways, is free of charge for hospital decision-makers and trains them to use state-of-the-art tools to mine data about clinical processes in the cardiovascular field. Pathways uses algorithms to analyse data produced by recording routine processes so that clinicians can understand how to ask questions, identify methodologies and use their professional knowledge to analyse clinical processes.

Finding Encouragement in New Technologies

It's clear that for big data to become fully embedded in the healthcare space, there needs to be proper, coordinated and cross-border investment in both people and processes so that healthcare professionals feel emboldened – and not burdened by – these technologies.

Dr Umar Naeem Ahmad is both a clinician and AI pioneer behind Abtrace. He's optimistic that infrastructure barriers to adoption are being overcome: 'I see that both frontline practitioners and national policymakers are now seeing innovation as a necessity rather than a luxury. If the top and bottom are on board, it may take a little longer for management structures to roll out aspects like data-sharing agreements, payment structures for AI-related services and open, interoperable systems – but things are changing.'

Robert Madelin, Honorary Fellow of the Royal College of Physicians of London, writes in the European Health Forum about the need 'to adopt an innovative mindset if we are to make the most of innovation opportunities for better health, more resilient health systems and better patient outcomes.' With the right training and support, in my view, we may be looking at healthcare professionals who are actively involved in the design of AI-enabled technologies, and can navigate their ethical considerations.

As big data absorb more of the routine work, it is likely that healthcare professionals will have more time to devote to patients. And if more human interaction is the key legacy of this innovative new technology, surely this is something to strive for.■

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Key Points

- Big data present enormous opportunities for improving the quality of life for patients and driving efficiency for healthcare professionals and health services.
- These opportunities include: more insights into the best patient management and outcomes, spotting trends in best practice healthcare delivery, the ability to predict epidemics and avoid preventable deaths including from chronic diseases, thereby reducing spending inefficiencies and resource wastage.
- However, there are barriers to the effective use of big data, partly due to the challenges of combining and analysing data across regional and national boundaries to draw meaningful, actionable conclusions.
- In addition to the fragmentation of data formats in Europe, alongside the ethical and legal issues surrounding data sharing, there is also the question of whether already overloaded healthcare professionals are supported and trained to take advantage of these life-changing technologies.

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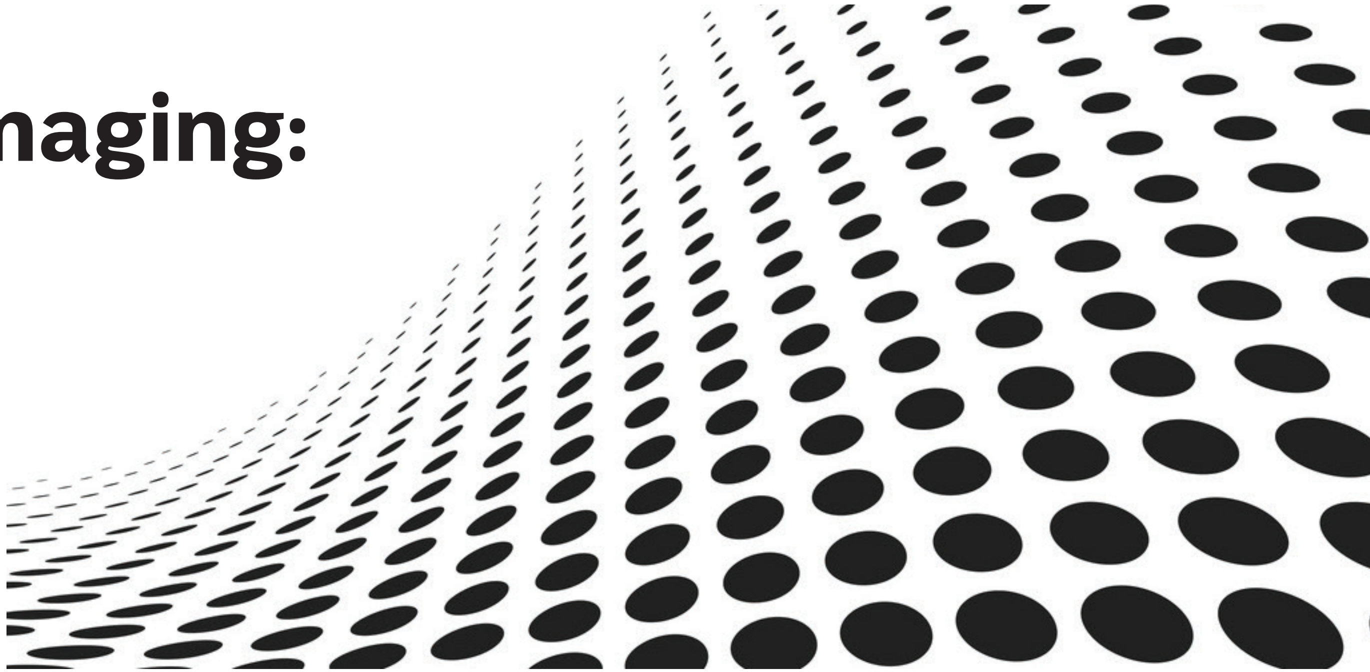
Radiomics and Imaging: The Need for Standardisation



Summary: Radiomics holds great promise for personalised imaging but without a set of standards for all modalities, the data extraction method will falter. A leading proponent of standardisation for MRI radiomics speaks to HealthManagement.org about the opportunities and pitfalls ahead

Why is it important that standardisation protocols are established for radiomics in different imaging modalities?

Encouraging recent clinical research in the field of radiomics has led to an increasing desire to translate radiomic image analysis into routine clinical practice. However, this process has to be preceded by an extensive knowledge of the robustness and reproducibility of the respective quantitative imaging features.

Unfortunately, an increasing number of studies has demonstrated so far, that these features are highly influenced by the technical settings used for image acquisition, reconstruction, and post-processing and that most of the features are not very robust when derived from images acquired with different technical settings.

As a consequence, the lack of standardisation in medical imaging represents the major hurdle for radiomics to be overcome in the future. Without achieving standardisation at the major points of the radiomics pipeline, a valid translation of radiomics to clinical practice will not be possible.

How could radiomics benefit patients?

Thanks to a large (and still increasing) number of interesting radiomics studies over the past few years, we have seen many different fields where radiomics might add information regarding diagnosis, therapy monitoring or prognosis of individual patients, thus enabling imaging to proceed on its way towards precision medicine.

The largest field in imaging, where radiomics has been widely applied so far, is oncology. We all know that most tumours are not composed by a single tumour cell clone, but rather are a "mosaic" of genetically different subclones. These subclones might also change again during therapy due to mutations. These phenomena are subsumed under the header "intratumoural clonal heterogeneity." What we currently do in radiology, is measuring sizes, at least when it comes to the standard criteria used in clinical studies such as the RECIST criteria. We all know the limitations of these criteria, and it is easily imaginable, that much information, which is in our images, gets lost while only measuring the size of a tumour. It has been shown, that radiomics might be able to detect the underlying intratumoural heterogeneity in our images and shows correlations to histopathology. Therefore, one wide field where radiomics might benefit the patient is the field of precision oncology, where the diagnostic and therapeutic management might be influenced by radiomics and where the non-invasive assessment of a tumour might become more important in the future.

Radiomics can add also prognostic information, which might benefit our patients. It is important to understand, however, that radiomics is not only applied in the field of oncology. There are various other fields, where radiomics is an interesting new aspect of imaging, such as in neuroimaging, musculoskeletal imaging or cardiovascular imaging.

I am very much engaged in the field of cardiovascular imaging and radiomics, where I am trying to improve the non-invasive diagnosis of myocardial inflammation, for example. We can show in some first proof-of-concept studies, that radiomics might add very relevant information about the (in this case inflammation-induced) inhomogeneity of the myocardial tissue, thus leading to potential novel biomarkers for a more precise diagnosis of active myocardial inflammation.

Which barriers stand in the way of standardisation in Magnetic Resonance Imaging (MRI)? How does this compare to other modalities?

The special challenge of MRI is the relative nature of signal intensities depicted on standard MR images. In contrast to the more or less standardised Hounsfield Units in CT or the absolute SUV values in PET, these relative signal intensity values with their inherent variations impose a huge problem to the extraction of standardised, robust, and reproducible radiomic features.

We could demonstrate in a phantom study, that the robustness and reproducibility of radiomic features strongly depend on the MRI sequence used for image acquisition (eg FLAIR sequences delivering a much higher amount of robust features than T1w sequences) and the used reconstruction matrix size. Thus, the large amount of available MRI sequences for different scanners, field strengths and vendors imposes a huge challenge to feature standardisation.

Currently, it is nearly impossible to perform reliable radiomics studies on MRI datasets, since the test-retest robustness (which is one of the most important factors when it comes to clinical applicability) varies so much between the various acquisition settings. In my opinion, each radiomics study in MR should include an analysis of the robustness of the used features in the selected imaging setting in order to allow the reader to assess the generalisability and translational impact of the study.

What role/s can AI, ML or even DL play a role in radiomics?

AI with its subfields ML and DL already plays a role in "standard" radiomics analyses, since the large amount of quantitative data ("Big Data") requires techniques from this field for statistical analysis. Usually, traditional statistical procedures are not capable to deal with the large amount of data, and ML techniques are required to reduce the feature set and select the most important features for a certain classification task.

In addition, ML and especially DL might be of special importance when it comes to the challenging step of achieving standardisation. Since the standardisation at the level of radiomic feature extraction appears to be challenging (at least for MRI), standardisation might be achieved through image harmonisation. First studies have been performed demonstrating the capability of DL techniques to achieve harmonisation of MR images acquired with different acquisition and reconstruction settings. This is a very interesting field, which has to be pursued in future research.

One wide field where radiomics might benefit the patient is the field of precision oncology

Finally, there is of course the possibility of applying ML/DL techniques directly to the acquired images, without the intermediate step of "handcrafted" radiomic feature extraction. In my opinion, however, this approach suffers from the same limitations as a traditional radiomics approach, and the lack of interpretability of the trained models hinders its translation to clinical practice.

What advances have you seen in the area of standardisation for radiomics and MRI and what is your view of them? Do they offer solutions?

For CT/PET-CT, the Image Biomarker Standardisation Initiative (IBSI) has been formed by Zwanenburg and colleagues, who provided valuable recommendations towards standardisation of the feature extraction process in radiomics. Unfortunately, there is no such initiative focused on MRI with its inherent challenges. That was actually the reason why my group started to focus on investigating the robustness of radiomics in MRI.

Currently, we and other groups are working intensively on this topic, potentially leading towards valuable approaches for standardisation. However, currently, there are no "ready-to-use" solutions available yet. Nevertheless, we are starting to better understand the influencing factors on robustness and reproducibility of radiomic features in MRI, and this is the first crucial step in the process of standardisation.

What role could mapping, ADC or DCE-MRI play in standardisation, if any?

Quantitative MRI techniques are extremely interesting for radiomics research, since they do not suffer from the inherent limitations of MRI sequences displaying relative signal intensities. T1 or T2 relaxation times derived from T1/T2 mapping, for example, sometimes are called the "Hounsfield Units of MRI." Thus, quantitative MRI parameters might be more robust when it comes to radiomics analyses than standard qualitative MRI images. However, quantitative MRI techniques also suffer from several unsolved limitations, which again have to do with lack of standardisation – for example, values are not comparable across scanners, field strengths or different sequences. We are currently investigating quantitative imaging techniques regarding robustness and their potential to deliver more reproducible radiomic features.

Is it possible that MRI is simply not the right modality for radiomics? Could it be better to simply have data derived from CT and PET radiomics in mind when analysing MRI images?

Yes, this is possible. If we do not manage to solve the standardisation problem, there will be too much variation in the features, which will hinder a valid translation into the real-life clinical setting.

In clinical studies, it might be feasible to adhere to constant acquisition parameters, but this will not be possible in the real-life setting. However, we are facing similar problems with CT and PET, so, I am not sure if this is true only for MRI and radiomics.

How easy is it for radiologists to train in interpreting data/images from radiomics? What sort of training would be necessary as far as MRI goes?

Well, radiomics is basically a bunch of numbers. The interpretation strongly depends on the individual disease and setting. Sometimes, it is possible that only one or two combined features allow classification between healthy and diseased, while most of the times, there is a set of several (between 5 and 20, sometimes much more) features needed for classification.

In those cases, an ML algorithm is usually trained and validated in order to perform the classification task. It appears to be feasible that in the future, once the current challenges have been addressed and the standardisation problem has been solved, these trained algorithms will be integrated into the diagnostic decision making pipeline such as in a CAD system, and the trained algorithm then classifies images into predefined categories.

To me, it does not appear feasible that the radiologist himself has to calculate a bunch of numbers, makes some advanced statistics and then combines the numbers into a meaningful diagnosis. Techniques like radiomics will only be applicable in routine clinical practice if fully integrated into the clinical workflow and automated as much as possible. This still is a long way to go.

What would you like to see in the next 2 to 5 years in the field of radiomics standardisation and MRI?

Firstly, I would be very happy to see fewer radiomics studies performed and published with poor methodology and instead adhering to the quality guidelines, which have been published in recent times. Radiomics studies with ML methodology and without at least a small separate testing dataset should not be published anymore. Of course, most of us started with small studies without any validation or testing datasets, but since there is increasing awareness of the limitations including lack of generalisability of such studies, we should adhere to stricter standards.

Secondly, I would like to see more researchers and clinicians accepting the current limitations of radiomics and the concomitant need to address the issue of standardisation. Hype does not contribute to a valid clinical translation, and if radiomics is translated to clinical practice too early without addressing the limitations, the technique will be dead before we had the chance to solve all the problems.

Finally, I would like to see more studies investigating the influence of various image acquisition, reconstruction and post-processing settings on the robustness of radiomic features and more efforts to address the standardisation problem. This might also be something, where the different vendors might contribute (but I am rather skeptical if they want to standardise their protocols and sequences). Therefore, I guess we will have to find other solutions for harmonisation and standardisation of the images underlying radiomics analyses. ■

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Hotspot: AI and Ethics in Health Innovation

Summary: AI holds great promise, yet also raises many ethical questions. The field of health and care has much to contribute to and a huge interest in the related technology, governance and regulatory debates.

Artificial Intelligence (AI) was certainly a hotspot of attention last year. It is likely to continue to attract much attention this year, even if we may be reaching the peak of a hype curve. We can expect new and amazing applications of AI in 2020, notably based on big data machine learning, as well as fundamental progress. Recent emerging and exciting areas include creative AI, scientific discovery by AI, and AI to test AI.

There may be no field that has more interest in making use of AI than healthcare, given its huge data intensity. Massive amounts of data are generated by medical imaging, hospital information systems, and recording of activities of daily life. These are all areas where today's machine and deep learning are strong. Moreover, it is in health that we already see progress that immediately benefits patients. AI is as good as world-leading doctors to determine the correct treatment for over 50 eye diseases (De Fauw et al. 2018). Health apps offer advice by a virtual doctor with the help of natural language recognition and AI-powered diagnostics. 80% of health executives think that by next year AI will work next to humans in their organisation (Accenture Consulting 2018).

Such great progress is not without significant concerns about AI. All of us have heard of deepfakes, ie AI-generated fake videos, photos and texts that are almost impossible to distinguish from real. They are spread around in order to trick us into political bias, identity theft and financial scams. Here, however, I do not intend to focus on such misuse, but rather on the more general ethical concerns with AI. Many AI and ethics frameworks have been developed. A recent analysis by ETH Zürich (Venema 2019) showed convergence around ethical principles of transparency, justice and fairness, non-maleficence, responsibility and privacy.

Putting AI and Ethics to the Test

AI and ethics frameworks are being put to the test. One of the more well-known exercises is the piloting of the AI and Ethics guidelines (European Commission 2019) of the European Commission's High-Level Group on AI. In the summer of 2019, EIT Health decided to also contribute to such piloting by running a survey and a set of case studies as reported (EIT Health 2019a) and presented at the World Health Summit (EIT Health 2019b) in October in Berlin. EIT Health is a short name for the European Institute of Technology's Innovation Community on Health and Ageing. This EU-wide initiative funds innovation projects, stimulates entrepreneurship, and advances professional education.

Obviously, but still important to recall, the health community and its researchers and innovators have much to say about ethics. Ethics is after all a key consideration in their daily health and care practice. Ethics is at the sharp edge as individuals and their lives are at stake. Perhaps less obvious is that the health innovation community is also already much engaged in AI. An estimated 20% of EIT Health activities utilise AI in some form. A conservative estimate is that this will double in the next few years.

The EC High-Level Group's AI ethical guidelines address seven areas:

- Human agency and oversight.
- Technical robustness and safety.
- Privacy and data governance.
- Transparency including traceability.
- Diversity, non-discrimination and fairness.
- Societal and environmental wellbeing.
- Accountability.

The EIT Health survey found that respondents give the highest priority to privacy and data governance (which includes data protection and access to data) as well as to technical robustness and safety (which includes cyber-resilience and reproducibility of the AI). These were followed by traceability and human agency and oversight. Not quite expected was a rather strong confidence in existing procedures and methods for accountability. Respondents also expressed needs for further clarification of the guidelines and concerns about bureaucracy.

Learning from Health and Care

Respondents to the survey also provided insight in their concrete practices. These show that ethical considerations are often part and parcel of innovation and application. These practices also illustrate ways of working with ethics (including ethics and AI) that many other sectors may not yet be familiar with. For instance, ex-ante ethical impact assessment committees and (clinical) trial guidelines. These also include ex-post deployment practices such as post-market surveillance in order to frequently monitor the performance and related ethical impact of health innovation, as well as auditing, reporting and redress procedures.

These established procedures may not always, and not by everyone, be appreciated. They can be costly, may stifle innovation, and can, at times, be gamed (Dillner 2012) or bypassed by rogue actors. Health scandals are all too familiar as are price hikes that are justified by supposedly high innovation costs. Nevertheless, ethics procedures in health and care give us a most valuable reference point for the governance of AI and ethics. Exchange between health and other sectors on best and bad practices could much contribute to building understanding of options for the practical governance of AI and ethics.

80% of health executives think that by next year AI will work next to humans in their organisation

Dilemmas

The EIT Health survey and case studies also provide interesting examples of ethical dilemmas that come with AI. Let me mention two of these: human vs machine and individual vs collective.

The human versus machine dilemma is related to safeguarding human oversight and respect for human autonomy. One fear is that human judgment gets sidelined as AI is so much faster and possibly more accurate than humans. Generally, however, respondents to the EIT Health survey stressed that – currently – AI provides an input only, while human judgment prevails. This situation must, however, be carefully monitored as it will likely evolve. Another fear is that jobs of medical professionals will be taken over by 'the machine.' That fear is not confirmed by the survey.

The second dilemma is a well-known one: the interests of the individual versus the interests of the public. It is getting more pronounced due to AI and big data. Thanks to massive amounts of data and AI, early detection of certain health conditions now becomes possible, enabling the prevention of huge treatment costs. A case study in the EIT Health report concerns brain stroke. As we are also faced with exploding health and care costs one could argue for a collective obligation to make use of such cost-containing AI analysis. But such economic-health public interest may not be enough ground to allow overriding individual rights such as personal data protection. The debate is still open!

Watch This Space

In the meantime, important developments are ongoing that should be closely watched by the health innovation community and – in my view – also actively involve that community. Firstly, in the technology realm: AI continues to develop at great speed where from a health innovation perspective we need to particularly be attentive to security and safety issues, such as the risk of data poisoning. We need to insist on improving transparency of algorithms. Most importantly, we need to resolve data access and data usage issues, from dynamic consent to dealing with heterogeneous data (in terms of their format, semantics, quality and their variability over space and time).

Secondly, industry and civil society are advancing in governance and understanding of the use and impact of AI. A range of consortia address this. A few prominent include openAI (openai.com), FutureSociety (thefuturesociety.org) and AI4People (eismd.eu/ai4people). I'd love to see such a responsible-AI platform for health innovation too! Perhaps a joint venture of WHO and innovation initiatives across the world? The opportunity but also the urgency is to develop global governance: health is after all a global common good, a shared interest that can transcend national sovereignty concerns.

Thirdly, regulatory and self-regulatory initiatives are advancing at great speed. Health innovation should be a partner in these developments. A clear majority (60%) of respondents to the EIT Health survey expect that their AI solution will require regulatory approval. Even large digital platform companies, such as Google, are now calling for regulatory conditioning of AI.

In Europe, recently the German Datenethikkommission (Data Ethics Commission) published an extensive analysis of responsible AI with an interesting five-level AI risk classification scheme. The EC's High-Level AI Group has come up with recommendations on investment, with reporting from piloting of their AI and ethics guidelines provided by the European AI Alliance (ec.europa.eu/futurium/en/eu-ai-alliance). Another expert group has analysed the impact of AI on liability regulation in Europe. They concluded that while existing liability regimes provide basic protection AI comes with potential complexity and limited predictability that make it more difficult for victims to claim compensation. The European Commission is preparing further measures, possibly also regulatory ones, on AI as well as on data access and reuse and health data spaces.

Challenges of the Year 2020

Let me wrap up by raising three issues that I would like to see addressed in 2020. First, we need to develop specific health innovation guidelines for AI and ethics. The general guidelines are very helpful but need to be tuned to the specific, high sensitivities as well as to the wealth of risk management experience in health and care.

Second, we should actively engage in exchanging insights between sectors, in order to transfer the important experiences from health and also for health to learn from the emerging and possibly more flexible approaches in other sectors such as smart mobility.

Third, a health and care innovation community, we should actively take part in shaping AI (and data) regulatory frameworks, in particular as regards governance, ie processes, procedures and authorities. We should take care to keep flexibility rather than cast governance forever into stone as I have argued elsewhere (Timmers 2019). As 'law' and 'code,' ie governance and technology, are to a degree interchangeable, we should actively stimulate technological innovation to keep governance effective, efficient and lean. This is generally true, but of specific relevance in healthcare where there are established health authorities yet where there is scope for new governance schemes.

In conclusion, 2020 will be an exciting year, a year of great opportunity and of great responsibility for the health and care innovation community to engage in responsible progress of AI. ■

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Key Points

- AI holds great promise especially for health and care, yet raises many ethical questions.
- Health and care have much to contribute on both ethics and AI, being at the sharp edge of both.
- EIT Health recently reported valuable insights on AI and ethics guidelines from its European innovation community. These include practical guidance, ways of responsibly managing risks but also ethical dilemmas and the need for further clarification specific to health and care.
- Health and care innovation should in 2020: 1) develop specific AI and ethics guidance, 2) engage with other sectors for mutual learning on AI and ethics, and 3) be part of actively shaping AI and data regulatory frameworks.

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Facing Digitalisation Head On

Summary: Healthcare digitalisation looks good on paper but putting it into practice is complex, challenging personnel, different departments, modalities and education, to name a few factors impacting implementation. HealthManagement.org spoke to two leading lights on how they think healthcare chiefs need to adapt, to successfully embrace the paradigm of digitalisation.

This question is a tough one to answer as the situation might be quite different from country to country or even between institutions, but there are already a lot of radiology chiefs embracing the paradigm of digitalisation and actively adapting their departments.

We, as a society and the radiology chiefs, need to work on implementing those changes into the educational system, while paying close attention to the different needs present in the various countries.

We need to reach out to pathologists to work on strategic interactions, as their discipline is becoming increasingly digitalised, and should join efforts towards combined training programs in the future. In addition, education in bioinformatics, data management and molecular biology is crucial for radiology residents.

Data integration systems hold the ability to become learning healthcare systems and AI based imaging analytics tools are very likely to be our future.

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Many of us have learned in biology class the notion of structure and function. In some ways, medicine itself is defined by both structure and function. The hegemony of our hierarchical medical system drives behaviour that creates the system. The chief of medicine, the senior attending, the fellow, the intern, and the medical student all have a place in this structure—this human structure. The question is how to move beyond this paradigm and drive adoption of technology that augments and may even replace the human players in this drama.

Automation, robotics, and cognitive tasks are transforming the workplace as we speak. These changes are also happening in medicine. Beyond the simple adoption of a new amplified stethoscope or advanced imaging technology, the question is more fundamental: How can clinicians establish a new perspective and relationship with technology where it becomes almost a partnership? AI offers the ability for clinicians to assimilate and process information that, in certain instances, the human brain cannot. There's just too much data coming out of the clinical fire hose.

The paradigm of digitalisation is forged out of necessity. Technological adoption is emerging as an imperative that will transform medicine and clinical practice. But as we know, adoption varies with individual and circumstance. To borrow that fearful phrase from the exam room, "this won't hurt a bit."

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THE FUTURE IS DIGITAL

1 Current Challenges in Healthcare

- Affordability
- Inequitable healthcare access
- Uneven outcomes
- Increasing demand
- Ageing population

Source: https://iii.hm/11lf

2 Facts & Figures

Findings from a 2018 study with 400 global healthcare executives found:

- Only 2% had completed their digital transformation initiatives
- Around 32% had completed them in some areas
- Approximately 54% were still piloting their transformation initiatives
- Around 23% were still in the planning stage
- 70% of the healthcare leaders said modern technologies are essential for healthcare
- 86% ranked this mission critical to success five years out

Source: https://iii.hm/11lg

3 Fourth Industrial Revolution in Healthcare

- Artificial Intelligence
- Machine Learning
- Big Data
- Biotechnology & Bioengineering
- Internet of Things
- Cloud Computing

Source: https://iii.hm/11lh

"It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change."

Charles Darwin

5 The Future is Digital

✓Smart Care - precision medicine, robotics, medical printing

✓Care Anywhere - connected homes, virtual care, broader access

✓Empowered Care – patient-centred, active decision making, data ownership

✓Intelligent Healthcare Enterprise - data-driven solutions, real-time patient monitoring, maximum efficiency

Source: https://iii.hm/11li

6 What Should Healthcare Managers Do?

-Shift focus from managing inputs to delivering outputs

-Analyse resources and identify capabilities needed to succeed in future

-Create a culture of innovation

-Focus on the patient experience

-Liberate data sources

-Invest in data standards and infrastructure

-Establish interoperability requirements

Source: https://iii.hm/11lj

4 Benefits of Digitalisation in Healthcare

→Faster access to services

→Early screening, detection, and prevention

→Better health outcomes

→Greater patient engagement

→Reduced healthcare costs

Source: https://iii.hm/11lh

Surgical Template Design and Guided Surgery with Virtual Reality in Medicine

Summary: Computer scientists in Pisa are developing Virtual Reality software that shows how 3D technology from dentistry can be applied to the imaging space.

Figure 1

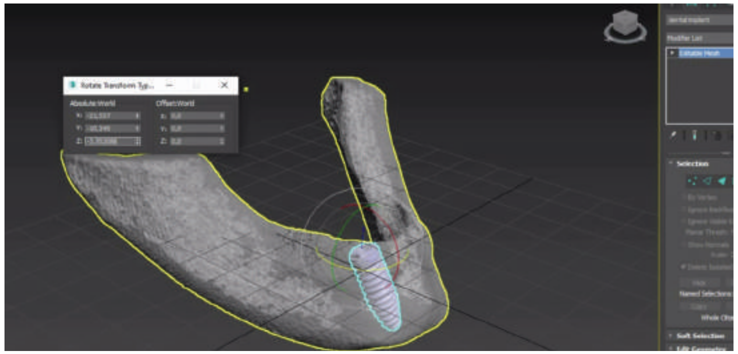

Figure 2

Virtual Reality (VR) is an increasingly applied technology in medicine and surgery. The possibility for the user to experience a totally immersive three-dimensional environment, together with real-time activity simulation, makes VR an interesting tool both for medical training and surgical planning. In the last few years applications have been proposed in several surgical fields ranging from orthopaedics to vascular surgery (Kusumoto et al. 2006; Hirsch et al. 2013; Jou et al. 2001).

The application of haptic-based simulation with VR increases the close-to-reality effect of the virtual environment, reproducing the surgical setting, thus supporting preoperative planning and improving the understanding of the procedures (Junlei Hu and Xiaojun 2018).

Most frequently, the VR system includes a haptic device to be worn by the operator, which replicates the movement on a screen (Figure 1). The higher the visual rendering bandwidth, the better the rendering, especially in cases of complex scenarios where several elements need to cooperate.

In oral and maxillofacial surgery, VR simulators have been developed for implantology, trauma, and orthognatic surgery (Junlei and Xiaojun 2018; Kusumoto et al. 2006; Hirsch et al. 2013; Csaszar and Niederdellmann 1999; Elby et al. 2017; Buchanan 2017). To our knowledge, however, VR has never been used for implant planning or for CAD design.

Methodologies

A new VR tool for addressing the latter application has been developed in which the operator represents 3D using the 3 Cartesian axes XYZ, where the z-axis indicates depth. This allows us to represent the 3 planes of space on a sheet or on a monitor which by their nature are 2D, that is, they do not have depth. In this way the operator uses a graphical representation that is difficult to manage and requires a steep learning curve so that any modification on one plane is adequately represented in the other two.

However, if 3D CAD data are converted into augmented or virtual reality by using a 3D viewer, a realistic representation is obtained that simulates reality: an object will be seen by the operator as if it were real and with depth (Chi-Hsun et al.2018; Bakr et al. 2017).

The advantage of the idea is that the STL data (files used in CAD-CAM) are converted into VR, then the implants are gripped by the operator's hands which are equipped with special sensors. The implants can therefore be positioned inside the jaw with the same ease with which a fischer-type screw is inserted into a wax structure. The position of the implants is thus planned, ie their coordinates (Figure 2), are saved and then everything is automatically converted into CAD which can be sent to anyone who wants to further view or design in a traditional way.

All this is applicable to any type of CAD, be it dental or other (eg hip prosthesis). You can draw anything immersed in virtual reality where you operate in a 'virtually analogue' manner without the mouse, but with your hands.

What is done in virtual reality can therefore be printed onsite or sent electronically to remote locations.

As it is currently designed, it can be viewed in virtual reality even through a normal smartphone: one needs merely to purchase special cardboard boxes (eg Google Cardboard) in which to insert the mobile phone that will act as a viewer, and download a free app.

This technology, which has traditionally played a decisive role in mechanical, electronic or architectural engineering, currently encompasses many branches of medicine and various applications ranging from diagnostics to surgical simulation up to the creation of custom-made prostheses or surgical devices (Csaszar and Niederdellmann 1999).

Specific software technologies are used for this purpose, proposing a workspace in which digital models are automatically created and/or imported from a real model (Aras MA and D'Souza 2012).

In the first case, the digital models are already designed in numerical format as they are created by special software capable of drawing one or more entities. In the second case, they are generated by direct acquisition of a model thanks to the use of special capture devices, such as a simple digital camera (Photogrammetry), a 3D scanner and even a common 3D medical device, such as Computerised Tomography (CT) or Magnetic Resonance Imaging (MRI) (Marchal et al. 1996; DeLorenzo et al. 2009).

A limit of this known technique derives from the need of the CAD or 3D imaging to represent objects which in real space are three-dimensional (such as for example the aforementioned display) but in a two-dimensional environment.

Although it does not require a large financial investment or expensive computers, VR in medical imaging is not widespread enough

Cross-Sector Technology

Technological improvements on-going development of better performing computers means that CAD nowadays extends to an ever wider range of sectors.

The diffusion of information technologies in multiple forms of implementation has introduced computerised design systems capable of supporting both prototyping processes and the simulation of dynamic actions more or less articulated in countless areas.

Multiple skills are contained and made available within the technology commonly recognised with the acronym CAD, which generally identifies a set of IT tools to support the design activities.

By means of the various functional units that make up the electronic processor, such as mice and keyboards, the execution of the appropriate assisted design algorithms is possible. At the same time, thanks to a series of human-machine interfaces it offers the possibility of interacting with the software in the various virtual model manufacturing processes.

Development

Improvement can be obtained by working on several planes, usually orthogonal to each other, by means of multiple views possibly displayed side by side of the objects being studied.

However, it is evident that this limit is only partially obviated, and that it becomes even more marked when in addition to simply presenting an object or a compound assembly one must also modify, assemble or break it down.

As a consequence of these constraints, the operator operates with greater difficulty, taking a long time and obtaining results of lower quality or that do not fulfil the processing requirements (Clancy et al. 2002).

The appearance of 3D design software, the ability to produce artefacts using milling and printing techniques (industrial and in-house), and the availability of digital data collection methods (intraoral scanning, CBCT) have all significantly improved to the point that a new era of dental implantology has begun (Marchack 2017; Kattadiyil et al. 2014).

Thanks to the ability to customise screens, the software can show axial, coronal, sagittal, cross sections as well as panorex and 3D reconstructions and allows users to obtain the superposition of the DICOM data with the STL files, obtained through intra or extra oral optical scans. The software allows the selection of the most suitable site, shape and length of each implant, and predicts the need for, and required quantity of, a possible bone graft (Ganz 2016; Jacobs et al. 2015).

Further progress in dentistry is represented by computer-assisted surgery. Guided implantology is the result of the combination of clinical data, three-dimensional

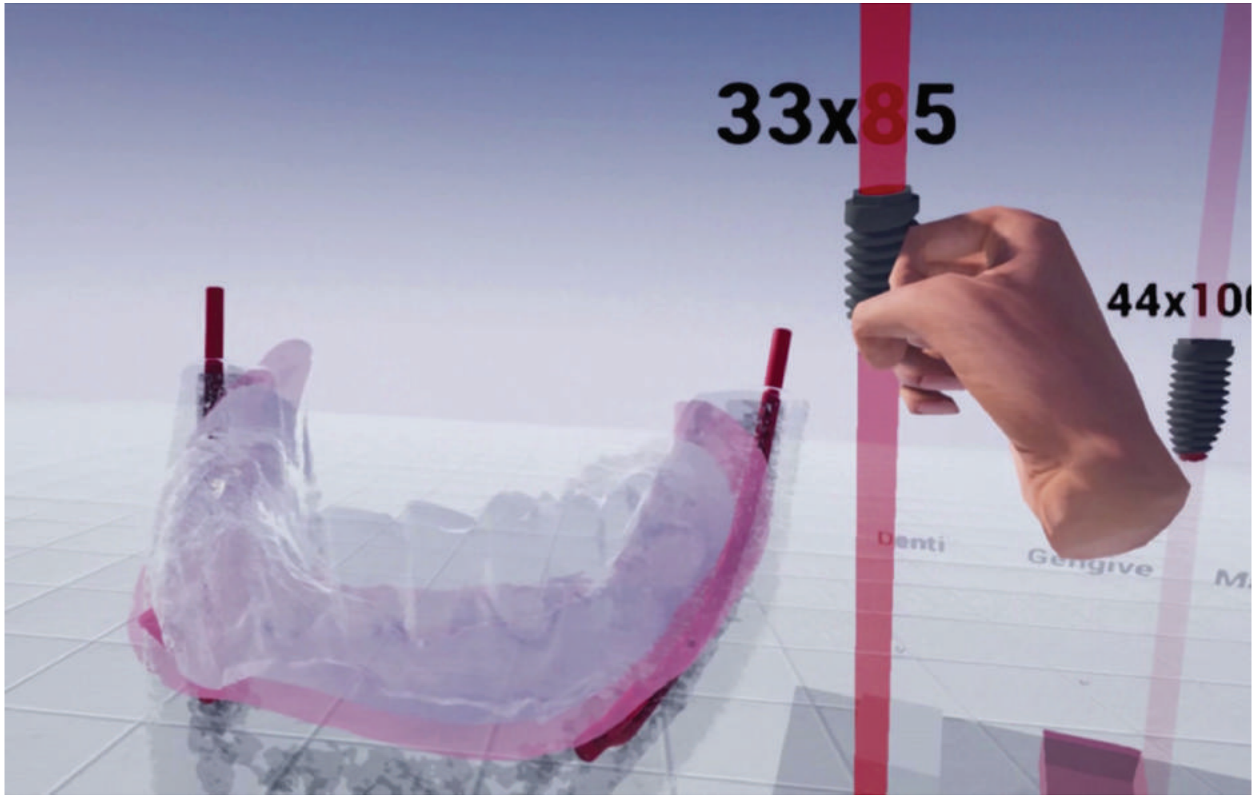

Figure 3

imaging, and CAD/CAM design of surgical guides (Kattadiyil et al. 2014).

This technique involves pre-surgical planning that is currently supported by the use of 3D diagnostic techniques for the study of bone and surrounding soft tissues in multiple cross-sectional views. It provides the possibility to first draw and then use a customised surgical template in which there are cylinders (sleeves) that constrain the direction of the drills during osteotomy and the optimal positioning of the implants in compliance with ideal axes and prosthetic components with the information of the final prosthetic drawing provided by the diagnostic wax-up (Buser et al. 2008).

Great Potential

The possibility of obtaining surgical guides and 3D models from CT images has dramatically improved the clinical precision in implant positioning with the possibility of pre-operative assessment of the size of the implant, ideal depth, and angulation (Arce et al. 2014). Moreover, prosthetically directed implant placement using dedicated software can ensure precise placement and predictable prosthetic outcomes in order to achieve aesthetic and functional success of the restoration. CAD/CAM technologies have been used to produce surgical guides (Kero et al. 2014).

The surgical template is a completely limiting guide that directs the drilling process and the subsequent implant positioning offering a significant advantage to the surgeon by improving precision and minimising complications such as mandibular nerve damage, sinus perforation, fenestrations, and dehiscences (Kattadiyil et al. 2014; Koop et al. 2013).

When working with 3D images, like CBCT, MRI, CT or CAD, it is difficult to represent the 3 Cartesian planes on a monitor. The difficulty is to build a 3D model and work on it on a two-dimensional screen (Jasinevicius et al. 2004).

Dr. Luigi Rubino introduced a software called VRubino, which simplifies a great difficulty that all physicians or CAD designers of any discipline have: designing computer interventions working with the 3 Cartesian planes but using a two-dimensional monitor, which by its nature is 2D, that is, it does not have depth. Dr. Rubino delegated the development of the software to a team of computer scientists from the ITALIA 3D ACADEMY School in Pisa.

Planning or drawing any element in 3D is very complex and it requires a steep learning curve. Understanding what happens on the x or z planes when moving an object on the y plane (or vice versa) is not so intuitive. With normal computers, the operation is lengthy and complex and it often discourages newbies.

This is why CAD drawing or implant planning in guided surgery is the prerogative of only few expert operators. On the contrary, with virtual reality, planning a surgery now becomes very simple. When the operator wears a viewer on his/her eyes and sensors with haptic-based simulation on his/her fingers, he/she can immerse into a virtual world.

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For example, the jaw that is seen by the operator wearing the viewer appears as if it were suspended in front of him/her. He/she can look at it from below or from above simply by lowering or raising it, respectively.

Thanks to the sensors in his/her hands (Figure 3) he/she can rotate it, move it or even take an implant from a library and position it with his/her hands in the ideal bone site giving it the optimal inclination on the x, y, and z axes (Ferreira 2002). This is done in accordance with the prosthetic project, ie, in accordance with the diagnostic wax-up which can be superimposed onto the image of the jaw by a simple movement of the hand. The position thus chosen can be saved and reported on the starting CBCT, after which one can proceed to the possible drawing of the surgical template, or it can be printed or sent as a 3Dfile wherever it is needed.

In other words, this method allows to 'virtually bring the operator into an analogic world' where he/she places the implants in the virtual jaw with his/her hands with the same ease with which it is possible to insert screws into a plasticine structure and then save their position.

Once the planning in VR is completed, all the obtained data is converted back to a traditional CAD CAM system, and one can proceed with the design of the surgical template and any 3D printing of what is planned.

Looking Ahead

Presently, VR technology is ripe. Although it does not require a large financial investment or expensive computers, VR in medical imaging is still not widespread enough.

Radiologists, CAD designers, dentists or anyone who has to work with the 3 Cartesian planes can easily and quickly transform the 3D digital representations into forms that are compatible with the virtual reality environment in which the visualisation, the simulation or the diagnosis is simpler.

The VRubino software has added a further new functionality: the possibility to 3D design and/or plan a guided surgery directly in the virtual environment.

It is a new, easier and more natural method that does not require a steep learning curve, it can facilitate and speed up the work of the more experienced operators and could encourage beginners to approach 3D imaging.

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Key Points

- Virtual Reality is increasingly being used in the medical setting.
- Computer scientists are developing a new VR tool for implant planning and CAD design.
- 3D design software has opened doors to a new era of dental implantology.
- Virtual Reality can improve diagnosis in the imaging setting.

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The Digitalisation of Healthcare

Summary: Where can digitalisation in healthcare be applied to yield quantum leaps in efficiency, cost-savings, patient safety and care quality?

Almost no other area in healthcare offers so much potential for increasing process efficiency, for improving medical quality as well as patient safety, and finally, for achieving sustainable economic success, as digitalisation.

In particular, applications in the area of quality assurance, knowledge management, Operation Theatre (OR) management, supply-chain management and precision medicine contribute toward process efficiency. Furthermore, digitalisation offers disruptive strategic opportunities in providing medical services globally. Mayo Clinic has announced that it will serve more than 200 million patients annually worldwide in 2020 (Dacy and Olsen 2014) through deployment of smartphone technology, internet communication and telemedicine.

Functional Areas of the "Digital Revolution" in the Healthcare System

Medical services are provided in processes that are subject to the division of labour as well as inter-sector care networks. Digital technologies enable need-oriented solutions and the provision of preventative, clinical and rehabilitative services. In three areas, it becomes evident what impacts forms of treatment, care concepts, the image of the medical profession, and the role of patients: digital health, big data and 3D printing technology. Considered in terms of IT strategy, these areas relate to the opportunities for formulation of hospital processes subject to the concept of "hospital 4.0." New diagnostic and therapeutic approaches are developed with the support of IT management in the context of a "precision medicine" approach.

Digital Health

Digital health refers to the integration of medical knowledge with IT applications or IT technologies, with the aim of improving the medical care and supervision of patients. By doing so, it is possible with a smartphone to determine, round-the-clock, whether a patient has taken prescribed medications, as well as monitor vital data, (pulse, blood pressure, oxygen satura-tion) and it is also possible to determine through body temperature and movement patterns, whether a patient has fallen down in the home.

Digital health technologies should contribute to the following:

- The elderly being able to remain longer in their familiar social environment, instead of moving to an old age home/care home.
- Enhanced compliance of the therapeutic behaviour of patients.
- Avoidance of unnecessary hospital admissions.
- A prevention-oriented way of life.

In this area, a market worth billions has developed in which players are now investing, who were not previously present in the health area (Apple with its health-monitoring watch and Google with contact lens with glucose monitoring function).

This market for digital health has revolutionised business models in the area of health insurance, as well as those related to organisational forms of medical care, and have also changed the role/relationship between doctor and patient. This is demonstrated by the introduction of an early warning system for heart patients after a pacemaker or defibrillator implant. The

CardioMessenger system for a remote domestic monitoring of arrhythmia patients contributes to avoiding unnecessary hospital admissions as well as reducing the treatment cost of patients by approximately 10%.

The savings potential through digital health is estimated at billions - particularly in the area of medication management

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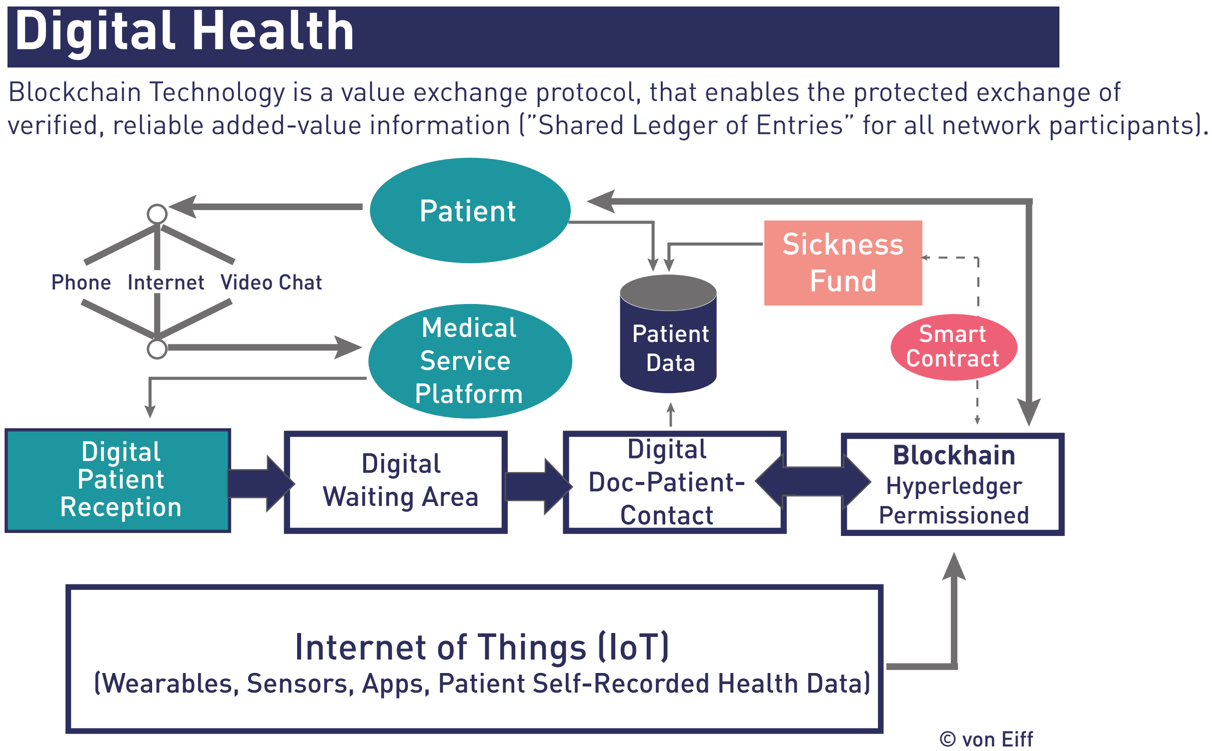

Figure 1: Digital visits and the associated data streams

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3D - Printing-Technology

3D-Printing-Technology makes it possible to build up three-dimensional work pieces made of fluid and/or solid material.

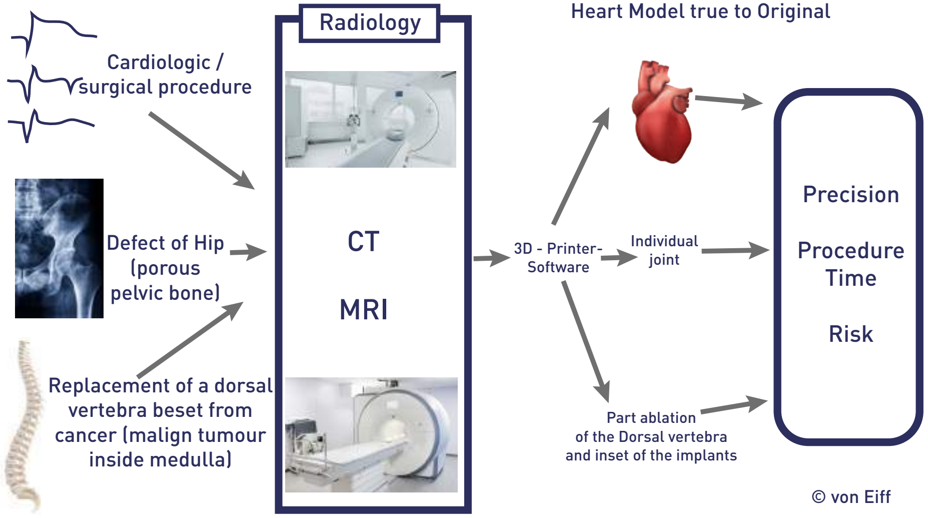

Figure 2: 3D-printing technology supports individual therapy approaches

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CardioMessenger system for a remote domestic monitoring of arrhythmia patients contributes to avoiding unnecessary hospital admissions as well as reducing the treatment cost of patients by approximately 10%.

The savings potential through digital health is estimated at billions - particularly in the area of medication management.

Digital health applications (such as acoustic reminder functions for taking medication at the right time) can contribute to raising therapy reliability as well as enhancing a prevention-oriented lifestyle (eg through glucose monitoring, or movement control).

The digital health card is another example of digital health application.

The advantages of electronic health cards can be summed up as follows:

- Increased patient safety through (automatic) reaction control (interactions) with newly prescribed medications (integration of regulatory software).
- Reduction of treatment costs of patients (avoiding duplicate examinations).
- Goal-oriented, medically appropriate treatment through the availability of laboratory findings, knowledge of previous illnesses, visual data from MRT, CT, US, OCT, etc and process controls of important parameters (HbA1c-values, left-ventricle function, blood pressure).
- Rapid availability of second opinions from specialised medical centres.
- Declining costs through a direct accounting system between doctors, pharmacies and hospitals (estimation: approximately €200mln per year) (Müller 2017), through avoiding insurance fraud (picture of insured on the card; estimation: €1bln a year) (Statista 2018). In total, experts assume that savings through electronic health cards (EHC) in the health system are achievable, which could lead to a reduction in member contributions to a level of 3.7 percentage points (Arthur De Little 2013).
- The costs of the EHC-introduction are estimated at €1.5 bn Euros (Krüger-Brand 2006).

In a digitalised "Continuum of Care," medicine comes to the patient, which is enabled by smartphone technology in combination with the telemedical infrastructure and leads to a change in the doctor-patient relationship. The Medgate approach is a good example (see Figure 1), which, via the Internet, provides the patient with the option to come into contact with an appropriate doctor for his or her particular complaint and to make an appointment directly, as well as to receive medical treatment through a teleconsultation. During this teleconsultation, health data,

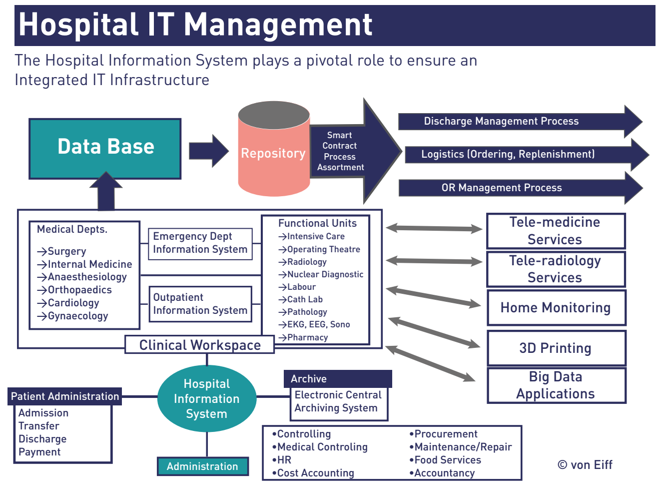

Figure 3: The clinical workplace and the central data base have a capstone function in the digitalised hospital 4.0.

including that provided by the patient (eg through Apple Watch) as well as data from the Internet of Things (Home Care Monitoring), is integrated. All data is saved securely by means of Blockchain technology. Through a "Smart Contract" function, the hospitals receive the accounting data derived from the treatment data.

Big Data

Big data, ie dealing in a structured manner with large quantities of data, makes it possible to derive information that is relevant for decision-making purposes. This can then generate goal-oriented knowledge in the shortest possible time for use in a problem-oriented and problem-solving manner.

Because of its use so far for military, secret-service or economically-oriented applications, the concept of big data tends to have a negative connotation. In the same manner, big data technology enables the development of patterns of buying behaviour of shoppers in supermarkets or book purchases from Amazon, for example

In the field of medicine, big data applications aim at:

- Raising the precision of diagnostic practice.
- Shortening the period between primary diagnosis and therapy.
- Raising therapeutic precision.

Particularly in the area of tumour diagnosis and tumour therapy, the advantages of big data become evident. For example, in order to provide a genetic sequence for the purpose of ana-lysing the genetic material of tumours within 24 hours, as well as comparing tissue samples within a maximum of two days, it is necessary to use super-fast computers. These, by means of an effective method of data compression, generate a variety of molecular biological information for generating goal-oriented knowledge.

The potential for personalised medicine (precision medicine) can only be exploited partially without the use of big data technologies.

3D Printing Technology

A 3D printer is a device for creating three-dimensional works (models, bodies, organs), which are computer controlled and made out of liquid or solid materials (synthetic materials, synthetic resins, ceramics, metals). 3D technology enables the development of complex forms, although for their manufacture, no forms are necessary and the manufacturing process pro-ceeds without material loss, because no materials are wasted in the process (screwing, drilling, milling or cutting).

3D models are useful in medicine in order to obtain a precise understanding of the anatomical particularities of an individual patient with the aim of preparing for complex operations. The production of a model (eg heart, hip, arteries), proceeds on the basis of MRT and CT data, which by means of special software is converted into a 3D model and produced by means of a 3D printer. In this manner, tailor-made, individualised heart valves, jaws, hip implants, etc can be manufactured (see Figure 2).

Examples of applications are already very convincing:

- Accordingly, there is a report of the splinting of a tracheobronchomalacia of a 20-month-old baby (University of Michigan) with the aid of a bioreabsorbing splint.
- As well as the production of individual prostheses sockets in the context of leg amputations in Uganda.

The application of 3D printing technologies (see Figure 2) offers in the field of medicine a series of qualitative and economic advantages.

In the orthopaedic area, the technology enables individual implants from 3D printers with the following effects:

- Shortening of operation time.
- Reduction in after-care and convalescence time.
- More effective functioning of implants.
- Dispensing with adhesive material (cement, screws, external fixators) in the replacement of cancerous vertebrae.

Also, for heart, vascular and neurosurgery, 3D printer models enable a precise preparation for complicated operations. Roughly 1.5-5% of the population develop an aneurism over the course of their life, in the form of a ventricle aneurism (heart wall aneurism), in other words a bulge in the heart wall as a result of the thinning of the wall tissue. Through the sack or spindle formed extension of the heart wall, the danger arises that these sack-like bulges can burst, which, for example, in the case of an aneurism in the head, can lead to death. Accordingly, an intervention is necessary. The size and location of the aneurism determine choice of therapy. Such interventions are, however, far from standard operations because each aneurism has a different structure. A working group from Hamburg presented at the annual meeting of the German Society for Neural Cardiology a method of creating original and accurate models of individual aneurisms on a 3D printer. On this basis, it is possible to test in advance which therapy is the most promising. Complicated operations can then also be tested on this model.

At the Research Centre for Medical Technology in Hamburg, as well as in the Clinic and Polyclinic for Neuroradiological Diagnostics and Intervention at the UKE Hamburg, researchers have developed a method for creating and manufacturing models of aneurisms through the 3D printer. Accordingly, the method can enable cost-effective, accurate and realistic replications of individual brain aneurisms of a specific patient, which can contribute substantially to therapy planning. The models can be used in order to determine which interventions should be used, because they can also simulate the passage through the aneurism. In addition, the exact placing for example of a platinum spiral (coil) can be simulated, and thus optimised, and finally, the operation can be rehearsed in advance.

The models may also be suitable for testing new medical products. Already, in Hamburg, the 3D models are being used for therapy planning in the context of complicated aneurisms. In a few years' time, in the view of the Hamburg researchers, all patients with complex aneurisms should benefit from this innovation.

The future vision is the production of body tissue and organs. On this basis, 3D technology will raise a series of ethical, medical, as well as economic and legal questions.

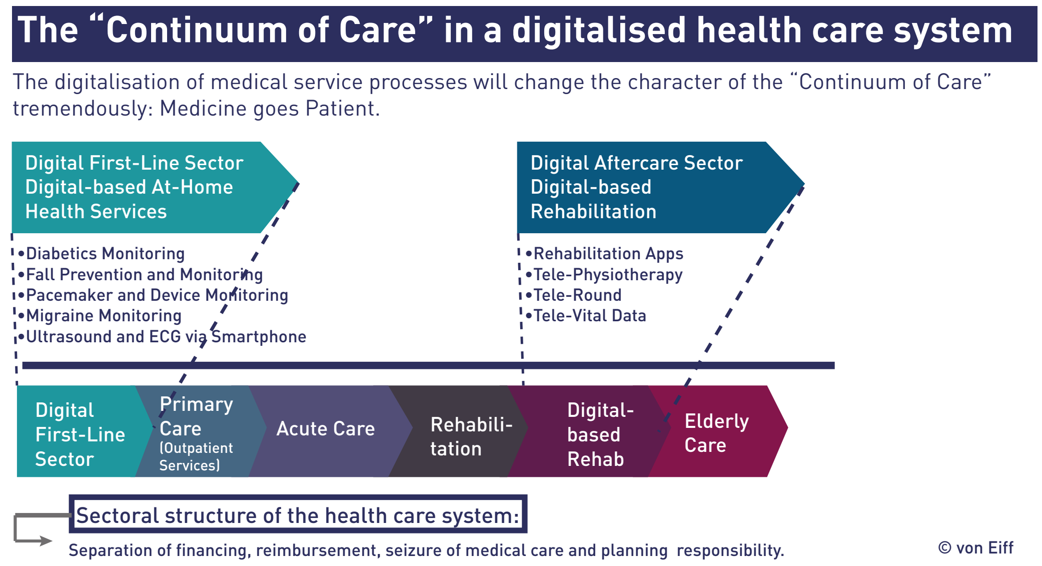

Figure 4: Digitalisation results in a new virtual sector in the health system.

POCT Technology

The critical elements of point-of-care testing (POCT) are rapid turn-around and communication of results to guide clinical decisions and completion of testing and follow-up action in the same clinical encounter. On the one hand, POCT is represented by laboratory tests directly determined at the bedside, in the emergency department, in the OR, and in the intensive care unit conducted by non-specialised hospital staff by using user-friendly technologies eg transportable handheld instruments and small bench analysers. These tests refer to rapid cardiac markers (troponin)inside the ED, infectious disease testing (MRSA, Chlamydia, Clostridium difficile), blood glucose monitoring (bedside or at home) and faecal occult biood analysis among others. On the other hand, the concept of POCT has gone beyond its use in laboratory services to also encounter technologies like ECG pulse oximeter, ultrasound and echocardio-graphy based on smartphone devices (Lumify), and patient data management systems (PDMS) as well as physician order entry systems whereby diagnostic results were presented electronically to the physician at the point of care. POCT devices contribute to enhanced clinical quality, higher patient outcome, more efficient use of resources and reduced costs.

Artificial Intelligence (AI)

AI (including the subclassifications machine learning and deep learning) in healthcare is the use of complex algorithms and software to emulate human cognition in the analysis of comp-licated medical data or of complex medical interactions in the human body. AI technology is able to gain decision-relevant information out of complex systems and recognise patterns in behaviour by using machine learning algorithms.

One aim of health-related AI applications is to analyse relationships between prevention, diagnostic or treatment techniques and patient outcomes. Furthermore, AI programmes are used to improve diagnostic procedures, to develop treatment protocols (eg in cancer therapy), and to personalise medical regimes. Also in medication management, AI applications contri-bute to enhanced patient safety, higher effectivity of therapy and cost containment when using algorithms to identify drug-drug interactions.

Using AI software in the medical area of imaging a lot of different applications will be common in near future. These include:

- The X-ray of a hand can be combined with an automatic calculation of the bone age. Skin cancer could be detected from images more accurately (detection rate 95%) by an AI software than by a dermatologist (detection rate 86%) (Esteva et al. 2017).
- AI-based thermography to detect breast cancer operates as follows:
  - works without any exposure to radiation,
  - happens without any body contact and therefore is a non-invasive and painfree procedure,
  - is a low-cost application,
  - is highly sensitive in detecting cancer in a very early stage of illness, also in women under forty years old and
  - detects the tumour before a lump is palpable.

Hospital 4.0

The digitalised Hospital 4.0 is characterised by four main elements:

- Realtime communication about clinical and administrative data between clinical workplaces, medical controlling, purchasing and logistics, as well as the finance and personnel departments. This

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Key Points

- Digitalisation will leave no healthcare area untouched.
- Effective deployment of technology will lead to a sustainable system through improve-ments in efficiency, care quality and cost savings.
- Big data, POCT technology and 3D printing are contributing toward better healthcare.
- Eldercare will benefit from integration of technology through remote home monitoring.

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The Inner Workings of a 'Smart' Hospital

Summary: For the last five years, a Belgian hospital has been searching for innovative ways to optimise their operations in care and supporting processes. From motion sensors and tablet PCs used by the cleaning service, to Bluetooth-based asset and patient tracking, to robotics and wearables – these are just a few of their promising projects discussed in this article.

AZ Maria Middelares, located to the south of Ghent, Belgium, is a medium-sized institution with 542 licenced beds and 99 beds for same-day care. 1,850 medical staff and over 200 physicians attend to 150,000 patients per year. The hospital's reputation is based on services and disciplines such as cardiology and heart surgery, its Ophthalmology Centre, its integrated Cancer Centre, physiotherapy (with interactive programmes and a spinal unit) and its Foot Centre, the biggest in Flanders.

In 2016 and 2019, AZ Maria Middelares received accreditation from the American Joint Commission International (JCI).

Leading the Facility Management and Safety domain in the hospital, I am responsible for cleaning, food/catering, stock management, medical equipment, safety and purchasing. My work contributes to different strategic objectives of the hospital, including high-tech expert care, innovation and research, quality-assured patient-oriented care, stimulating working environment, strategic partnerships and financial health.

New Chapter

In April 2015, AZ Maria Middelares moved to a brand-new hospital with high-tech infrastructure. The move had required extensive preparation and not only in physical terms. In fact, a new organisation had to be developed with new processes, functions, teams, tasks, etc, and this was initiated as early as 2012 with the focus on technology in both infrastructure and operations.

The hospital has been Wi-Fi-covered from the beginning, and at a later stage the Bluetooth network was added. The electronic patients file has been in place since 2008.

From Automated Lighting to Occupancy Measurement

Many rooms (offices, meeting rooms, waiting rooms, etc) in the hospital are equipped with motion sensors. They contribute to energy saving, eg the light is automatically switched off when no one is present in the room. This technology has been in use since 2015. Back then we didn't think that the sensors also provided valuable information, but now we are trying to utilise them in the broader space monitoring, eg to measure the space occupancy.

One novel application is in cleaning service – the sensor data provide insight into how frequently spaces are used, which ones require cleaning, etc, and our cleaning department was very interested.

In June 2019 we brought together several companies – the one that provided the motion sensors, the one that installed the automated lighting control, the building management one and the data management one – and tasked them with connecting all those elements in order to measure the occupancy of the space, from wards to toilets to meeting rooms. By September 2019, we had a proof of concept for a platform integrating all the sensors' data to optimise the use of the space through advanced data analysis. Now we are in the process of collecting the necessary amount of data to see the full picture, and once that is done, we will integrate this process into our software for cleaning.

Digital Cleaning

In 2019 we fully digitalised our cleaning services. All cleaning carts are now equipped with tablet PCs (Figure 1). There is an interactive digital map of the hospital in place. The cleaning team, therefore, has a full picture of the work needed to be done at any given moment and autonomy in planning this work. This year we will add the occupancy tracking module in their system.

It should be noted that before we introduced this technology, we had processes in place, which we first optimised through discussions with nursing and cleaning staff. These were later refined with technology increasing efficiency and helping the staff to self-manage their work.

One such process concerned discharge when a patient room needs to be cleaned before the next patient is admitted. Previously the communication was done with paper notes, by phone or email, and the system was chaotic. In 2017 we analysed and mapped the process, and together with an external partner used the data on discharges from the EHR to develop a platform. It could, on the one hand, withdraw the discharge notification from the EHR and, on the other hand, generate a prioritised task list for the cleaning staff. The communication was based on codes, and gradually the written and phone interactions were phased out.

Figure 1. A Cleaning Cart Equipped With a Tablet PC.

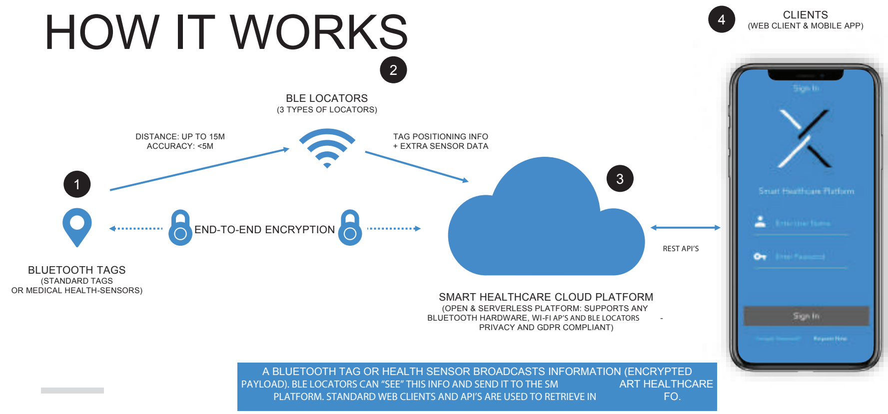

Figure 2. Smart Healthcare Platform.

Also, the system saves time since there is no need for nurses to handle the discharge reporting – it is registered automatically and can be checked in the system at any moment.

Now each member of the cleaning team can log into the system with their personal badge to see interactive floor plan of the hospital, checklists with tasks, overviews of tasks per room. Illustrations provide additional information, for example, if a 'wet floor' sign is placed correctly (see Figure 1).

The latest addition is an autonomous cleaning robot, which we call 'Broom.' We are the first hospital in the EU to have a robot assisting the cleaning staff in their duties – and they are happy to share the work with it.

Training

Another important issue is the adoption of this new technology by the staff. There were doubts initially about whether they would be able to handle the tablet PCs. However, with the internal training all of them are now not only capable to use the system but also feel very enthusiastic about it. They were trained by their own management, who also work on the floor and know the processes – this was a big advantage. Plus they now have access to the intranet, can report issues, register for additional training, etc.

In other words, the technology benefits the general wellbeing at work. There has been, for example, a sharp decrease in absenteeism rates and an increase in retention rates, and a very positive dynamic of collegiality has developed among the cleaning staff.

Culture of Help

This is part of our culture – we are not controlling, we are helping. And if you help the staff, they start helping each other. With the new system they have information on the overall amount of work and each other's workload, and the management don't need to tell them to do their job anymore – they take the initiative and work as a team helping each other. They say, "I will do the job if a colleague is busy."

Of course, this is partially due to the kind of people we hire. Good cleaning staff is really hard to find. They need to be team-oriented, friendly, willing to work. As they interact with patients, they also have to speak our language – personal contact is a very important element of the overall patient experience.

Since 2018 we have been collaborating with the state employment agency to find the right people for professional cleaning in healthcare. After recruitment and selection by the agency and a 14-day internship in the hospital, people with the right motivation and values are offered a permanent job. This process takes a lot of effort, but it is worth it – we get the best of the best. Appreciating this, we are continuously developing tools to help them to do their job, but also to ensure they like it. This is an example of not only technological, but also social innovation.

Asset Tracking

As I have already mentioned, we have a hospital-wide Wi-Fi network. It was installed in 2014–2015, and upgraded in 2019 due to security reasons. As part of that upgrade, we complemented each Wi-Fi antenna with a Bluetooth module, which allows for the hospital to have Bluetooth coverage as well. As a result, we started testing and integrating hardware and software components that can track and trace various assets in real time via the Bluetooth protocol (Figure 2).

Our first project focuses on the 2,500 surgical instrument sets. These sets are constantly circulating between the operating room and the central sterile services department, and the rotation rate of a set is very high. Sometimes the precise location of sets was difficult to identify, for example, because of incorrect labelling or storing the set in a wrong place.

We saw the asset track-and-trace system as a solution to this problem. Our options were passive RFIDs, which couldn't be used hospital-wide, or active RFIDs with Wi-Fi tags, which are expensive. Another challenge was that tags are frequently exposed to very high temperatures and humidity during the sterilisation process, so they needed to be autoclave-resistant enduring the temperature of 135°C for 1 to 2 hours.

Eventually we had found a company willing to develop an autoclave-resistant active RFID tag using Bluetooth protocol, which made it possible to be applied hospital-wide at a much lower cost.

The project began in January 2019, and by the end of Q3 2019 we had a proof of concept for the system. It enables us to track and trace any asset that has a tag on it, be it a smartphone, a keyboard or an infusion pump. The system now works for a small part of the surgical instruments sets, and in 2020 we are planning to expand it to medical equipment and other assets, to be able to locate the devices quickly and to map their utilisation patterns. Analysis of these data would allow us to better assess the equipment life cycles, manage it more efficiently, and adjust our investments.

For now the track-and-trace systems are internally-focused (we are also looking into the possibility of installing an alarm for when a tag-equipped item leaves the hospital territory). There is no tracking beyond the hospital, but we are already in discussions with partners and suppliers about using Bluetooth tags for their assets, such as carts or instruments, for us to be able to track those. For this we need to develop an open cloud-based platform to store the data, so that other hospitals and vendors could use them.

Patient Tracking

Another project being discussed with our physicians working in the operating room and surgical department is tracking of patients. Initially we want to run this in the surgical day clinic tracing as the patients come in the morning, go to the waiting lounge, prepare for anaesthesia, have the surgery in the operating room, then recover and go back home. We hope to have this system in place by Q2 2020.

At a later stage certain data points (checkpoints) can be automatically added to the EHR combined with identification by nursing staff. This would provide us with a more accurate, comprehensive real-time view of a patient's route in the hospital and help to optimise the process, eg reduce waiting times for patients and eliminate the delays caused by the manual recording of these data by the staff.

The data could also be shared with a patient's family so that they know at which treatment stage exactly is their beloved one. This is a very important and delicate task as we need to decide on the specific information we would provide to the patients and their families. We must find the most friendly and correct way to do this.

This process would be a combination of personal communication (by a nurse or a physician) and technology. On the latter part this will be done through personal health records – a secure digital platform, to which patients and their families would have access. Hopefully, we will start testing this platform sometime in June-September 2020.

Innovation Cells

Several years ago our CEO introduced what we call Innovation Cells. They are small multidisciplinary teams of innovative specialists – physicians, engineers, nursing, ICT, administration staff – that meet every two months to get new insights and ideas and give feedback. With the special innovation budget allocated, they can initiate, discuss and run various pilot projects, involving external partners if needed. Every project follows certain principles, such as ethical responsibility, safety, accessibility, and is assessed by applying five key criteria, namely:

- Better clinical outcome.
- Better patient experience.
- Higher staff satisfaction.
- Cost/benefit.
- Overall value/risk for the hospital.

At the moment there are three Innovation Cells.

Wearables/mHealth deals with biosensors (automatic EWS registration), telerehabilitation (moveUP) and smart asset tracking.

Digitalisation/automation/robotics focuses on automatic guided vehicles (AGVs) for delivery of goods, medication or operating sets as well as patient transportation and drone deliveries; 3D printed implants; and robotic process automation (billing and biotech records).

AI/Big Data/AR/VR is involved in development of a virtual hospital (virtueelziekenhuis.be); the Hololensproject

(holographic animation used to provide additional visual information during procedures and for patient education); and medical data warehouse among others.

One of the recent discussions in Innovation Cells concerned automation; there was a presentation on introducing robotics into our logistics. AGVs are already in use in many hospitals around the world, eg in Italy, the Netherlands, the U.S., but usually those hospitals have been specifically designed with AGVs in mind. That is not our case, so we need to find a tailor-made solution and at the same time introduce some substantial technical adjustments, such as in lift and door design.

Wearables

Following the initiative of an Innovation Cell, we have also partnered with a company to introduce wearables into the clinical assistance process, for an early warning score (EWS) procedures automation. Since 2012, every patient's vital signs, such as respiratory rate, temperature, blood pressure, pulse/heart rate, AVPU response, are systematically monitored three times every 24 hours. If the patient's condition deteriorates, the measurements are performed every 30 minutes. Thus we always know the status of the patient and are able to identify trends and predict whether a crisis is coming.

The wearables pilot project is implemented among patients with EWS scores of 3 or 4, of which approximately 22% usually are directly transferred to a higher level of care – this is currently the best, but also the most expensive solution. And we hope that wearables would help us to decrease this share as they allow for the patient to be constantly monitored while being in their ward. Over the last five years, we have managed to decrease the number of reanimations by 80%. The irony is that we are losing financially as a result, no longer being paid for these complex procedures. But the quality of care always comes first for us, so we view it as a benefit.

In addition, wearables provide more freedom to a patient (eg for an independent visit to a toilet) and simultaneously unburden the nursing staff, who no longer need to neither perform the time-consuming measuring procedures nor frequently accompany the patients, and let them optimise their schedules. Wearables also alleviate stress in patients who know they are being constantly monitored.

The fact that the data from wearables are automatically recorded in the EHR means that chances of errors or misinterpretation are nil, and hence the overall risk is decreased. In the future we plan to install dashboards to have the overview of all these data. Another addition is a contact-free monitoring system (a membrane plate with sensors) to detect the motion-related fall risk in immobilised patients and provide continuous control with a more limited number of parameters. We have been testing it since Q4 2019 and are now expanding it.

Smart vs. Traditional

There is a fine line between traditional and smart building management. There are systems which measure temperature, humidity – we think of those as traditional systems. However, you could extract the data from those systems and apply it in a novel, 'smart' way – such as we do with the occupancy measuring project. Smart building management is more about work processes and experiences, and the means used for their optimisation could easily be found in traditional systems. In other words, traditional and smart become integrated to improve overall experience for patients, visitors, staff, etc.

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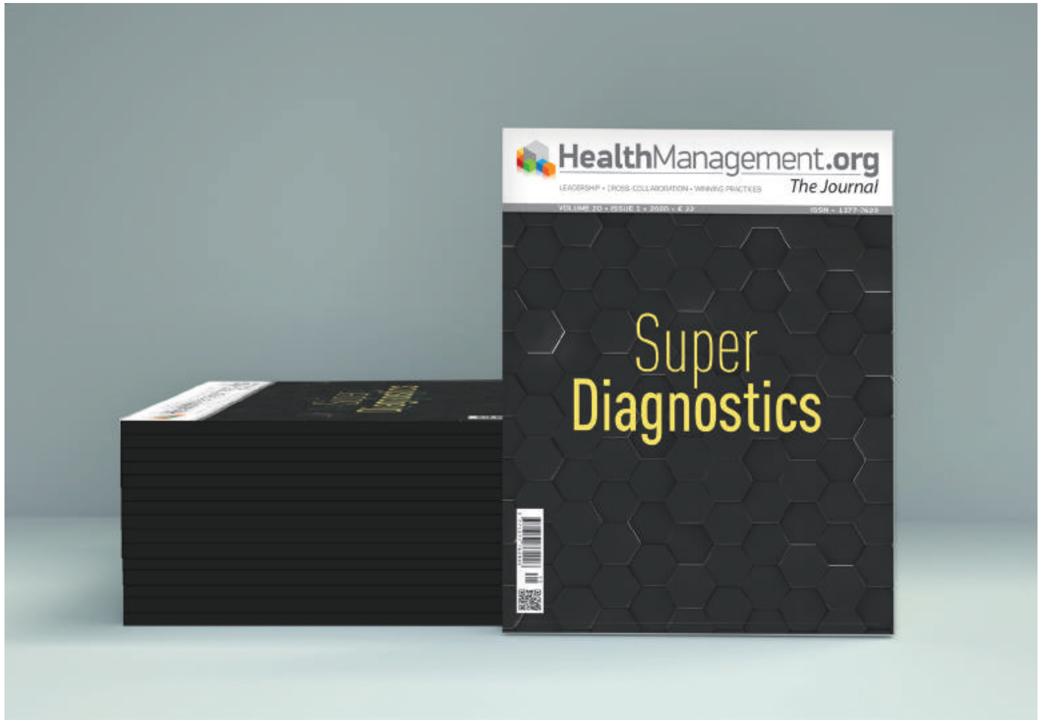
Key Points

- Moving to a new hospital was not only physical but also required a profound organisational change.
- The motion detection system will be used to measure the occupancy of the spaces. These data will help the cleaning service to have a clear view of the workload.
- Cleaning staff were successfully trained to use the new digital system. The technology also inspired the development of a culture of help among them.
- Asset tracking promises to become a solution to a number of issues in the hospital. Bluetooth tags allow to use the system hospital-wide and to scale it beyond the hospital walls.
- Patient tracking is hoped to optimise the clinical assistance and provide data to be shared with patients and their families in a friendly and considerate way.
- Three Innovation Cells are an effective way to test innovative solutions. Latest examples include introducing AGVs and using wearables for patient monitoring.
- Smart building management is not an isolated practice. It is built upon and tightly integrated with traditional management systems.

Upcoming Issue

Cover Story: Super Diagnostics



Recent advances in technology have led to a major shift in prevention, diagnosis and treatment of disease. A one-size-fits-all approach is moving towards a personalised patient pathway. Genomics, preventive lab tests and personalised treatments have created new dynamics. In this issue, we will explore how the entry of major players like Amazon, Apple and Google into healthcare will play out and how fast will we see progress. What fresh ideas and diagnostic solutions will change the game? This and much more in Super Diagnostics!

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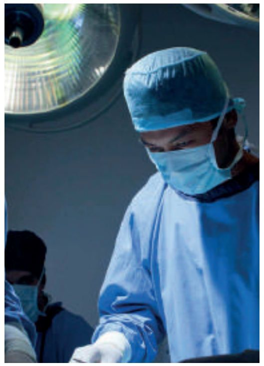

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