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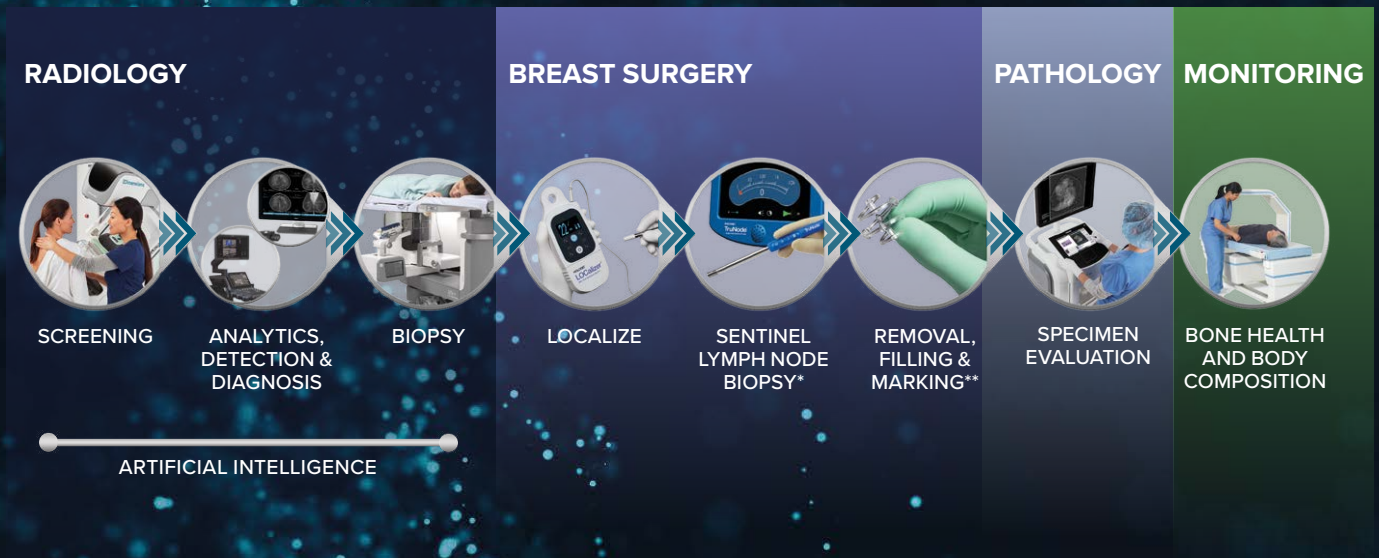

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Editorial

Prof Lluí Donoso-Bach
Head of Diagnostic Imaging
Hospital Clínic of Barcelona
University of
Barcelona, Spain
HealthManagement.org
Editor-in-Chief, Imaging

Health and the City

The COVID-19 pandemic has made it abundantly clear that healthcare systems worldwide need significant transformation and change. There is an urgent need for new models of care to improve patient outcomes and be better prepared for future health crises similar to the recent pandemic.

With the increasing prevalence of chronic disease and a consistent increase in urban population worldwide, the goal of healthcare systems should be to build healthy cities that have the ability to create physical and social environments that are designed to improve public health. It is time to use technology to build smart cities and provide care beyond the hospital walls through tech-driven solutions supported by enhanced community care.

In this issue, our contributors explore how healthcare systems operate in the wider urban context and analyse the challenges and opportunities of interconnected systems. They discuss the concept of healthy cities and how the process will require collaboration, integration and participation from government agencies, policymakers, healthcare organisations, investors, public and private health sector and patients.

Seet Cher Lui Stephanie and co-authors talk about Clinic Without Walls, a strategic innovation programme that aims to redesign care, digitalise processes and transform the healthcare workforce to deliver person-focused care beyond clinics into the community. Nimish Biloria and co-authors explore the intricate connection between our built environment and a techno centric approach to distinguish health and wellbeing from a multidisciplinary perspective while Henrique Martins discusses home-based, patient-centred healthcare and the role of emerging connected technologies such as smartphones and wearables and Ambient Assisted Living technologies and solutions.

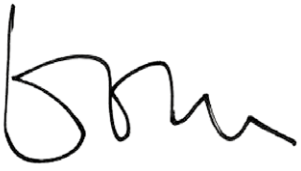
Simona Agger Ganassi discusses the importance of integrated care and the need for cooperative creation of healthy cities and urban environments based on social equity, inclusion and health support for all. Ana Rita Londral and co-authors talk about CardioFollow.AI, a real-world pilot programme to improve patient safety and remote surveillance of cardiothoracic surgery patients.

Massimiliano Claps, Nino Giguashvili and Louisa Barker highlight how cities and their ecosystem partners can enhance their resilience by leveraging data and digital technologies to predict, prevent and respond to health risks, while Chris McCahan offers insights on how private healthcare companies can succeed commercially in the long term when operating in a low-income setting.

Daniela Pedrini is in the Spotlight in this issue as she talks about healthcare's response to COVID-19, climate change, changes that healthcare systems need to make and how healthcare architecture will take shape in the years to come.

We hope you will enjoy this issue. As always, your feedback is welcome.

Happy Reading!



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Contributors

Salomé Azevedo,
Portugal

Salomé Azevedo is head of Digital Health in VOH.CoLAB. She holds a MSc in Biomedical Engineering and is a PhD student in the Engineering and Management Programme at IST, Lisbon University, exploring the determinants of digital technology, its innovation risk and impact in healthcare, and developing other theories and strategies that would overcome the obstacles inherent to this sector.

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Lluís Donoso Bach,
Spain

Prof Donoso Bach is chairman of the diagnostic imaging department at the Hospital Clínic of Barcelona and Professor of radiology at the University of Barcelona. He has served the European Society of Radiology in various capacities, including as President in 2015–2016.

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Louisa Barker,
United Kingdom

Louisa Barker is a Research Manager in the European IDC Government Insights team, leading research on smart, sustainable, and resilient cities and communities. She has international experience providing analysis, policy advice, and consultancy to the public sector on disaster risk management, urban building and planning regulation, and smart cities.

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Xavier Battle,
Siemens Healthineers

Xavier Battle is the head of Marketing and Sales for the Digital Health Business Line for Siemens Healthineers where he has responsibility for the global digital health commercial operations. Xavier trained as an engineer in the Ecole Centrale in Nantes, France, has a Ph.D. in Biophysics and an MBA.

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Nimish Biloria,
Australia

Nimish Biloria is an architect and emergent technologies and design specialist with over 16 years of experience in the emergent technologies and transdisciplinary innovation sectors across Europe, Asia, and Australia. He works at the University of Technology Sydney (UTS) as an Associate Professor. His areas of research include empathic environments, the study of human-environment-interaction with its underpinnings in urban science and human computer interaction.

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Massimiliano Claps,
Italy

Massimiliano (Max) Claps is the Research Director in European IDC Government Insights team. His research empowers technology suppliers and public sector professionals to embrace disruptive technologies such as artificial intelligence, edge computing, and cloud, to realise the benefits of strategic initiatives such as smart cities and citizen-centric government services.

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Pedro Coelho,
Portugal

Pedro Coelho graduated from Universidade de Coimbra in 1993. From 1996 to 2002, he completed his residency in Cardiothoracic Surgery. PhD in Medicine in 2019 with a thesis on "Cost-Benefit Analysis of Cardiac Surgery in patients over 65 years of age". Since October of 2019, Pedro is responsible for the management of the Cardiothoracic Department of Hospital de Santa Marta, Lisboa.

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Miguel Fornes,
Spain

Miguel is a consultant in digital marketing in the technology sector in the development of B2B marketing campaigns and lead prospect generation. Previously, Miguel developed his work in the commercial development of GIS projects and more recently in the development of conversational technology for the tourism sector.

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Simona Agger Ganassi,
Italy

Prof Ganassi has over 12 years of experience as member of the Ministry of Health Evaluation of Health Investments Team. Other areas of expertise include strategic planning, hospitals and energy, health urbanism and public procurement of innovation for the health sector.

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Nino Giguashvili,
Czech Republic

Nino Giguashvili, is a Research Manager at IDC Health Insights for Europe. Her core research covers key ICT developments and trends in European healthcare and life science markets, analysing key technology and business issues facing healthcare payers, providers, life science companies, and their ICT vendors, offering in-depth insights into the primary factors shaping the industry.

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Hwee Ching Lee,
Singapore

Lee Hwee Ching, a public health physician, is the Director of Operations in Tan Tock Seng Hospital. She currently leads the operations for the Division of Medicine, as well the strategic planning and development of ambulatory services in the hospital, including specialist outpatient clinics and the masterplan for the Medical Centre.

332 Clinic Without Walls (CoW): Care Anytime, Anywhere

Michael Leng Chew Leow,
Singapore

Michael Leow is the Assistant Chief Operating Officer (Patient Operations) at Tan Tock Seng Hospital and Central Health. He plays a key role to help define the vision and mission of care delivery and strategises the approach on care management to provide quality healthcare services through sustainable and cost-effective models.

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Ana Rita Londral,
Portugal

Ana Londral is director of Value for Health CoLAB and researcher in CHRC, Nova Medical School, Lisbon, Portugal. She studied Electrical and Computer Engineering at Instituto Superior Técnico and holds a PhD in Neurosciences from the Faculty of Medicine, University of Lisbon. She has collaborated in R&D activities with many international organisations to develop digital health systems and assistive devices.

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Contributors

Henrique Martins,
Portugal

An Internist MD and Management PhD, Henrique Martins headed SPMS (Portugal) leading numerous nation-wide eHealth projects and co-chaired the EU eHealth Network. He is an Associate Professor at ISCTE – University Institute of Lisbon in Portugal, where he teaches and consults on Digital Health, health transformation, management and leadership. Henrique Martins is also an Editorial Board member for Health Management – IT.

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Jaime Garcia Marin,
Australia

Jaime Garcia is a senior lecturer in Games Development at the University of Technology Sydney (UTS). His research interests lie in exploring the use of interactive video game technologies as a tool to improve physical and mental health of the elderly. He holds a PhD in Software Engineering and Information Systems and a BSc in Computer Science and Engineering.

336 Urban Health and Wellbeing in the Contemporary City

Chris McCahan,
USA

Chris McCahan is Chief Investment Officer and Global Sector Lead for healthcare and education services at International Finance Corporation (IFC), a member of the World Bank Group. For almost two decades, Chris has appraised, structured and led negotiations for complex and innovative investment transactions in many parts of the world.

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Sergey Morozov,
Russia

Sergey Morozov is a Professor of Radiology, expert in clinical imaging, healthcare management and informatics. He is also the Chief regional radiology and instrumental diagnostics officer, Ministry of Healthcare, Russia and the CEO of Diagnostics and Telemedicine Center, Moscow.

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Yih Yng Ng,
Singapore

Yih Yng Ng is an emergency and public health physician with Tan Tock Seng Hospital as well as the HomeTeam Chief Medical Officer, Ministry of Home Affairs. He currently leads the Digital and Smart Health Office of TTSH and the Central Health region as Associate Clinical Director of the Ng Teng Fong Centre for Health Innovation to lead digitisation efforts across TTSH and the Central Health Region.

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Sourabh Pagaria,
Siemens Healthineers

Sourabh Pagaria is responsible for Siemens Healthineers' business in Southern Europe. He is a thought leader on how data, Artificial Intelligence and joint public-private approach can reshape the future of healthcare.

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Daniela Pedrini,
Italy

Daniela Pedrini is the President of Italian Society for Healthcare Engineering and Architecture (S.I.A.I.S.) and President of International Federation of Healthcare Engineering (IFHE). She has a long career in the health sector, with important roles in the management of technical aspects of the hospital. She has been honoured with a medal of the Italian Republic Order of Merit.

344 The Future of Healthcare Architecture and the Battle Against COVID-19 and Climate Change

Hamish Robertson,
Australia

Hamish is a geographer with experience in health, ageing, disability and multicultural issues. He is interested in spatial science applications in the health, ageing and disability sectors including spatial visualisation as a tool for collaborative research and analysis. Other areas of interest include big data, health informatics, race, diversity, cultural heritage issues, and antimicrobial resistance.

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Alessandro Roncacci,
Affidea

Alessandro Roncacci joined Affidea in 2019 as Country Clinical Director. Since June 2020, he took over the role of Chief Medical Officer Interim for Affidea Group. Dr Roncacci has 15 years of experience as radiologist and holds a Ph.D. in Surgical Physiopathology and Gastroenterology and a master's degree in Healthcare Management.

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Jorge Pinheiro Santos,
Portugal

Jorge Pinheiro Santos graduated from NOVA Medical School in 2014. In 2016 he started the residency of Cardiac Surgery at Hospital de Santa Marta, Lisbon. Jorge completed the Harvard Medical School - Portugal Clinical Scholars Research Training (2007-2019) and is currently. Currently enrolled in the PhD Programme in Health Sciences of NOVA Medical School/UN.

361 CardioFollow.AI - A Digital Follow-up Service Expanded Beyond the Hospital Walls

Stephanie Cher Lui Seet,
Singapore

Stephanie is the Assistant Director overseeing the masterplan for Tan Tock Seng Hospital's Medical Centre, spanning 36 specialist outpatient clinics and ambulatory facilities. She is a public health professional with more than a decade's experience in health policy and management, as well as community care services.

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Wendy Hui Zhong Tan,
Singapore

Wendy is the Manager of Operations of the Medical Centre Masterplan team that has overseen the transformation of the Medical Centre since 2009. To date, she has completed the renovations and setup of 20 Specialist Outpatient Clinics and has spearheaded the beginning of Tan Tock Seng Hospital's outpatient clinics digital transformation journey with mobile registration.

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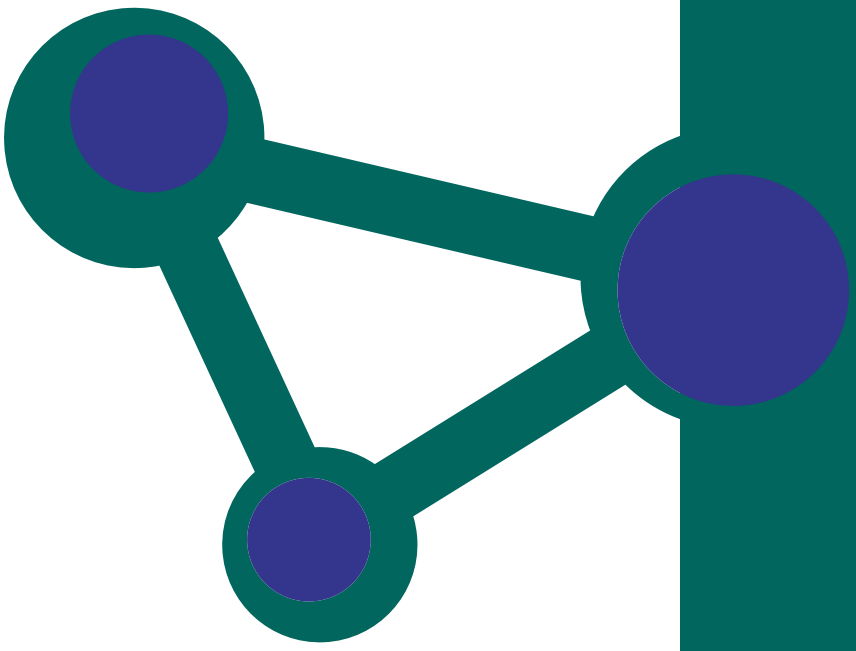

MANAGEMENT MATTERS

"A common thread in our research is that it is important for companies to search outside their own structure for new ideas to grow, innovate, and improve." *page 323*

How to Make a Sustainable Healthcare Business in a Low-Income Setting

Author: **Chris McCahan I Chief Investment Officer and Global Sector Lead I Healthcare and education services I International Finance Corporation I** Washington DC, USA

Investor Chris McCahan offers insights from recent client case studies that shed light on how private healthcare companies can succeed commercially in the long term when operating in a low-income setting. Some tips? Look beyond borders for the best global practices, align the company's mission with broader public health goals, and be open to innovations.

Key Points

- Companies should search outside their own structure for new ideas to grow, innovate, and improve.
- Achieving—and sustaining—high standards require continual investment, recruitment and training.
- Patient and customer needs are never static and it is always possible to find a better way of meeting a need.
- It is in private healthcare organisations' best interest to integrate within the broader health system in which they operate.

What are the key ingredients to success for private healthcare companies operating in low-income settings? At International Finance Corporation (IFC), the division of the World Bank Group that invests in the private sectors of emerging markets, this question is existentially important as we invest only in businesses that we believe are commercially sustainable or can become so with the right support and decision making.

We recently published some client case studies that offer some pointers. A common thread in our research is that it is important for companies to search outside their own structure for new ideas to grow, innovate, and improve. For example, one of our Latin American investees, Conclina, the largest private hospital in Ecuador, has worked consistently at improving the quality of care it provides. The hospital's founding leadership has sought to identify and align with global best practices, which has helped focus the hospital on what needs to be done to ensure the highest standards of care for patients.

In 2011 they became the first healthcare provider in Ecuador to gain Joint Commission International accreditation. Currently, they are adopting a newer set of global standards, Planetree, that seeks to embed patient-centred care and wellness.

"It is difficult to achieve high standards, but it's even more difficult to sustain them," Conclina's Director of Quality and Operations, Monica Lana, said. "You have to keep investing, to keep everything new and updated. You have to recruit and train people continually. You have to update the medical equipment, and that means updating your electric power and communications infrastructure, because the new equipment requires it."

For Nyaho Medical Centre, a family-owned business in Ghana comprised of a hospital and four satellite clinics, this has meant following an innovation process known as 'design thinking', developed at Stanford University. The company's managing director, Dr. Elikem Tamaklo, explained that this involved always finding a better way of meeting a need, understanding that these needs are never static. Nyaho has been applying design thinking to make various improvements and overhauls, from how their medical equipment is maintained to installing a new IT system, to designing a new

maternity and paediatrics centre.

Another client, Tanzania-based medical equipment distributor Pyramid Group, has invested a great deal of time and money in enhancing its expertise in equipment maintenance and repair. Pyramid sent its technicians to the plants of large medical equipment manufacturers in Europe and the United States for high-level training. Having to budget travel, accommodation, and training costs for dozens of staff was not easy, but they decided it was necessary to maintain quality and grow their business.

Hospitals and clinics in Africa tend to be wary of making medical equipment purchases, partly because the equipment is expensive to maintain and requires specialised knowledge. Without ongoing financing for maintenance, and with difficulties finding people who know how to maintain the equipment, healthcare providers can end up with machinery that they cannot use after a few years. Pyramid sought to change that by building a reputation based on excellence in after-sales service, so that hospitals and clinics may then recommend them to their networks, enabling the company to expand its customer base, the key being to build customer trust.

Another ingredient for sustainable success is for private healthcare organisations to effectively integrate themselves within the broader health system in which they operate. For example, at the start of the pandemic Nyaho stepped forward to assist in the national effort, becoming the first government-approved private facility in Ghana for testing COVID-19 patients. Nyaho's Dr. Tamaklo said the company also used their communication channels to educate the population on COVID-19 hygiene, mask wearing, and social distancing. "The frontline against the virus is not the private sector or public sector. It is really just the front line," he said.

We will have more case studies in the months ahead and I hope to be able to share additional insights. It is clear that for private healthcare organisations operating in emerging markets, the key to commercial sustainability is fostering long-term relationships with patients, customers, communities, and public authorities. And that these relationships should be grounded in their confidence that your overarching goal is to provide quality healthcare.

For private healthcare organisations operating in emerging markets, the key to commercial sustainability is fostering long-term relationships with patients, customers, communities, and public authorities

Conflict of Interest

None. ■

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SPOTLIGHT

"We live in unprecedented times, and we share two key challenges that face our world: the pandemic and climate change." *page 328*

The Future of Healthcare Architecture and the Battle Against COVID-19 and Climate Change

Author: **Daniela Pedrini | President | International Federation of Healthcare Engineering |** Italy

The COVID-19 pandemic presented a major challenge to healthcare systems across the globe. As the world continues to fight this battle during the fourth wave, HealthManagement.org spoke to Daniela Pedrini, President of the International Federation of Health Engineering (IFHE), on healthcare's response to COVID-19, changes healthcare systems need to make to be better prepared for such challenges in future, how healthcare architecture will take shape in the years to come and why the world needs to focus on two key challenges - the pandemic and climate change.

Healthcare systems around the world have experienced a significant jolt because of the COVID-19 pandemic. Why do you think healthcare was so unprepared to handle such a crisis?

It is impossible to give a comprehensive answer to such a complex issue. The striking aspects are the rapidity of the COVID-19 pandemic diffusion, the duration of its impact, the global similarity of its effects, and the continuous development of variants.

For technical people like me, who have spent a great part of their professional life working side by side with the medical staff of hospitals and researchers, the first reaction was to ask "expert colleagues" why we were so unprepared and what could be done to make a fast and efficient comeback.

The difficult questions led me to search for a better understanding of studies and scientific publications. My first surprise was finding many publications in the recent past that highlighted the risk of the upsurge of a "new" pandemic. Hence, it is important to underline that there already was a scientific awareness of the great danger. Furthermore, some of the alerts were specifically addressed to the highest levels of governments and institutions in charge of the common wellbeing and safety of citizens.

As an example, in the July/August 2005 issue of the Journal of Foreign Affairs, Professor Michael T. Osterholm, of the University of Minnesota, Director of the Center for Infectious Disease Research and Policy, and now nominated as one of the scientists working in the team created by President Biden, alerted global governments to get prepared for a pandemic that would hit many countries in a few years. Before that, in May of the same year, Prof Osterholm had sent the same message to his colleagues in the article "Preparing for a new pandemic" published in the New England Journal of Medicine.

He was not the only one sending those warnings, but I mention him because he was among those who did not keep their perspectives only in the inner scientific circles. He went as far as to also alert global leaders.

I believe the answer to the question you have posed should be searched in global terms in the mechanisms that almost universally transfer/filter/interpret reality and real needs into government programmes and actions, with obvious differences and shades, all over the world. Differences and shades that, needless to say, account for the gravity of the impact with which COVID-19 has marked its presence in different parts of the world and among different nations.

To this general view, I would like to add something specific to the Italian situation. The unpreparedness in my nation has especially been the result of decades of basically playing down the multifaceted importance of the health sector. Health services and supporting infrastructures were considered

as an economic burden. Allocations of funds to the sector were progressively reduced or at least not increased in proportion to the demand for healthcare. Hence, when the pandemic hit our nation, we were not only surprised, but we also had to make all kinds of efforts to adapt and/or produce the necessary territorial infrastructures that were never created to fulfill the needs or were ironically dismissed. The total dedication of medical and technical staff in hospitals was mitigated against what would have been an even worse hit of the pandemic.

In your opinion, which areas in healthcare need to be prioritised and undergo a significant overhaul based on this recent experience?

Among the scientific communities, the concern of possible new pandemics is largely diffused. My evaluation is that there is more than one need to be prioritised in terms of timing and coordination, and correlation. There is no doubt that the architecture of the health facilities, starting with hospitals, will need to be properly examined, and comparative evaluations among different hospitals should be done. Some requirements have already been identified: accurate redundancy, flexibility, increased oxygen distribution, materials and details not previously considered, more advanced digitalisation, etc.

The focus on hospital changes, however, should not be the only priority. In Italy, it has been understood that greater attention has to be also given to the "territorial health infrastructure", which should be at the forefront when evaluating primary care.

Improving hospitals' resilience and creating a territorial network of care are interventions that will have to receive financial support from European and national levels and then be realised at the most appropriate government level, with high local collaboration.

Planning for mitigating the hit of a future pandemic must be on the agenda of every public health agency, school board, manufacturing plant, investment firm, state legislature, food production and distribution.

We need to stress immediately, however, that although this is a necessary factor, it is not sufficient. Healthcare leaders and managers need to understand the basic lesson of the pandemic: to fight the diffusion of a possible new one needs to go hand-in-hand with the battle against climate change, air pollution and all the factors responsible for the destruction of our planet and its biodiversity.

What healthcare innovations have you seen in your region, or which ones do you foresee that could improve healthcare's response in future?

Italy has been heavily hit by COVID-19 and, like other countries, is reflecting and preparing for the most efficient and effective use of European and national public funding and the contribution of private investments.

In addition to investment in safety and sustainability for hospitals, the recently made and approved National Plan for Recovery and Resilience (PNRR in Italian), by the EU, is introducing two relatively new infrastructures in healthcare: the "Case della Salute (Homes of Health)" and "Community Hospitals". The latter is present among other nations in Europe. Italy is also accelerating the process of digitalisation and study for the use of Artificial Intelligence (AI). This had already started before the pandemic hit but is now getting more attention and funds from the PNRR.

Technology is undoubtedly an integral component of healthcare. How do you see healthcare architecture and Health IT evolving in the years to come?

There is no doubt technology is important for the advancement of healthcare. Big Data is certainly a great support for IT-connected tools to make good use of them.

However, there are aspects that are not sufficiently addressed:

1. Technology is a tool, and it will not be the saviour for the healthcare systems as well as for the climate change dramatic issues.
2. A new understanding of complexity is the basic issue to confront. In other words, we live in a world increasingly characterised by interconnection and interdependence. We need to substitute our linear approach - "action A will produce effect B" - with a systemic approach, and understand that health systems are, in effect, sub-systems of a more complex one that encompasses individuals, communities, nationalities and planet life.
3. Healthcare architecture has to find a way to express that hospitals represent a temporary place for patients and should be shaped to facilitate patient-centred care. Digitalisation and AI should be the catalyst of those changes.

As President of the International Federation of Healthcare Engineering and the Italian Society of Architecture and Engineering for Healthcare, what is your vision for 2021 and onwards?

Healthcare engineering is undergoing changes coming from experiences and internal reflections that are symbolically represented by a change in our name from "International

Federation of **Hospital** Engineering" to "International Federation of **Healthcare** Engineering". This was not simply a change of name. In January 2021, we celebrated the 50th anniversary of its foundation, which happened in Rome in 1970. Due to COVID-19, we had to organise a digital event, our first virtual congress. On that occasion, the Italian Society of Architecture and Engineering for Healthcare (S.I.A.I.S.) presented the *"Charter of Rome"* that indicates a new vision of healthcare engineering. The four pillars of our vision in defining the evolution of our role are:

- Healthcare respectful of our planet
- Healthcare for a different globalisation
- Healthcare for social responsibility
- Healthcare and complexity

Our commitment is to solidify this aim in our 27th Congress in Toronto in 2022 - *"Unleashing Innovation: Healthcare Engineering Excellence"*. Awards were announced already in the last Congress (IFHE2020) for studies and concrete realisation to tackle that important issue: Energy and climate change and the contribution of the healthcare sector.

The "Environmental Sustainability Policy" document has been updated and approved by IFHE (https://www.ifhe.info/news/enviromental-sustainability-policy). IFHE and IFHE-EU contributed to drafting a best practice guide for Healthcare Estates "A healthcare engineering roadmap for delivering net-zero carbon" (https://www.ifhe.info/news/a-healthcare-engineering-roadmap-for-delivering-net-zero-carbon). The roadmap outlined in this document, if diligently applied, and will form a significant part of the required changes as they apply to the NHS and public sector estate.

IFHE has launched the first-ever Energy Awards programme to honour and recognise healthcare facilities for reducing their energy use. Winners will be announced at IFHE Toronto in 2022 (https://www.ifhe.info/news/global-energy-healthcare-awards).

As current President, our work and purpose at IFHE is to promote and share knowledge within the healthcare community and build and develop relationships. We are represented worldwide, not only by engineers and architects but also by all health technicians and experts. At the moment, we are expanding our networks and improving our member experience through a new communication strategy.

IFHE encourages and facilitates the exchange of information and experience in hospital and healthcare facility design, construction, and engineering. With so much advancement in technology and the rapid growth in digital health and AI, how do you see this integrated with hospital design and construction in the future?

We live in unprecedented times, and we share two key challenges that face our world: the pandemic and climate change. The topic of AI is important as a technology for the future and as a tool that can benefit healthcare and make healthcare accessible to more people. We have to make sure that the technology benefits the people who need it most, especially those in low-income countries or in countries where healthcare simply isn't affordable to many.

I understand this well as we had our virtual congress here in Italy in January where we couldn't see our friends and colleagues face to face. However, the restrictions gave us one positive thing: the digital technology to do the congress online, and we had a fantastic event. We were able to reach over 1000 people in 60 countries. This was an opportunity that we could never have had without the new online technology.

Today, we have to work with these technologies; we have to be agile in the way we work and communicate, with new working models and new engineering processes. We need to develop flexible working systems, whether it is remote working or up-skilling, to improve operational practices. But above all, we have to keep our people safe, inside and outside our healthcare system and hospitals from COVID-19 and future pandemics, and we have to do that without harming our planet and ecosystems. We also have to guarantee that we don't compromise our fight against climate change in our preparation against pandemics. This is our greatest challenge. The topic of AI is an extension of that, and I believe it can contribute to our working methods and our social security and social fabric.

Can you tell us something about IFHE's Global Climate Action in Pandemic Times? What does it entail, and what has been the progress so far?

The members of IFHE like S.I.A.I.S. and other organisations such as Health Care Without Harm – EU and the International Federation of Doctors for Environment activities, aim to diffuse the awareness of the connection of human and environmental health with climate change, the systemic connection among prevention – healthcare – urban conditions, and the need to change our lifestyle.

In the meantime, we are promoting what we call "science in action" with contributions and expertise addressed to all levels of public governance.

We see that climate change is not taken seriously at a global policy level. Why do you think this issue is important for the health and wellbeing of our population?

Congruent with the WHO, the IFHE believes that in the global context and alongside patient safety, environmental sustainability in Healthcare Facilities Management is the issue of most significance to be promoted. The IFHE will embrace every opportunity to positively promote improvements in Environmental Sustainability Policy to its member associations.

IFHE Objectives

The International Federation of Healthcare Engineering will:

- Ensure that environmental sustainability is given appropriate coverage in its activities;
- Develop and promote publications that will draw attention to issues of environmental sustainability and will showcase projects and lessons learnt from the global experiences of its member countries. This will continue to be done through its official publication, the IFHE Digest and its associated journals and bulletins;
- Use its online presence and other social media platforms to promote awareness of environmental sustainability issues and opportunities;
- Ensure that the bi-annual IFHE Congress will always have environmental issues and sustainability as subjects for promotion, education and shared learning;
- Make and use opportunities for promotions in the appropriate public media to encourage an awareness of environmental sustainability in the healthcare sector;
- Advocate for change in areas of influence through member organisation, and globally through international bodies [e.g. World Health Organisation (WHO) and the United Nations (UN)];
- Seek, develop and maintain partnerships with other associations, research and academic institutions and experts to promote environmental sustainability;
- Support members to focus on sustainability by education, promotion and information sharing;
- Request from each member in its biennial report to Council a summary of any sustainability initiatives, activities and programs that have been undertaken;
- Establish a specific role or appoint a specialist project officer to coordinate this work on behalf of the IFHE;
- Develop technical and practical recommendations on issues of environmental sustainability in healthcare facilities.

You have received the Italian Republic Order of Merit. Can you tell us which specific contributions resulted in this honour?

In 2006, I was awarded the Italian Republic Order of Merit medal for my contribution to the diffusion and promotion of hospital engineering, culture and innovation in Italy. In the increasingly complex world of healthcare, in order to ensure correct, safe and appropriate provision of care and to meet the expectations of patients, a multidisciplinary approach has been essential in addressing risk assessment and management, which guarantees safety and high standards and recognising that the role of technicians (engineers, architects, etc.) has become increasingly fundamental and irreplaceable. In other words, "healthcare technicians" have to guarantee construction continuity of the healthcare facility while maintaining the functionality and safety of structures, plants, technologies, ICT and medical devices to reduce clinical risk while at the same time managing costs, to make the "health" system sustainable while respecting criteria of ethics, transparency and legality. ■

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COVER STORIES

"Population ageing and urbanisation were the two major trends shaping the 21st century (WHO 2007). However, as recent events have shown, we can add climate change and technology to that mix of significant trends". *page 336*

Clinic Without Walls (CoW): Care Anytime, Anywhere

Author: **Seet Cher Lui Stephanie I Assistant Director, Ops Ambulatory Block & MEC Masterplan I Tan Tock Seng Hospital I** Singapore
Author: **Tan Hui Zhong Wendy I Manager, Ops Ambulatory Block & MEC Masterplan I Tan Tock Seng Hospital I** Singapore
Author: **Lee Hwee Ching I Director, Ops Ambulatory Block & MEC Masterplan I Tan Tock Seng Hospital I** Singapore
Author: **Ng Yih Yng I Lead, Digital and Smart Health Office I Tan Tock Seng Hospital I** Singapore
Author: **Leow Leng Chew Michael I Assistant Chief Operating Officer I Tan Tock Seng Hospital I** Singapore

Clinic Without Walls (CoW) is a strategic innovation programme. CoW, which is part of Tan Tock Seng Hospital's (TTSH)'s digital transformation journey - The Hospital without Walls aims to redesign care, digitalise processes and transform our workforce to deliver person-focused care beyond our clinics into the community (Soh et al. 2020). Through deployment of digital tools (e-kiosks and HealthHub mobile application), we aim to activate patients to take greater ownership of their health and manage their care in the community, while making sure that we leave no patient behind. CoW is complemented by physical changes to our clinic layout aka the Counter-less Clinic, which sets the stage for care digitalisation. This article details the programme and features which will be rolled out in phases over three years.

Key Points

- Care anytime, anywhere: Providing patients with seamless access to their health information, with personalised prompts customised to patients' health concerns, encouraging patients to more proactively manage their own health.
- Clinical decision support and partnership: Integration with clinical systems would allow real-time sharing of patients' health information with other healthcare providers, which in turn, supports clinicians' decision-making and collaboration to improve patient care beyond the hospital.
- Productivity and role redesign: Through digitalisation, time saved on attending to patient registration and payment can be used for patient service associates (PSAs) to upskill their competencies as part of their career development and progression, and ultimately to provide value-added services (VAS) to patients. The PSAs can embark on basic nursing and allied health competencies and in turn, the nurses and allied health professionals may progress to focus more on higher-level acuity proficiencies.

Programme Infrastructure

At TTSH, we have taken a modular, stackable approach in building the programme infrastructure. The ambulatory care digital stack is built on a common infrastructure, HealthHub, a one-stop portal and mobile app jointly developed by the Singapore Health Ministry and Integrated Health Information Systems (IHiS), the national technology agency for the public healthcare sector. HealthHub provides Singapore residents online access to their health records and relevant health content, with the view to improve their health literacy and encourage adoption of healthy lifestyles.

HealthHub is linked to SingPass, with a base to house datasets managed by existing hospital IT systems. SingPass stands for Singapore Personal Access, a secure online platform by which Singapore residents can access Singapore government e-services. SingPass is managed by the

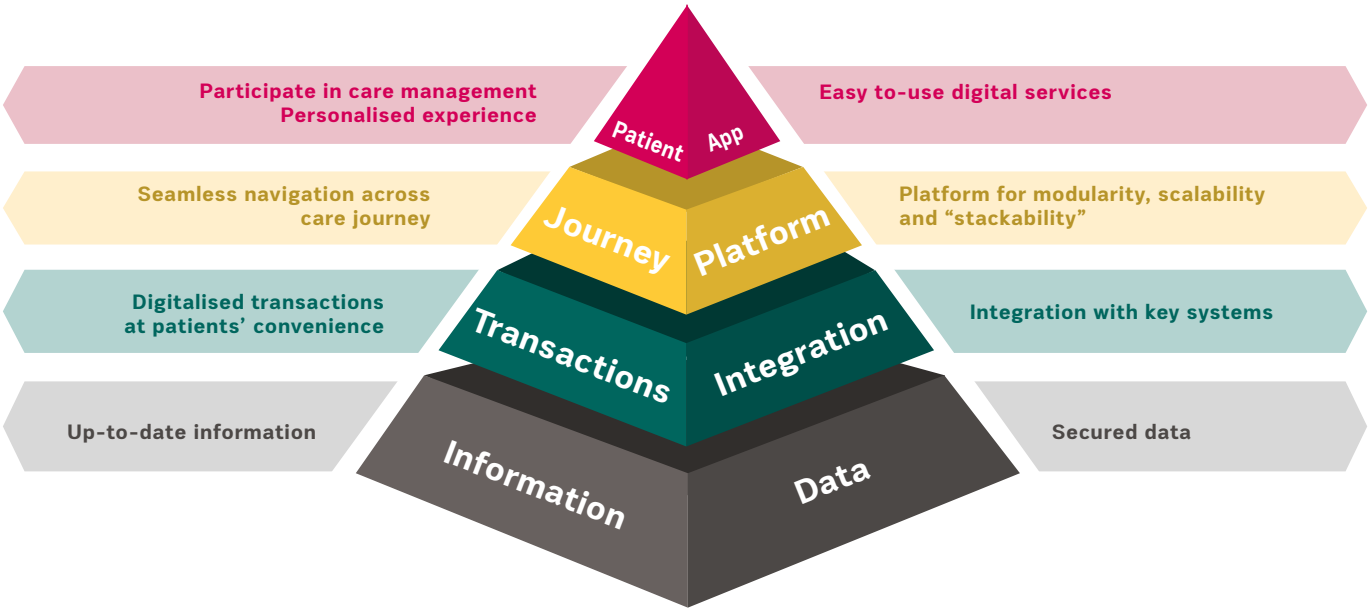


Diagram 1: Ambulatory Digital Stack

Government Technology Agency of Singapore (GovTech), the designated governmental agency which provides the national-level infrastructure to harness infocomm technologies, networks and big data to create tech-enabled solutions.

A digital "marketplace" platform sits on top of this common infrastructure where modularised tools and services will be available for selection and stacking to build new application functions rapidly, and add on other functions befitting to new needs. Leveraging on common national-level infrastructure reduces the development time, as there is no need to build an application from scratch and also future-proof its usability. This approach will allow us to focus on designing and customising emerging solutions, without having to worry about the underlying infrastructure.

Key Features

The digital stack is mapped to mirror the patient perspective and aims to deliver the care model through three strategic thrusts, **MyAssistant, MyHealth,** and **MyGuide.** Each thrust is tailored to provide the patients with personalised access to ambulatory care.

MyAssistant (rollout between FY20 to FY22) consists of features that allow patients to manage their essential outpatient clinic transactions such as registration and e-payments, giving them better control of their schedule. An e-itinerary for the upcoming visit and queue status keeps them informed by providing them with up-to-date information. Profiling of their digital identity will help us better understand their preferences so that we can better personalise their care and experience:

Registration: Much like the online check-in process before a flight, patients can choose to register on the mobile app ahead of their clinic appointments to minimise their waiting time at the clinic.

Queue Status: Leveraging on the mobile queue itinerary, patients know how many people are ahead of them, giving them better control of their schedule.

E-Payment: Patients can leave the hospital straight after their medical consultations without having to queue at a counter using their phones.

Personal Profile: Patients can update their personal particulars any time through the application to ensure that they receive the latest notifications and allow us to deliver more targeted healthcare to them.

Appointment: Appointment rescheduling and cancellation can be performed at a touch of a button without waiting on the line to speak to an operator during peak hours.

Under **MyHealth** (rollout between FY20 to FY24), patients will have access to their health and medication records, diagnostic results, order a resupply of medication, improve their health literacy and even activate teleconsultation. These features are designed to support patients to take better ownership in managing their health:

Health Records Management: Patients would be able to access their personal health records from their mobile app.

Diagnostic Results Management: Results from diagnostic investigations would be accessible on the mobile app, shifting away from reliance on physical records.

Prompts: Other than appointment reminders, prompts will also include fasting instructions, no-driving reminders, and customised education content based on the patient's customised profile to help them manage the health challenges that they face.

Health Journal: The app can serve as a platform to

encourage relationship-based care between the patient and clinicians. Patients can connect wearable devices and connected medical devices to record their health information, journal their day-to-day symptoms and capture information that may be related to their condition such as exercise, sleep, diet, hydration etc. In return, we could help them analyse the data in the context of their overall health to generate personalised insights and digital prescriptions on the app. Clinicians can also utilise the additional information, aided by visualisation and machine learning tools to better understand their health needs and behaviour. This can eventually lead to precision medicine and personalised care.

MyGuide (targeted rollout in FY23 and beyond) features functionalities such as indoor navigation, car finder and an events portal, which support patients and visitors to effortlessly navigate between their homes and hospital. Beyond physical navigation, integration of billing and insurance systems could allow automatic e-submissions of insurance claims for hospitalisation expenses. Other potential applications include allowing patients to check their eligibility, and apply for healthcare subsidies, financial aid or other grants without having to provide supporting financial documents. Such end-to-end solutions would ensure that nobody in need of healthcare would be deprived due to administrative or financial constraints.

In line with our overarching model of leveraging on national-level IT infrastructure, these features should be integrated with existing applications, which would allow patients to search for government, social and wellness services near their homes. With access to these applications, patients would have ready access to information, such as services offered by social service agencies, health-promoting activities and events. Here are two examples of such applications which fit this model:

LifeSG app: It allows users to access over 40 government services, ranging from checking their eligibility for subsidy and support schemes, assistance with job search, housing matters, to financial and legacy planning.

Healthy 365 app: Managed by Singapore Health Promotion Board, this application aims to encourage users to adopt a healthier lifestyle by availing a calendar of complimentary health activities (e.g. Pilates, kickboxing, Zumba etc) and a National Steps Challenge to encourage physical activity. This is complemented by an incentive structure to encourage participation.

Future Plans - Potential and Possibilities

The features above describe mainly transaction-level and selected journey-level interactions. These functions lay the foundation for broader clinical integration with other SIPs and the Next Generation Electronic Medical Record (NGEMR).

Each SIP focuses on a different aspect of patient care transformation such as inpatient care, resource monitoring and utilisation and others. The NGEMR is a critical piece of Singapore's healthcare IT infrastructure, serving as a centralised platform which records the entire patient journey from the point of admission to discharge, including both medical and administrative data.

Providing healthcare providers across different settings (e.g. primary care, intermediate and step-down care and the community) with real-time access to pertinent medical information will promote more informed decision-making and foster stronger provider-provider collaboration for seamless care delivery beyond the hospital.

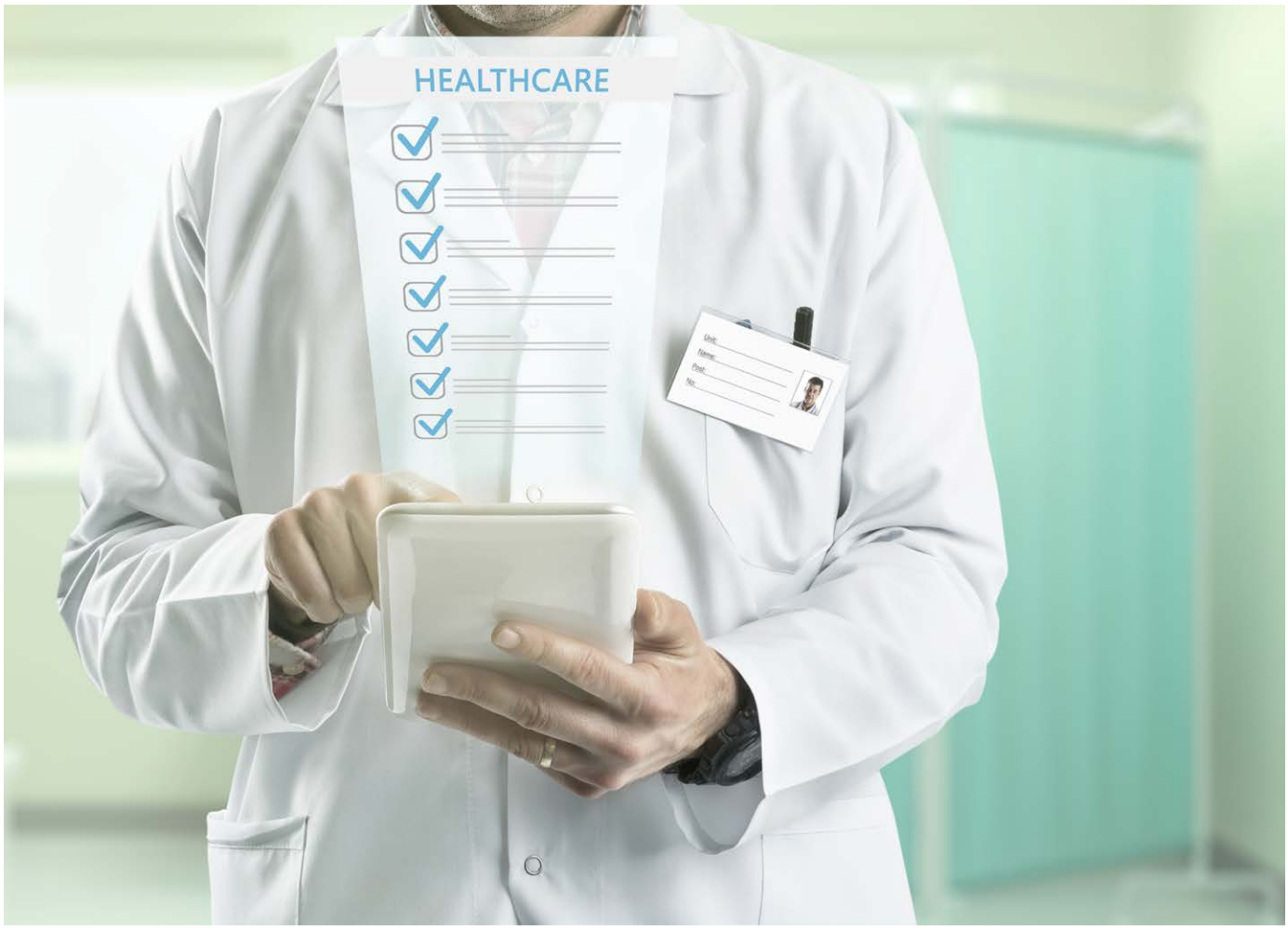
Under MyHealth, patients will have access to their health and medication records, diagnostic results, order a resupply of medication, improve their health literacy and even activate teleconsultation

Another exciting aspect is the potential of harnessing artificial intelligence capabilities to derive predictive clinical insights. A machine learning algorithm could be developed to analyse multi-dimensional facets of an individual patient's health data (e.g. biomarkers, healthcare utilisation or health behaviours) to identify patterns or antecedents leading up to an acute health episode, which would then trigger personalised prompts to the patients or alerts to designated healthcare providers for early intervention. These prompts would also be applicable in preventive health, such as when they are due for health screenings or to remind individuals with a positive family history to seek targeted screening and early medical attention.

Fundamentally, the goal of healthcare digitalisation is towards the betterment of patients' health outcomes. We aim to generate tailored health insights to educate and empower individuals to become activated agents who take charge of their own health, so that they stay healthy as long as possible and help them integrate it into their busy lives.

Impact on Patient Experience and Workforce Transformation

While CoW leverages on digital tools, it is by no means an IT project alone. Rather, it supports the shift towards a relationship-based clinical model with a view to provide a personalised and enhanced patient experience. The business model that supports and complements this relationship-based clinical model drives the phases and thrusts of CoW.



Innovation is key to the approach we have laid out from taking an information-/ (data-) driven baseline to attain person-focussed care, which is centred upon personal activation (through the app).

With the phased implementation of CoW, routine functions like registration, appointment scheduling and payment can be undertaken through enablers, such as the HealthHub app. Time savings through digitalisation presents an opportunity for workforce transformation, whereby the competencies of our patient service associates (PSAs) can be enhanced to take on higher-level work like basic nursing skillsets (e.g. venepunctures and castings). Our nurses, in turn, are freed up to practise at the top of their licence, to take up roles such as nurse-led arthroplasty assessment and counselling, and Prolia intramuscular injections and counselling, which are traditionally undertaken by doctors.

Conclusion

TTSH's digital transformation journey is complemented by the redesign of our outpatient clinic spaces to embrace a counterless concept. Patients who arrive for their appointments are met with a neater and more aesthetically pleasing layout from the clinic entrance. Friendly PSAs are on hand to assist with registration where needed, either at the self-service e-kiosks or via the HealthHub app. After consultation, patients can make payment at Self-payment kiosks (SPKs) or via CoW's mobile payment platform. These physical changes to our outpatient clinics collectively set the stage for our initial journey towards digitalisation of care.

Conflict of Interest

None. ■

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Urban Health and Wellbeing in the Contemporary City

Author: **Nimish Biloria I Associate Professor I University of Technology Sydney I** Australia
Author: **Hamish Robertson I University of Technology Sydney I** Australia
Author: **Jaime Garcia Marin I University of Technology Sydney I** Australia
Author: **Miguel Fornes I Cybersecurity Consultant I SIA – Indra I** Madrid, Spain

This paper explores and debates the intricate connection between our built environment and an increasingly technocentric approach to distinguish health and wellbeing from a multidisciplinary perspective. The authors profess the dire need for rethinking the 'smart' within the city by reconsidering models of urban development and focusing on the democratisation of technology for the purpose of enhancing our lived urban experience and psychophysiological wellbeing.

Key Points

- The changing role of space, technology, people, and health within today's high-paced data-driven urbanised culture.
- Four approaches can shape our built environment and health:
  - The increasing need of developing people-centric empathic environments.
  - Establishing the fundamental relationship between space, technology, and chronic diseases.
  - Acknowledging the role of neurosciences for understanding human behaviour.
  - Articulating the role of virtual and augmented reality platforms for the vulnerable population.

Introduction

In its guide to age-friendly cities, the World Health Organization (WHO) stated that population ageing and urbanisation were the two major trends shaping the 21st century (WHO 2007). However, as recent events have shown, we can add climate change and technology to that mix of significant trends. All four of these trends have considerable implications for the way our shared futures unfold, and, as complexity science indicates, their intersectional nature compounds the challenges they pose to us. In addition, the role these trends play in the health of populations and the dynamics of population health needs to be explored in more detail, and at an accelerating rate, if we are to have healthy and sustainable future environments.

In this paper, we explore these issues from the shared perspective of an architect, two geographers, and an applied neuroscientist. All share an interest not only in technology but in the implications of emerging technologies for vulnerable groups in the community and the established systems of care and support that societies have in place. The focus here is, therefore, on how this type of negotiated and interdisciplinary perspective might inform developing responses to the complexities associated with health and the city.

Beyond the Machine That Goes 'Ping'

As the Monty Python skit illustrated decades ago, we have a fascination for technology such that it is often seen as independent of the functions it serves and that it can be virtuous simply because it is new or 'innovative'. This is problematic in an ageing world where social, environmental factors such as ageism and poor design can compound the inequalities and inequities experienced by older people and other, often overlapping, categories of people such as those with disabilities, the very young and so on (Arcieri 2021).

COVID-19 has only affirmed this understanding in many contexts, including the impacts on older people, people with disabilities and people of colour across the globe (Bhanot et al. 2020).

Consequently, our perspective is that the future of design more broadly and technology design needs to more effectively address the issues confronted by ageing populations, including their wants, needs, capacities and potential limitations. As the Universal Design paradigm has indicated for some time now, design that produces liveable and manageable environments will endure because it better meets the needs of the whole community and any individual's needs as their life trajectory progresses (Hamraie 2017). In this context, because 'health' is an evolving and dynamic polysemic concept, the support and maintenance of health in the city of the 21st century is necessarily an adaptive process. It is not a fixed or immutable entity.

Design that produces liveable and manageable environments will endure because it better meets the needs of the whole community and any individual's needs as their life trajectory progresses

We already acknowledge that as populations and individuals age in contemporary societies, they face a variety of challenges, including changes in their patterns of physical and psychological health. These include shifts in capacity across a range of domains, many of them closely connected to neurological and neuropsychological capabilities (Cabeza et al. 2018). Recent research suggests COVID-19 may contribute to changes and growth in aspects of this pattern going forwards (e.g., dementia prevalence). While we do not endorse a purely pathological view of ageing, since people generally adapt to the realities of progressive age as best they can, the concept of being healthy should expand if we are to incorporate age-related changes into our vision of the liveable and health-sustaining city. Such changes include the more obvious factors associated with potential reductions in physical mobility, as well as sensory and cognitive impairments.

Many of the emerging design principles in this space, including those of biophilic design in which a key aim is that design supports and enhances health wherever possible, have this emphasis on technology for more than a set of functional purposes (Xue et al. 2019). This can include the external built environment but also the types of internal environments associated with hospitals, aged care facilities and the like. Here again, as BIM technology increasingly illustrates, the connectedness of smart design can be ecological in nature as functions previously separated between external and internal can be connected using the same spatial and data exchange technologies, both real and virtual (Jutra et al. 2019).

More than this, though, we have a growing capacity to monitor and respond to dynamic environmental factors that have direct, often urgent, health implications. For example, acute events such as the 2016 Thunderstorm Asthma event in Melbourne saw ten people lose their lives and hundreds more contact emergency services (Thien et al. 2018). The level of preparedness for this type of event appears to have been low. Confusion emerged, and people took themselves to the hospital rather than wait for an ambulance because confusion produces a behavioural response – in this case, people took action themselves. This compounded the situation at local hospital emergency departments.

As the recent IPCC (2021) reports show, we can expect as fire, flood, and related environmental emergencies grow in number, frequency, and magnitude that these scenarios are only likely to increase. Many of these will impact more heavily on vulnerable groups in the city, including labile patients who have medically managed health conditions that are sensitive to changes in the environment. Naturally, there may also be workforce implications, especially health and emergency care workers since exposure events and surge factors have scheduling and workforce availability implications. Lastly, a blockage in any one part of our health and aged care systems have flow-on effects because they are tightly coupled in ways that are elevated during crisis events. One of the fields with considerable potential for smart human-oriented cities, drawing on these interdisciplinary developments, is that of empathic environmental design.

Empathic Environments

The recent IPCC report (2021) justly attributes our deteriorating climatic condition to human doing. One of the biggest contributions which directly impacts the climate and our health and wellbeing is the act of top-down unabated urban development in the form of cities. Cities as agglomerates of quintessential services, cultural mix, job opportunities,

and prosperity have thus far attracted 55% of the global population. Expectation to touch the 68% mark by 2050 (UN 2018) is evident considering the rise of megacities with a population of over 10 million: from two megacities in the 1950s to 30 megacities today and an expected 43 megacities to be established by the year 2030 (The Economist 2015). While contributing 75% of the global GDP (McKinsey 2016), such man-made havens are also responsible for consuming 64% of global energy production; producing 70% of global greenhouse gas emissions (in 2013 alone) (IEA 2016); more than 80% increase in climate change-related disasters globally over the past four decades (Climate Centre 2020); 4 billion tons of garbage being dumped in the oceans annually (National Geographic 2015); 4.2 million deaths due to exposure to ambient air pollution globally (WHO 2016).

Such factors, let alone the inequitable distribution of resources - a resultant of a neo-liberal mode of governance, are critical contributors to the decreasing levels of liveability and holistic wellbeing within our urban environments. Techno-centric governance approaches to solve rather complex urban issues take centre-stage, which tend to exclude socio-cultural, ethical and inequity based urban problems that are beyond the reach of technology. Understanding the 'human condition' as a critical parameter underpinning the shape of our built environment is thus typically overlooked, resulting in biased, inequitable, and non-democratic modes of operations.

Developing *empathic environments* implies embracing a bottom-up 'Person-Environment-Interaction' approach towards place-making (Biloria 2020). This implies embracing a shift from being fixated on quantified justifications of 'efficiency' to a 'wellbeing and liveability' oriented perspective for analysing, understanding, and developing our built environment. Understanding the human condition by understanding psychophysiological issues (associated with stress, anxiety, boredom, social isolation, excitement, and engagement), re-positioning technologies for deciphering human behaviour, and developing embodied intelligence within the built environment are thus critical areas that come to the fore. The Empathic Environments approach thus puts understanding the 'human' and his/her behaviour at the centre of the environment under consideration. The built environment can thus be considered as a complex socio-technical system, akin to an 'Ecology', or the study of interactions of an organism (in this case, the human) and its biophysical environment (both biotic and abiotic). In the case of the built environment, four interlinked components: People, Context, Technology, and Economics, and their intersections are key to understand and develop environments that are desirable, valuable, viable, and equitable. This ecology model is based on the premise that people perform actions as a response to their immediate context with the aid of technologies, and these have economic implications.

Acknowledging the fact that people are dynamic actors who change their requirements and look for improvements and innovations to impact their wellbeing should lie at the core of developing an empathic networked practice. Therefore, solutions sought at the intersection of these four components while keeping in mind the dynamic cyclic nature of evolution and thus the inherent scalability of socio-technical solutions should constitute the design solution space. Such ecosystems of implemented solutions should ultimately define how smart a city is. This mode of thinking is equally vital for developing healthy environments wherein human behaviour and our innate instinct to respond to and, in doing so, shaping the built environment to reduce the impact of environmental stressors, can come to fruition.

One of the fields with considerable potential for smart human-oriented cities, drawing on these interdisciplinary developments, is that of empathic environmental design

Experiencing pleasure - an innate human instinct, from what we observe in the built environment, is highly reliant on the way our designs focus on removing stressors by addressing various factors – urban morphology, architectural form, material use, biophilia, symmetry, noise, visual complexity etc. while promoting a sense of relaxation, safety, belonging, and social and environmental connectedness. This is primarily because of the way the human psyche is geared, making our survival instinct take precedence over our pleasure instincts. Empathic environments should thus focus on developing ways in which lived experience information can be extracted from the community, which, in turn, will aid in evidence-based decision making at multiple scales: Architectural, Interior, Infrastructural, Land-use adaptation etc., to mitigate psychophysiological stress faced by urban residents. Sociologist David Williams thus rightfully points

out that 'where we live, learn, work, and play have more to do with our health than going to a doctor'.

This shift in focus also implies a much more holistic rethinking for improving people's quality of life by using ICT in a technologically democratic fashion while adhering to the fundamental quality of being adaptive and responsive to user needs by gaining behavioural insights. IoT and sensor-based networks have already promoted large scale big data initiatives. However, the tendency to start the transitioning from big (often siloed) data sets to a linked data (relational and networked) Is highly required to truly understand urban dynamics from an ecology perspective. Opportunities in the form of geotagged data sets and crowdsourced data – including citizen science initiatives that are relevant to understand health behaviour, need to be explored and cultivated much more.

A big gap, however, within this gamut of IT pertains to harnessing user experience pertaining to the impact of the urban environment on the human body. Limited studies (Dritsa and Biloria 2021) have been performed in this regard and much more targeted research to extract lived experience certainly needs to be performed to promote an empathic approach towards informed placemaking to mitigate psychophysiological stress witnessed by urban residents. Fusing personalised physiological data with typical routing applications can also provide alternative ways of personalised navigation, which are beneficial to one's health, thus promoting active mobility via reduction of stress. Similarly, interior environments have a lot to benefit from by adhering to principles of neuroscience, psychology, and behavioural economics, which ultimately translate into behavioural design attributes. This fusion of disciplinary thinking is critical to creating the much-needed momentum for empathic environments. Facilities such as age care and disability centres, which are typically governed and expressly customised for maximisation of profit, could certainly benefit from a behavioural design-driven empathic environment creation where wellbeing becomes the primary focus.

Space, Technology and Chronic Disease

One of the major issues for urban environments is that they are fundamentally concentrations of people and the things associated with humans at scale. This includes direct health and illness factors such as the transmission of viruses and bacteria or susceptibility to naturally occurring events that can induce allergic responses, for example, thunderstorm asthma events or reactions to various allergens, both natural and manufactured. In addition, humans produce considerable quantities of biological and manufacturing waste, which must be managed. And that management has consequences in the smart city, including noxious smells and gases, noises, and potential irritants (Jiao et al., 2021). Recent heatwave and fire events in North America and Europe all indicate that direct and indirect factors – heat distress and particulates – are growing health problems for urban environments (Matz et al., 2020). There is, therefore, a complex of human and 'natural' (since some are induced or exacerbated by human actions) factors interacting with the health status of our increasingly ageing urban populations.

If the smart city can take a leaf from the growth in smart transport systems integration in Europe to connect patients, health services and emergency services and support, the potential is substantial for not only prediction but preventative planning and surge management

In addition, even with good planning, maintaining a balance across the complex of needs and wants of urban stakeholders of all types can be a complicated process. In the smart city context, this is both a fundamental feature of becoming 'smart' and potentially increasingly manageable not just through technological fixes (a much-critiqued focus) but through human-centred solutions using smart(er) technologies. Virtual earth software, for example, extends traditional geographic information systems technology to permit faster, scalable management of the intersection between natural and built environments and their human and animal effects (Liu et al., 2020). This leads us to the rapidly developing concept of smart urban ecologies (Colding and Bartel 2017). Here we take a more holistic view of the structural and interactional elements of the contemporary city that adds in broader environmental context and patterns. And given how much we are already relying on smart technologies

to monitor factors such as global warming and climate change, the translation of these techno-strategies to specific urban environments and their interconnected hinterlands is essential.

Where we believe this gets especially interesting and useful is in the integration of smart ecological monitoring with health and social care systems and their associated dynamics. For example, population ageing is closely connected to rising rates of chronic disease, multimorbidity and various disabilities and impairments (e.g., mobility, sensory, cognitive, respiratory, and so on). If the smart city can take a leaf from the growth in smart transport systems integration in Europe (rail and road especially), to connect patients, health services and emergency services (e.g., fire, ambulance, and police) and supports (e.g., social services, pharmacies, care workers, volunteers, and visitors etc.) the potential is substantial for not only prediction but preventative planning and surge management.

This could be strategic development for the better integration of community-dwelling patients who may be stable or labile and reactive to changes in environmental factors or who experience acute events. In addition, as factors like heatwaves increase in severity, the needs of older people who may need to stay at home during such events increase the need for more connected and responsive services. These could include food and medication deliveries, telehealth or in-person support for their conditions (while keeping the workers safe too), temporary respite (e.g., during heat and/or fire events – air-conditioned facilities, heap filters) all monitored not only in real-time but planned for based on detailed data and knowledge of the health implications of such events for patient types and segments.

Neuroscience and the Smart Healthy City

Given that many developed countries now have anywhere from 40-50% of their populations living with long-term health conditions, factors such as cognition, sensory perception, affect, and mood need to be considered as design factors for urban environments and integrated technologies. We know that design elements can support or reduce people's response to environments, including their levels of stress and/or resilience (Korpela et al. 2018). Factors such as loneliness amongst older and socially isolated people can be integrated into the smart city framework whereby the risks associated with loneliness could be managed more effectively by that community service, not-for-profit and associated supports.

More broadly, we know that brain function reflects the way these factors interact, and the consequences range from the neuropsychological to the physiological, including variables such as endocrine response patterns (Neale et al. 2017). In other words, as our conceptualisation of relative health status diminishes the traditional conceptualisation of health as an absolute (health as a fixed entity), the neurosciences and associated technologies increase their potential contribution to health maintenance and optimisation in urban and other environments. A variety of pilot projects have been developed by a member of this team that reflect how functional disability can be ameliorated and social interaction and engagement improved via gamification strategies.

Augmented and Virtual Reality for Vulnerable Groups

Two or three areas already stand out as offering evidence-informed potential for the expansion of technology that supports various categories of vulnerable people in urban environments. We know that, for example, virtual reality and augmented reality can provide experiences that educate care providers and support people with sensory and motor limitations in their engagement with their environments. Evidence by Garcia (2019) and colleagues indicates that gamification is another technology-informed strategy for supporting older people, for example, but producing interactive solutions that provide output data indicating clinical effects – the success of the activity (or not) and the opportunity to refine or modify the activity.

As factors like heatwaves increase in severity, the needs of older people who may need to stay at home during such events increase the need for more connected and responsive services

At a perhaps more material level, the city of Graz in Austria implemented enhancements to street navigation for visually impaired people to assist in safe mobility and navigation within the urban environment through a project called ways2see (Zimmermann-Janschitz et al. 2021). The physical modifications were supported by a geographic information software-supported app that assisted the user in negotiating this informed environment (Zimmermann-Janschitz 2018).

In this context, we propose that the concept of 'technologies can effectively range from modest physical innovations through to the kind of digital applications associated with AR, VR and AI in an integrative and assistive technoscape.

This adaptive and enabling element is key to the smart city concept, as it is not simply about designing and leaving the technology interface to be used by the client group but, instead, to provide a data-informed opportunity to monitor, evaluate and modify such offerings. Thus, the smart city can be part of a therapeutic ecology where subjectivities (the user experience) and data from such systems can inform sustainable solutions that potentially improve over time. This is likely to become even more important as the adaptive needs of cities grow in order to maintain and enhance their health-supporting capabilities under climate change.

Conclusion

Clearly, these approaches acknowledge the close connections between the natural and built environments as well as the evolving nature of our technologies. The focus on the needs of people in a broad sense, and not just as health-imposed limitations, can help us modify what the smart city means, what it looks like and how it functions. Rather than some techno-fantasy of digital connectedness, it can be about enhancing the lived urban experience of people by connecting what we know about physical and psychological health through technologies that are supportive across the lifespan. Here, we mean that not all health technology has to be curative in its focus but instead, especially where we may lack cures, it better helps us serve existing human needs in their current contexts. And because that context is changing rapidly, as the IPCC illustrates, our ideas for connecting health and the city must also change. To do this in a sustainable way that is adaptive to shifting human needs would be truly smart.

Conflict of Interest

None. ■

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The Benefits of Connected Care and Better Utilisation of Patient Data in Healthcare

Author: Xavier Battle I Vice President Marketing and Sales I Siemens Healthineers Digital Health

Connecting care teams and patients can drive patient engagement and help improve treatment processes that can facilitate cooperative care. HealthManagement.org spoke to Xavier Battle, the head of Marketing and Sales for the Digital Health Business Line for Siemens Healthineers, about the importance and benefits of connected care, the use and application of real-time data, Artificial Intelligence and wearable technology, combatting the challenge of chronic disease and improving the utilisation of telemedicine.

The future of healthcare will focus more on connected health and delivering care beyond the hospital walls. Do you think this is an achievable goal? What tools do you think are critical to making this happen?

I think it is a necessity and the current events related to the COVID-19 pandemic demonstrate how needed it is. Once this crisis is behind us, or more likely, when we have gotten used to living with this increased and constant risk, the ability to engage with patients remotely will remain. It is a matter of convenience and efficiency. The tools are, to some extent, there already: very vibrant innovations in personal and mobile devices, a steady trend towards connectedness and miniaturisation, and of course, increasing awareness and familiarity of the public. What is critical to making it happen is our attitude and openness to store, manage, share and exchange data within a growing network of healthcare providers in which patients become active participants.

Do you think improving patient access to their healthcare data is important?

Of course, it is important. First, it would allow physicians to access all the available data, including the patient history, instead of only the data that is available in their IT environment. This is especially important when people move or change providers during their care. Evidently, when patients engage more directly in their care, having access to the data opens the door to much greater communication between physician and patient, leading to a better understanding of the situation and subsequent decisions. Additionally, patients could more easily get second opinions and weigh into the treatment options offered to them. I would, however, like to point out that the close and trusting relationship between a patient and its care team is likely to remain the biggest driver of patient satisfaction – data access will solidify this trust.

What role do you think wearable technology and real-time data can play in improved decision-making and connecting care teams and patients?

It will play an increasingly important role. I observe that wearable technology and real-time data are established, nearly ubiquitous and de facto standard in the 'wellbeing' side of healthcare. Everyone can now know their heart rate, biometrics, track them over time and can even get recommendations on how to improve them. The same happens in some chronic conditions (e.g. cardiac arrhythmias when implanted defibrillators monitor the patient's condition and report to their physicians). I expect this trend to continue. As patients become actors in their care, they will need tools to record and analyse their data, connect to their physicians and receive personalised and continuous care. More than devices that provide direct care, personal devices will be essential vectors of rich and interactive communication between patients and physicians.

What role do you think connected care can play in combatting the continuous increase in the prevalence of chronic disease?

From a practical standpoint, chronic diseases pose the challenge of trying to live a nearly normal life despite a health condition that requires continuous attention. This would be, of course, incompatible with repeated stays in the hospital and too lengthy periods away from the active life. Following the tremendous treatment progresses, many people with transplanted kidneys, insulin pumps or pacemakers live a (nearly) normal life. The way to monitor and care for such conditions is also progressing to allow patients to stay out of the hospital for most of their routine care, be it for checkups or minor health conditions. Connected care is also a formidable way to level socioeconomic disparities in the access to care and allow patients in need to benefit from the best care, nearly independent of their location or access points. Last but not least, connected care, in the way it engages patients directly,

on a daily basis, can help improve their compliance with their care plan (e.g. medication) which ultimately will improve the overall outcomes.

The COVID-19 pandemic highlighted the benefits of telemedicine. Which tools do you think are essential to improve its efficiency and effectiveness?

As I pointed earlier, the tools and fundamental technologies are, to some extent, already there. Nearly everyone carries a powerful sensor and/or connection hub in the form of our familiar mobile phones. Wireless communication is ubiquitous, and bandwidth progresses rapidly to support full-duplex HD communication in most places. The obstacles to the wide adoption of telemedicine are more legal and regulatory than technological. In many countries, regulations will need to be adjusted to account for what technology can enable, be it for remote operations such as remote scanning or remote surgery or for much higher levels of data exchanges and sharing across jurisdictions or borders.

Do you think Artificial Intelligence is underutilised in healthcare?

I don't know if it is underutilised. It is for sure holding great promises in the goal of assisting physicians in dealing with exponentially growing amounts of data and complexity. Yet, the adoption of these novel methods is driven by the same criteria held for the adoption of any technology in medicine: it needs to improve patient outcomes, reduce costs, and overall provide better care and/or a better workflow. As such, I believe AI will be first adopted when assisting physicians with highly repetitive and routine workflows for which these methods are proving their strength. Then and beyond these necessary proof points for AI lies a more ambitious goal for our industry. When combining, in a so-called digital twin of the patient, the access to the longitudinal personal patient data (from historical records to current tests) with the ever-increasing computing abilities, we can foresee the ability to not only diagnose but also prognose the course of the disease, factoring in, for example, preexisting conditions and treatment options.

In your opinion, why has digitalisation of healthcare been so slow compared to other industries?

At least in the last 18 months, healthcare has demonstrated that it can be fast in adopting digital technologies to enable better and faster care. No one would have imagined entire hospital departments functioning largely remotely for such a long period. You are, however, right that compared to other industries, healthcare has been relatively slow to adopt digital technologies. This may be due to the combination of several factors. First, process complexity driven by the inherent complexity of medicine and the complexity of the associated economics (payers, guidelines, reimbursement policies…). Second, the inability to stop and "start new" with often a large and complex legacy to accommodate. Third, the heterogeneous IT environment where homegrown legacy solutions coexist with a whole array of products from multiple vendors and the corresponding lack of standardisation and interfaces.

Healthcare generates a massive amount of data. What challenges do you see in terms of managing and analysing this data, and what clinical decision support tools can improve data utilisation?

It is true than in an aggregate view, the healthcare industry produces very large quantities of data, yet I do not believe it is correct to look at it "all at once". Data are created by a multitude of equipment and devices. Data are held by healthcare providers for which they have access for the purpose of patient care. Subsequent access to the data must be given by the individual patients themselves and can be revoked at will. Even the notion of anonymisation is complex, and its definition varies. It is, in practice, not easy to access large quantities of data to conduct the sort of analysis that could support the development of novel methods. I believe that the industry as a whole (patients, payers, providers and Med Tech) and the regulators need to come together to define a mechanism for data exchange that would, of course, protect the patients but also enable access to large quantities of population longitudinal data – the precondition to developing methods that will enable true precision medicine. ■

The Future of Healthcare: One Million [Interconnected] Homes Initiative

Author: **Henrique Martins | Editorial Board member – IT | Associate Professor - ISCTE – University Institute of Lisbon |** Portugal

An ageing society and global health crises have increasingly meant that people are spending more time at home than ever before. While homes are thought to be "safe" environments, people – especially those who are aged or health-compromised – face multiple dangers such as falls, cuts, burns and drowning and increasingly, mental illness stemming from loneliness and isolation. What role can emerging connected technologies such as smartphones and wearables and Ambient Assisted Living (AAL) technologies and solutions play in the future generation of home-based, patient-centred healthcare and wellness prevention and environmental sensing? Prof Henrique Martins shares his vision.

Key Points

- A healthy home is essential for a healthy life. Environmental variables such as street noise, lighting, temperature, and air quality, collectively called exposome, are directly associated with quality of sleep, work productivity, allergic disease, and even heat-related cardiorespiratory mortality.
- Healthcare is moving from hospitals to homes, and from inpatient to home-based patient care. An ageing society and global health crises have increasingly meant that people are spending more time at home than ever before.
- Emerging connected technologies (e.g., smartphones and wearables) create opportunities to understand an individual's behaviour through the lens of systems biology, often called behaviourome.
- Ambient Assisted Living (AAL) includes the technologies and solutions for smart homes, as well as smart environments and cities, and has been a topic extensively featured in EU innovation, technology development and pilot projects over recent years.
- We now need to "join the dots" and combine all of the scientific and technical conditions into EU-wide continuous seamless telemonitoring from home to home, wherever home is, to each EU citizen at any given moment.
- The proposed "One Million (Interconnected) Homes" initiative can start small – between the EC and a few interested countries, building its governance, workstreams, and producing useful deliverables and then progressively grow to eventually be supported by an EC-funded Horizon Europe project for more sustainable work.

Healthy Homes and the Exposome

A healthy home is essential for a healthy life. An immense body of evidence accumulated over many years and covering many topics shows that our environment directly influences every part of our health. As an example, low street noise, night time lighting, isolation from sound and general quietness is associated with quality of sleep, which in turn is associated with better health or several health conditions, including children's school performance and adults work productivity (Halperin 2014). The quality of the air, the dust and other exposome (or collective environmental exposures beginning during the prenatal period) are determinants related with allergic disease (Burbank et al. 2017). A single environmental variable, such as temperature can be related with death. Morais et al. (2021) showed through hot spot analysis that the neighbourhood-scale spatial pattern of

heat-related cardiorespiratory mortality in the elderly, during the yearly warmest five months of a three-year period was associated with spatial variability in heat-related mortality. They concluded that studying human health outcomes at a neighbourhood-scale is relevant for public health heat-related plans and outlined suggestions to decision-makers and city planners designing strategies to reduce heat-related mortality (Morais et al. 2021).

That healthcare is moving from hospitals to homes, and from inpatient to home-based patient care is undisputed. That people spend much more time at home than anywhere else is equally undisputed. An ageing society and global health crises have increasingly meant that people are spending more time at home than ever before in recent decades. While homes are thought to be "safe" environments, people – especially those who are aged or health-compromised – face multiple dangers such as falls, cuts, burns and drowning and increasingly there is an additional smouldering danger - loneliness.

Emerging Connected Technologies and the Behaviourome

Outside of the home, emerging connected technologies (e.g., smartphones and wearables) create opportunities to understand an individual's behaviour through the lens of systems biology, often called behaviourome. Multimodal high temporal resolution data derived from connected devices can be used to build digital phenotypes and/or discover digital biomarkers of the behaviourome (Rashidisabet et al. 2020).

Homes are the ideal place to sense people's health or concentrate outside home sensing so as to reconstitute the person's behaviourome avatar. They can be data hubs to collect, recollect from wearables (devices people wear during the day even when away from their home) and connect into digital health systems. The data they will gather is digital health and "microenvironmental" health-relevant data which may allow novel micro primary prevention efforts targeted at the exposome and behaviourome, as a new type of personalised-medicine public/populational health.

In the prior example of heat-related mortality, following the temperature of households at a micro level may allow public health services to fine-tune interventions for elderly and medically compromised people who are living alone and are associated with much higher risk of overheating or suffering from hypothermia. Sensing temperature is hardly a technological challenge, however collective monitoring and regular communication and interpretation of the data, automatically raises a number of other technical, legal and ethical challenges.

Ambient Assisted Living Technologies

There are high expectations from telemonitoring technologies, and necessary strategy and services still need to be put in place in most EU Countries (Amorim et al. 2020). While the COVID-19 pandemic may have triggered interest in telehealth and telemonitoring, time has also shown that sustainable interventions require long term vision and strategy and a significant refactoring of the way healthcare systems have been designed. The scope for assistive technologies, however, are much larger than telemonitoring. Ambient Assisted Living (AAL), which often includes the technologies and solutions for smart homes, as well as smart environments and cities, has been a topic extensively covered by EU funding, particularly in innovation projects, technology development projects and pilots over many years. Too often, these have focused on the intersection between AAL technologies, homecare/prevention, and elderly citizens. Age and the conceptualisation of homecare as a sort of "safe harbour" for chronic patients, or elderly citizens at risk has prevented the realisation that young adults and even children can also benefit from telemonitoring, home sensing and the many benefits that AAL technological solutions can bring. Even the challenge of multiple-person sensing has often been neglected, as the most common focus for the use of homecare has been the "isolated elderly citizen living by him or herself in some remote location and requiring telecare/tele-vigilance". While it is a strong argument that this population group could benefit, there is a much stronger one that ALL population groups may benefit from AAL technologies, particularly as they transition to the new "home-health". As I explained previously, home-health will become a basis for a new sort of wherever and whenever people are where they "feel" at home.

One of the challenges with this vision, however, is that contrary to the stereotypical isolated elderly citizen or patient

Young adults and even children can also benefit from technological set-ups using homes not just for telemonitoring or assistive technologies but as wellness and sensing technology information hubs

with a chronic condition in their home (e.g. suffering from severe health failure or respiratory conditions requiring home respiratory support), young adults and children, move – they move a lot. They even move to other countries, particularly EU Member states for work, study and leisure. While their right to free movement is a fundamental cornerstone to the EU raison d'etre, the benefits they enjoy from "home-health" require a somehow continuous gathering and analysis of health-related exposome and behaviourome data. This means we need to foster cross-border mobility and a digital single market for assistive technologies so that interoperability and continuous connectedness is possible, even for active, moving EU citizens.

We need to foster cross-border mobility and a digital single market for assistive technologies so that interoperability and continuous connectedness is possible, even for active moving EU citizens

Legal and health imperatives exist. Fifth generation (5G) technologies, lightweight AAL wearables are increasingly available in the EU market and new models of home telemonitoring and health systems usage and even reimbursement of homecare have been piloted and extensively supported by EC funded projects. Data standards and transfer protocols have matured. We now need to "join the dots" and combine all of the scientific and technical conditions into an EU-wide capacity for continuous seamless tele-monitoring from home to home, wherever home is, to each EU citizen at any given moment. Our goal? To create an Ambient Assistive living healthy space at European scale.

One Million Homes Initiative

Under the current debate of the European Health Data Space (EHDS), in an earlier publication I have advocated for a place for social media. Here I argue that we also need health data places for data collected and provided by healthy individuals and/or from their homes. This will allow us to tailor interventions such as city planning, environmental legislation, micro-health environment surveillance and foster true assisted living which, in my opinion, need to move into assisting healthy individuals to live healthier lives. We need home health data collection communities and real-world evidence of how people interact with the environment and with each other if we are to design new medicines or digital therapeutics to fight increasingly common neurological conditions such as dementia and mental disorders while promoting mental health.

Health systems design and management is for the most part an EU member state prerogative protected and foresee in the EU Lisbon Treaties. The suggested ideas in this paper, would require such national level changes, while at the same time, the Digital Single Market, new Data Governance Act and other similar EU-wide initiatives on the free circulation of data, may serve as basis upon which to build EU-wide telemonitoring and ALL interoperable spaces. In 2020, the European Commission (EC), via DG Connect and a first set of Member States Ministers of Health launched the One Million Genomes initiative, which later led to the Beyond One Million Genomes project. This project combines EU-level responsibilities and capabilities with those at the Member States level, respecting their autonomy while creating a collective target and setting in motion a series of joint efforts to establish a "EU-Genome poll".

If we are to have an EU exposome and behaviourome while creating the largest functional and interoperable telemonitoring and AAL digital technology market, we need a "One Million Homes" initiative. Like its inspirational initiative – the One Million Genomes – it can start small – between the EC and a few interested countries, building its governance, workstreams, and producing useful deliverables and then progressively grow to eventually be supported by an EC-funded Horizon Europe project for more sustainable work. This should differ from the many "pilot projects" on telehealth or AAL in three main elements:

- **Scale –** only a very large-scale project can ensure definitions, standards and agreements create a large enough market momentum for SMEs to embrace them and to create EU-wide market players capable of being competitive outside the EU.
- **Cross-border nature –** most projects in telemonitoring or AAL have been local, institutional or national/regional implementations, even if multiple countries/institutions may have participated.
- **Data Connection –** as a "next generation" and European Health Data Space enabled initiative, it can be envisioned as one of the first large-scale health-related data donation initiatives.

Homes can also be connected between themselves in healthy virtual neighbourhoods. They should not just be "connected" to some abstract place to hold data somewhere

in the EHDS, but rather be generating useful data resources for research and innovation. Interconnected homes can establish new ways of telepresence amongst themselves, and collective tele-synchronisation of families and friends – something we learnt was essential to survive isolation during recent pandemic times. Isolation daunts many citizens, not just elder, chronic patients or those incapable of easily going outside their homes, and is responsible for several mental health conditions. Of course, loneliness, can also be felt amid a crowd. The current online social system does not address this issue. In fact emerging research shows that social media can have the opposite, detrimental effects (Marttila et al. 2021). Next generation interconnected AAL telecommunications such as sensing and other assistive telecommunications may thus be the new 6G, moving from supporting the Internet-of-Things (IoT) into supporting the Internet-of-Humans (IoH) or the Internet-of-Homes (IoH). The One Million (Interconnected) Homes initiative may be the start of this new paradigm.

Conflict of Interest

None. ■

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With the Unified Radiological Information System (URIS), the Moscow Health Care Department Has Laid the Foundations for Connected Care

Interviewee: **Sergey Morozov I Chief Regional Radiology Officer I Moscow Health Care Department I CEO at Diagnostics and Telemedicine Center I** Moscow, Russia

300 modalities, 1500 radiologists, 1500+ technicians, 10,000 referring physicians, 500,000 patients... Moscow's Unified Radiological Information System (URIS) and its unified digital infrastructure have become a 'one stop shop' to access patient imaging data across the megalopolis and beyond. And a core component of URIS is the unified Enterprise Imaging platform, offering the scalability and functionality for the present and the future of this ambitious project. Connecting all medical imaging devices into a single service, with Enterprise Imaging, supports "anywhere/anytime" access to the patients' imaging data, enabling 'true' teleradiology and enhanced patient care.

Making Medical Imaging More Accessible to Patients

The foundations for URIS were laid in 2012, during a large-scale modernization of Moscow's healthcare services. "Hundreds of CT and MRI scanners were purchased for and installed in the primary care and out-hospital facilities. Previously these modalities were mostly available only in hospitals," describes Professor Sergey Morozov. "The mission was to make these types of imaging more accessible to patients, in a cost- efficient way, through the outpatient primary care and out-hospital facilities. The success of this approach has enabled us to launch other key initiatives since then, such as a lung cancer screening program and an MRI prostate screening, to name only two."

Very soon after the installation of the new modalities, discussions began on how to connect them within a unified information system. "This would offer clear and necessary benefits, including overall standardization, increased efficiency, efficiency metrics, and harmonized workspaces and workflows for radiologists and technicians," Professor Morozov continues.

To enable this connection, Agfa HealthCare's Enterprise Imaging platform was selected. Professor Morozov: "We needed a solution that could work as a radiology archive, and provide advanced tools and workflow automation for radiologists and referring physicians. It was very important to select a vendor that delivers the highest international standard for enterprise imaging. But we also needed the possibility to scale in the future, especially in terms of adding many more modalities. So when I became chief radiologist of Moscow in 2015, I was very pleased that Agfa HealthCare's Enterprise Imaging had become part of the URIS project in 2014."

A Unified Service Offering Access to All of the Patient's Images

The overall goal was to integrate all local radiology services into the URIS service; the first challenge was connecting multiple modalities from different sites by February 2015- only one month after the signing of the contract. By mid-2015, all the CT and MRI modalities from the primary care and out-hospital facilities were not only connected but integrated in the advanced diagnostic workflow automated by Enterprise Imaging.

Professor Morozov: "Different workflow approaches were implemented, such as cross-reporting, where radiologists at one primary care and out-hospital facility would report studies carried out at another primary care and out-hospital facility. True teleradiology and remote reporting, dashboards for productivity analysis and peer review, were also tested, with more modules added to make this possible. We continue to tune these approaches, with the support of the Agfa HealthCare application specialists"

Enterprise Imaging Platform

1300	modalities
1500	radiologists
1500+	technicians
10,000	referring physicians
500,000	patients

Big Jump: From 700,000 to 5 Million Studies Annually

In 2018, the project took a huge leap forward, when the city's new vice-mayor in charge of healthcare decided to leverage all of the informatics, by having all CT, MRI, mammography, digital X-ray and X-ray angiography devices in hospitals and primary care and out-hospital facilities connected to URIS by the end of 2019.

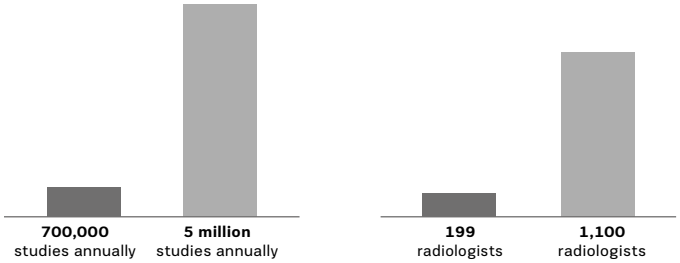
"This meant connecting 1200 more modalities. It was very important that Enterprise Imaging was able to scale to meet the massive growth in demand. It enabled us to increase from 100 to 1300 modalities very quickly and seamlessly," says Professor Morozov.

With the decision, the estimated yearly volume of images handled by the Enterprise Imaging platform exploded from 700,000 up to 5 million. So in 2019 Agfa HealthCare split the platform into two clusters: one for the primary care and out-hospital facilities, one for the hospitals. To handle the migration and upscaling, Agfa HealthCare, local partner ITco and the Moscow Department of Information Technologies (DIT) collaborated closely, 24/7, to support optimal performance while keeping resource allocation requirements in mind.

Following this evolution, the number of radiologists using the platform for viewing and reporting increased from 199 in 2015 to 1,100 by the end of 2020.

Worklist Management Supports 'Expert' Radiology

The task-based workflow management is a key functionality in Enterprise Imaging for each radiologist on the platform. It adds value not only for the radiologists, but also for technologists,



referring physicians, patients and the healthcare system overall. "Worklist management based on automated task assignment enables us to distribute studies among our radiologists, based on subspeciality rather than location. Every study is thus reported by an expert in that subspeciality, not, for example, the radiologist who happens to be in the hospital or primary care and out-hospital facility on that day."

This distributed way of working has had several very important benefits for radiologists across all locations, he continues. "Firstly, we can reduce second readings, because every report is already an 'expert' report. Secondly, radiologist satisfaction has increased, because these professionals are working with their familiar studies and pathologies.

Furthermore, as the radiologists have the specific knowledge needed for the studies they are working on, report turnaround time has drastically improved. Five years ago, it was five days. Now it is on average less than one hour! This is a very important metric for patient care quality, as it means the referring physician and the patient have access to the diagnostic information much more quickly."

Other functionalities enabling a more comfortable and efficient workflow for radiologists include the ease of switching from one working place to another, and helpful tools such as hanging protocols.

Report turnaround time
5 days >1 hour

"Report turnaround time has drastically improved. Five years ago, report turnaround time was five days. Now it is on average less than one hour!"

Prof. Sergey Morozov

Centralized Remote Reporting Enhances Productivity

The centralized, standardized platform was also key to enable the launch of the Moscow Reference Center for Radiology (MRC): the first teleradiology center created as part of the public healthcare system. Opened in 2020, it now has 96 radiologists remotely reporting some 25,000 imaging studies each week and plans are to grow the number of radiologists even further.

Radiologist productivity has doubled with the MRC, Professor Morozov explains. "Around the clock IT support, dedicated workstations with diagnostic monitors and automated worklist

management provide the radiologists with an environment that is very conducive to efficiency. In fact, because radiologist productivity has doubled, we can make the same number of reports with half the radiologists.

Not only is this more cost-effective, but it allows us to provide additional specialized training to upgrade the radiologists' skills. We can also deliver more and better services to remote locations. Russia is a huge country, and it is not possible to provide an expert radiologist for every CT machine. But by connecting those devices to the digital infrastructure, we can increase the reach of this critical imaging insight to more patients, and remotely report the studies. 'Expert As A Service', in a way."

Standardized Workplaces and Anywhere/Anytime Image Access

Beyond the centralized reading and reporting services at the MRC, the digital infrastructure and unified platform have enabled a standardization and harmonization of radiologist workplaces in every hospital in the city. "This allows us to smoothly transfer images from the primary care and out-hospital facilities to the hospitals, which reduces repeated studies," describes Professor Morozov.

The XERO universal viewer plays a key role, providing "anywhere, anytime" access to the patient's imaging record – not only for the radiologist, but for all stakeholders. "Radiologists might use XERO to quickly and remotely check a patient study that requires specific attention, for instance. And in the future, I am convinced the XERO functionality will be an important step in truly freeing radiologists from their physical locations," he explains.

As new service lines have been connected to the digital infrastructure, other specialists have been increasingly making use of the functionalities, as well. "When we connected the angiography devices, vascular surgeons began using the platform to inform about their decisions regarding operations on stroke and myocardial infarction patients, for example. Traumatologists and ENT surgeons also use it, to check CT, MRI and X-ray results."

Private PET-CT centers such as those specializing in oncology imaging are also connected, giving referring oncologists at the hospitals access to the PET-CT scans taken at those private centers. And with XERO embedded in their electronic health records, referring physicians can directly check patients' images: in the last year, nearly 10,000 did so.

Empowered Patients and Continuous Quality Improvements

Patients also have easier access to their own information: 500,000 patients have downloaded their imaging studies and reports from their electronic health records. "This access empowers the patient, making it easier for them to get a second opinion, for example. Looking back 20 years ago, patients were 'bound' to their healthcare provider literally because of the notoriously bad handwriting of the doctor: it wasn't legible, so only the doctor had full access to these notes. Now, patients can take their data anywhere.

It also raises the possibility that several years in the future, a patient may come back and say 'you missed a tumor in this lung image, and now it has grown from 1 mm to 10 cm'. But it is always better for the healthcare system to have information, rather than not have it. This kind of pressure on hospitals and physicians, which drives quality improvement, is good for everyone in the end."

Creating a Collaborative Learning Environment

"The Enterprise Imaging platform includes an online collaboration functionality, that enables a radiologist to contact a more experienced radiologist for support with a diagnosis. Peer review for us is definitely not only about quality review, but about creating a learning environment. The radiologist requesting the second opinion is learning from their more experienced peer. Normally, these consultation requests decrease over time. When they don't, we can monitor the situation and determine if the radiologist could benefit from some additional training. This provides more objective feedback and encourages more learning," Professor Morozov describes.

Peer review can also help to highlight possible discrepancies in reporting, for example a missed diagnosis or missed incidental finding. "It's important that the reading specialist pay attention to everything in the image, not just the 'target' area. For example, if the expert is looking at an aortic CT, and misses an ovarian tumor that is visible in the image, this is not acceptable. Peer review has enabled us to have very constructive discussions to make it clear what we expect, and that someone is watching and checking, to promote continuous quality improvement."

"The Enterprise Imaging platform includes an online consultation functionality, that enables a radiologist to contact a more experienced radiologist for support with a diagnosis. Peer review for us is definitely not only about quality review, but also creating a learning environment."

Prof. Sergey Morozov

Rapid COVID-19 Response

When COVID-19 unexpectedly hit in early 2020, the URIS digital infrastructure was ready to meet the needs and demands of the healthcare crisis. "We were able to leverage our set-up to support the response. For the first months, PCR testing was not widely available, and the doctors didn't yet have a clear vision on how to differentiate COVID-19 from acute viral disease. CT lung scans were the primary method for diagnosis."

Agfa HealthCare and its local partners worked closely with the Department of Information Technologies of Moscow (DIT) to connect the primary care and out-hospital facility cluster and the hospital cluster, to enable even faster sharing of studies

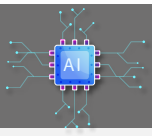
from one to the other. Federal and private centers were also connected.

"This allowed us to perform COVID-19 triage at the outpatient clinics, and quickly transfer patients to the hospital when needed. As hospital resources became overstressed, we were able to add the federal and private hospitals to the network," he explains.

"Using the digital infrastructure, we quickly standardized CT reporting for COVID-19 diagnosis, remotely taught our radiologists how to read them, developed a standardized CT scale grading for COVID-19 severity and pulmonary impact, and then spread that knowledge around the world."

Prof. Sergey Morozov

Artificial Intelligence



The standardization of the datasets in the archives is also supporting the development of Artificial Intelligence tools to further support the radiology services. "We have over 1,500,000 studies that are being analyzed by AI algorithms from different vendors: not only from Russia, but from around the world. The anonymized data goes directly from URIS to the AI tool and back again. The studies are then received by our radiologists pre-analyzed by the AI. This can help reduce the risk of human error, decrease the burden on the radiologist for routine tasks, and let the radiologist focus on the pathology and studies that require his expertise for prompt analysis and reporting," he describes.

"We also have a huge database of COVID-19 lung CTs, which we have used as the primary diagnosis tool during the pandemic. Our peers test their AI algorithms on our datasets, and they refer to our datasets, which include the classification of disease severity."

The Human Side of Technological Advances

While digital technologies in healthcare are fundamental to achieving the productivity, cost and care benefits Professor Morozov has outlined, it is important, he says, to remember that technology is an instrument, and the heart of both healthcare and technology is people.

The flexibility and dedication of the Agfa HealthCare team have played a critical role in the stages of the project over the years. Most recently, for example, Agfa HealthCare team resources have been instrumental in integrating a local, third-party voice recognition system, as well as for testing the integration with a number of AI algorithms.

"Furthermore, from the beginning, you have to keep in mind the people who will use the technology, how they accept it, whether they are ready for it, etc. And this digital infrastructure we have built with Agfa HealthCare is ultimately about people: including the local, technical and project expertise Agfa HealthCare has brought. I am very pleased that Agfa HealthCare is part of this project."

URIS

- 162 medical facilities belonging to the Moscow Health Care Department
- 1,102 radiologists
- More than 30,000 studies a day
- More than 10,500,000 studies uploaded - 5,284,556 of which in 2020
- 1,371 diagnostic devices connected:
  - 192 CT scanners
  - 97 MRI scanners
  - 53 angiography machines
  - 21 PET/CT scanners
  - 630 X-ray units
  - 30 densitometers
  - 119 mammography scanners
  - 3 SPECT-CT machines
  - 12 gamma cameras
  - 214 photofluorography scanners
- 10,000 referring physicians check images and reports online
- More than 500,000 patients have downloaded their images and reports
- Report turnaround time reduced from 5 days to 1 hour
- Half the number of radiologists needed for the same number of reports

Agfa HealthCare Solution

- Enterprise Imaging is a secure, scalable platform that converges images and imaging data so that it can be viewed and shared, in real time. The Enterprise Imaging platform transforms the medical imaging ecosystem; enables multi-specialty, multi-site collaboration; empowers extended and connected care, and provides physicians with the insight they need to make informed decisions.

Enterprise Imaging Platform

- The XERO universal viewer enables radiologists and referring physicians "anywhere, anytime" access to the patient's holistic imaging history.

City - Health - Healthcare: An Integrated Relationship to Undertake the Challenge of Change

Author: **Simona Agger Ganassi I Member of the Council of Health Care Without Harm - Europe (HCWH –EU) I Member of the Board, European Health Property Network (EuHPN) I Member of the National Council of SIAIS I** Italy

Prevention, Systems Approach, and a One Health concept appear to be the key to handle the complexity of our super-connected world and its challenges. But will people collectively accept the required change in their lifestyle? Will governments and healthcare policymakers comply with the actions required to go beyond the old definitions?

Key Points

- Prevention, in this context, refers to the condition of the urban environment that prevents the upsurge of specific health problems (clean air with regard to lung health) or facilitates healing (good housing with regard to allergies).
- Health refers to the definition given in 1948 by WHO - "A state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity".
- Systems theory and systems analysis is the basic approach to study and handle our living environment, in single elements (houses, roads, green area etc.) and when evaluating the interaction among the different elements.
- Complexity theory in this paper is addressed to underline that our existing systems are super connected, and the linear theory based on cause-effect is no longer sufficient to explain the effects that a certain action can produce.
- Determinants of health include a variety of factors which are connected with our physical environment, including quality of water and air, social and economic status, personal habits, good services etc.
- One Health is a collaborative, multisectoral, and transdisciplinary approach with the goal of achieving optimal health outcomes while recognising the interconnection between people, animals, plants, and their shared environment.
- New Generation –EU (or NG-EU) is the general programme of the EU for helping the economic and social recovery of European countries. Recovery and Resilience Facility (RRF) is the major programme included in NG-EU.

Framework

Urban areas have been at the forefront of the COVID-19 crisis, with 95% of all cases recorded in the first few months in cities. They, consequently, faced a rapidly evolving public health crisis, along with challenges to provide safe public transport and use of public spaces, ensure increased water and sanitation needs, and cope with economic consequences. Many cities in the European Union (EU) had to suffer difficult periods of lockdown amid coronavirus surges.

Apparently, there is a general support for the statement that post-COVID-19 cities cannot return to the "old normal", but the correspondence with real actions and measures is

still to be seen. The challenge of producing the "new normal", is, certainly, not an easy task and should not be left in the hands of "a few". The effort of producing this new normal lies in the capacity of choral, cooperative creation of healthy cities and urban environments, based on social equity, inclusion and health support for all. This will have to go in parallel with a much more diffused awareness of the changes that need to be made in comprehending and acting in front of the epochal challenges we are facing.

It is time to take a second look at the assumption that the major agents of change are the city and the healthcare systems. These two elements have to be seen, and dealt with not as two separate organisations, but as complementary entities, having a common point of reference - qualified and measured actions, concretely responding to a *"one health approach"*.

Let's go back for a bit to the impact of the pandemic. An overall hasty evaluation of healthcare's response points out the non-preparedness to this disastrous pandemic. This is attributed to two factors: the inadequacy of the models of health and the shortfall of the urban environment. In other words, the pandemic's impact has been, on one end, put under necessary scrutiny in terms of handling the assault to health by an exceptional event, and, on the other end, has highlighted the fragility and inadequacy of our everyday living conditions.

An essay published by the European Development Bank provides data than can put some light on the most recent process of urbanisation of the European continent. "Observing the journeys that European cities have taken from 1970 to 2020 reveal some startling facts. Today, 72% of the EU population lives in cities and urban areas, but this average conceals pronounced differences between countries. Urbanisation rates vary from about 50% (Luxembourg, Romania, Croatia) to beyond 80% (Italy, Netherlands, UK) ... by most definitions, Europe has no megacity. There is no single municipal area with more than 10 million people. But the wider city-regions of London, Paris, and Milan each have more than 10 million". Size is certainly playing a role and there are several other large cities in Europe with a consistent urban sprawl, with degraded areas in unplanned expansions, but sometime urban decay and poor living conditions are present also in historic centres. Furthermore, as we said, expansion took place in many cities of Europe after World War II. This expansion occurred mainly under the banner of private building speculation, or, to speculate bluntly, mostly according to criteria, models and standards in which the economic values of the land were prevalent and profit was the primary goal. The public governance, in many cases, lacked economic means and effective legal tools for controlling the development. Most of the local authorities, elected to manage public affairs, lacked a true awareness that urban policies could influence the quality of air, space and water, the common use of public space, and access to essential services. This facilitated the insurgence of some diseases and the diffusion of others.

Today there is more advanced knowledge and awareness of the consequences of urban policies and decision making on the environment, the psycho-physical health of urban people, and on the quality of urban life. This has additional relevance since the trend of growth is expected to be around 90% in Europe.

Public health management and urban planning policymakers have operated separately in a neoliberal framework within academic, political and strategic compartments, representing one of the important obstacles, rarely mentioned, for moving towards a "new normal", as we will illustrate, digging into the parameters that could potentially make this possible.

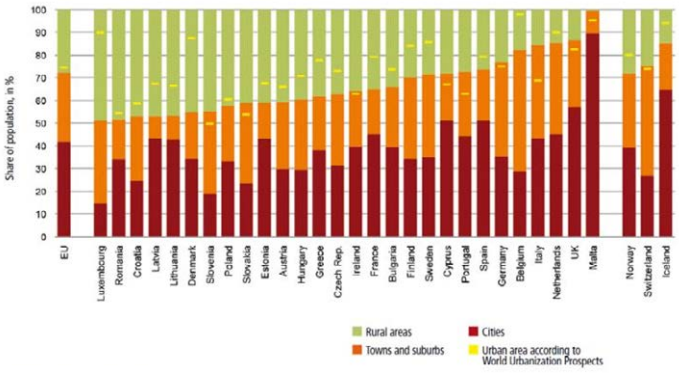


Figure 1: Share of urban population in EU and constituent countries as percentage of total. Source: Eurostat and World Urbanization Prospects 2014

First Steps Along the Journey Toward Change

As underlined before, the need for a post-pandemic "new normal", in other terms for change, is recognised, or should be recognised, as regarding the two "organisms" on which we have focused: the city and the healthcare systems. We consider that there will be no change unless a few important aspects are bilaterally understood. These include:

Prevention

It is well understood and accepted that the health of people is not only a matter of medicine, and therefore, does not completely fall under the responsibility of health systems. This is especially true if we look at the 1948 definition of health by the World Health Organization (WHO). The definition today has become more and more diffused. This has been expressed quite eloquently by the title of Nagel Krisp's last book - "Health is made at home, hospitals are for repair", echoed by Prof Rafael Grossman proposing to change healthcare into health repair.

There is some truth in this, considering that medical doctors themselves indicate that medicine, including care in hospitals,

covers no more 15-20% of the average health needs of a person during his lifetime. A large majority of the medical doctors and scientists stress that a part of medicine should be dedicated to preventing illnesses. Other important scholars have also put the current approach of many European countries under scrutiny in terms of how prevention is conceived and practiced and why there is a need to change the concentration on "diagnosis and care" as the way to prevent diseases.

Saracci et al. (2021) in a recent article stress that the pandemic has given evidence that such systems are obsolete and there is a need for new parameters. They also stress on "the policy of co-benefits". As an example, they indicate that interventions aiming to the reduction of greenhouse gases (GHG), through reducing the use of fossil fuels will jointly prevent diseases induced by air pollution and those induced by climate change.

This is an important aspect and gives a more interesting perspective on how a hospital needs to come out of its isolation. Analysis of the impact of the COVID-19 pandemic, as mentioned before, has brought attention to the fact that there was not enough presence of health infrastructures in most global territories. This is correct, but not enough.

Focusing on improving the infrastructure according to quantitative parameters is a positive change and could bring healthcare systems closer to the needs of patients, but this will still not be part of the real prevention that can come from a city, that, with the collaboration of healthcare, can generate larger co-benefits.

Another factor is the pressure for improving the quality of housing. For example, taking care of asthmatic children in a hospital knowing that, once home, these children would become sick again due to the poor living conditions. This is currently not considered a problem of the hospital and this, in itself, indicates how much space there still is in establishing a common understanding between hospital and city government based on the policy of co-benefits.

During these times, when urban planning tools are under re-evaluation, it has become essential that a priority alliance between healthcare and urban governance gets established to focus on a common understanding of the definition of **prevention** and elaboration of a common strategy to help the urban environment become, as I have defined in another article, the **gym for health**. The "policy of co-benefits" already mentioned is certainly an important tool.

Even before the pandemic, WHO in its Global NCD (Non Communicable Diseases) Action Plan 2013-2020 recognised the primary role and responsibility of the government and highlighted the importance of urban planning related to life conditions and environment. The document also emphasises another important point: urban policies and healthcare governance are among the main determinants of prevention, but involvement and actions have to extend to a transdisciplinary participation, and they have to be oriented by the principle of "health in all policies".

Complexity and Systems Approach

Scholars and urban theorists have, for a long time, conceived that in the field of urban planning and policymaking, the approach had to be "rational" positivist, based on objective data, deductive analysis, and systematic comparison of alternatives. In recent times and especially with the pandemic experience, this approach now feels obsolete. In fact, since the pandemic started to intrude and upset our lives, we have had to recognise that we live in a world characterised by multiple connections, with continuous variations which don't obey to the linear thinking based on cause and effect – a concept that has constituted the basis of our thinking for many centuries.

"A new way of thinking is becoming imperative because the systems in which we live, urban and environmental and biological, social, financial and economical, to mention some of the most relevant, don't follow linear logics of cause and effect. Given the high presence of non-linear relationships, in complex systems the effect of a stimulus is not proportional to the force that generated it " writes Antonio Bonaldi (2020).

Recognising the complex nature of urban policies and healthcare organisation and delivery of health services, obliges us to also look at the common ground of prevention and the need for a new way of thinking and new approaches. The fundamental of this has been constituted by the **Systems Approach**. It represents, in fact, the support in understanding and building the transdisciplinary relationship involved in reaching the goals related to a health-protective urban environment and a healthcare system that is a pro-active participant in its realisation.

To make more concrete the understanding of what would work within the framework of the systems approach, here is a small example. Reopening schools safely has been and still is, a matter of debate - from politicians to parents - not only in Europe but around the world. In effect, the first attempt of reopening schools was focused on life inside the schools (e.g. changing school desks or chairs, sanitisation etc.). But this proved to be a great failure. Only recently, many of the previously non-considered dimensions, such as transportation of children/young students, safety measures for teachers and all other people involved in school life and activities, family organisation etc. are now being taken into consideration, that will hopefully produce the desired result.

Certainly, the Systems Approach is necessary in understanding more complex problems such as the way to build healthy cities also depends on the need to limit the increase of the effects of climate warming and climate change. It is a systemic view that is advocated, among others, by Richard Heinberg in his many books and articles highlighting the profound links between ecological problems and the way human society acts.

It needs also to be said that systems analysis is not a new discipline. An explosion of systemic research, started by Jay Forrester with his "Urban Dynamics" produced way back in

the 70's and the work of Club of Rome with M.I.T. "The limit of Growth" highlighted the relationship between growth of the population, industrial production, food production, depletion of natural resources, and pollution. It may be worth it to rediscover that period, without the superficial use and abuse of the reference to systemic approach. This leads us to another important concept that needs less superficial attention.

One Health

The ***One Health*** approach seems a very easy concept to grasp and use. In reality it isn't so. Let's take one of the many definitions proposed by the Centre for Control of Diseases and Prevention (CDC): *"One Health* is a collaborative, multisectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognising the interconnection between people, animals, plants, and their shared environment".

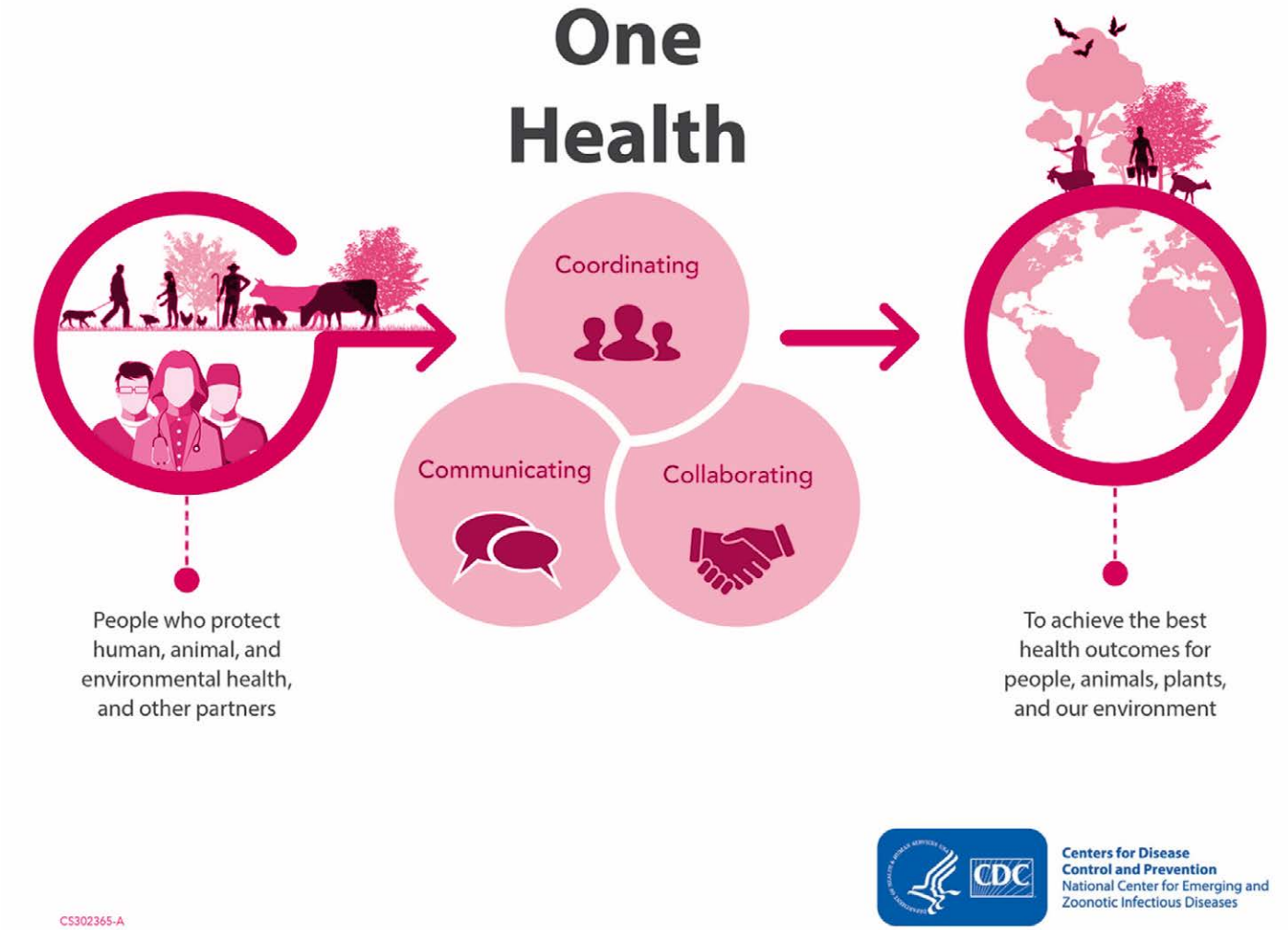
As mentioned before, there is at least one serious ancestor of this concept. It was the attempt by the European Union to introduce the health factor into the different sectorial policies of EU. Working on the high level committee in Brussels, I remember the complicated cube we produced to provide a tool to ensure that EU policies were having a positive impact on health or, at least, were not inducing consequential health problems.

Our work did not go as far as it should have gone. WHO took it further, however, in 2013- 2014 when it produced a document defining five key elements of a "Health in All Policies Approach" (WHO 2014):

- Health, equity and sustainability. The Health in All Policies philosophy holds that health, equity and sustainability are closely linked
- Intersectoral collaboration
- Co-benefits: Benefit multiple partners
- Engaging stakeholders
- Creating structural or procedural change

What appears from these brief references is that *"One Health"* represents the evolution of a concept with a very big step forward created by the consciousness of "one planet, one health" - that is human health cannot be separate from animal and environment health.

To give concreteness and impact capacity to this concept is a battle certainly not yet won. Some tools have to be created, even at the risk of excess of bureaucratisation, and in any case,



the results for a new normality will not be achieved without massive people involvement.

The Italian First Steps Toward Recovery and Resilience: A Case Study

The presentation of this very recent planning action by the Italian government aims to reinforce the concept already expressed: change is difficult and with it the realisation of a "new normal". The "Next Generation EU" (NGEU) is the well known European plan for Recovery and Resilience. This is a unique effort made by European institutions to help EU countries recuperate after the crisis produced by the pandemic. Recovery and Resilience Facilities (RRF) is the most important of the programmes financed by NGEU.

We will analyse some of the aspects of PNRR (National Plan for Recovery and Resilience) - the Italian plan that has an allocation of 191,5 million Euros. The reason for the selection of this plan is because documentation for Italy is available to the writer. The complementary assumption is that difficulties and the risks facing Italy would have, in large part, similarities with several other EU countries.

The regulation lines of the RRF indicate six pillars as the focus for each national plan. These include:

1. Green transition
2. Digital transformation
3. Intelligent, sustainable and inclusive growth
4. Social and territorial inclusion
5. Health, economic, social and institutional resilience
6. Policies for new generation, childhood and youth.

The Italian plan has divided the resources in sixteen parts, called components, grouped in six missions. One of these missions is dedicated to health. The first critical evaluation comes from comparing how pillar five is defined by the EU-RRF compared with the Italian setting. In the latter, HEALTH is defined in reductive terms. The reference is only to some sectors of health assistance. In the EU guidelines, "health and consequently all what contributes to determine health, has to be privileged, being influent on the growth capacity of the states to grow." In the Italian document, health is considered only in reference to some limited aspects of the healthcare organisation". This point has also been highlighted in the article by Saracci et al. (2021).

The role of territorial assistance appears to be one of the weak points in the protection against the impact of the virus It is again seen as part of the health infrastructure, not an occasion of integration within the social fabric and an element to build a common vision between health policymakers and local governments. This is certainly a confirmation that there is no real vision that should take us towards the "new post-pandemic normal".

There is a total absence of any reference to "prevention", the importance of which has been highlighted at length both for the city and the healthcare system, and which is critical for working together. Another lesson that can be derived from the Italian PNRR is that although the ***One Health Approach*** is frequently mentioned, it is not put into practice. A real understanding of its value would have certainly induced to see health involved in many, if not all the other missions, from mission 2 to mission 5. However, health is mentioned only in mission 1, and that too, related to digitalisation of medical records. Furthermore every action outlined in the components of the missions written in the PNRR are examined based on their impact on the economy. They should also be critically examined with regard to the favourable or negative impact on health, but this would only happen if the ***One Health Approach*** should have been concretely understood and made an important part of its initiatives.

Conclusion

We have at length, expressed our concern that the great occasion for change will not become a reality, or even if it does, it will produce low results. Getting back explicitly to the question of the present issue of HealthManagement.org, we are certainly in a period of great challenges and opportunities for change. We have the opportunity to produce healthy cities thanks to the collaboration of local governments and communities with a healthcare system, public mostly, but also private, to integrate prevention and use of the criteria of co-benefits as a different view of care. At the moment the efforts don't seem to encourage optimism. We must, however, concede that to make plans operative, we will require plenty more studies and definitions, which can address omissions and some wrong visions and approaches. For Italy, a comparison with other countries will certainly be of great help. Globally, it will help the diffusion of new visions and concepts, including the ones we have discussed in this article.

Conflict of Interest

None. ■

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Developing Connected Healthcare Systems and Accelerating Digital Transformation

Author: Sourabh Pagaria I Executive Vice President & Head of Southern Europe I Siemens Healthineers

With urban populations increasing worldwide and technology making smart cities a reality, there is a great potential of improving healthcare services by expanding them beyond the hospital walls. Both immediate health emergencies, such as COVID-19, and long-term strategies can be addressed with new, tech-driven solutions supported by enhanced community care. HealthManagement.org spoke to Sourabh Pagaria, Head of the Southern European business of Siemens Healthineers and discussed healthcare systems in the wider urban context and the challenges and opportunities of interconnected systems.

It is believed that the future of healthcare will focus on delivering care beyond the hospital walls. Do you think this is an achievable goal?

With the increasing need to manage a larger chronically ill patient population and the need to expand access to healthcare beyond urban neighbourhoods, especially to the sub-urban and rural population, health systems and hospitals are increasingly looking at a model to deliver care beyond the hospital walls, whether this is in the form of opening satellite sites closer to communities or conducting community outreach programs like mobile screening etc.

However, one of the major barriers they face in the implementation of this strategy is workforce shortage. Hospitals are increasingly understaffed, and there is a mismatch in workforce demand and supply (Siemens Healthineers Insight Series Issue 24). United Kingdom-based publisher BioMed Central estimates a global shortage of more than 15 million healthcare workers in 2030 (Liu et al. 2017). The global trend of urbanization poses additional challenges as well. Staff shortages are particularly apparent in rural areas. Since it is particularly difficult to find skilled medical professionals to work in rural areas, the capital investments made in these satellite sites often experience downtime, which impacts the bottom line. Yet studies have shown that 57% of people think that the most important factor in deciding where to obtain care is the ability to receive timely care (kyruus.com/2020-patient-access-journey-report-lp).

There is a need to provide consistent, high-quality care across the region around the clock. To solve the myriad challenges, hospital networks need to be creative in employing digital technologies to deliver more efficient care. Telehealth not only provides the convenience that patients are looking for today, but it also connects care teams and empowers caregivers to deliver care in a more streamlined way. With the strategic use of telehealth technologies along the entire patient pathway, health systems could reduce inefficiencies and achieve their growth objectives without increasing their footprint.

What role can technology play in helping achieve this vision of providing care outside of the traditional care setting?

Technology plays a central role in enabling healthcare providers to expand access to quality care cost-effectively. Technologies like virtual consultation, remote machine operations and robotics-assisted procedures can help improve access to higher quality healthcare to the large population across the globe. Remote monitoring can make healthcare more continuous, and last but not least, technologies like AI could drive triaging, and AI-powered clinical decision support systems could help free up precious physician and specialist time which could then be used by them to provide

more emphatic and personalized care to the patients as comprehensively and productively as possible.

Do you think the new model of a bed-less or wall-less hospital can result in greater patient empowerment?

Patient empowerment is closely linked to the evolving trend of consumerism in healthcare. Consumerism is not merely about supporting hospitals, insurance companies and other involved businesses. Instead, it is mainly being driven by patients, who are increasingly turning into consumers. Furthermore, consumer-centered healthcare is becoming heavily reliant on digital technology. This rings especially true when we look at how the COVID-19 pandemic is still transforming healthcare. Telehealth adoption has fueled consumerism breaking down the traditional geographical proximity advantage for some healthcare providers and opening the field for increased competition with virtual competitors.

Self-monitoring, another catalyst in the transformation of healthcare, is not as difficult as it was once touted to be. More and more people are buying self-monitoring medical devices online. Pulse oximeters, devices that few had even heard of before the pandemic, are now being sold at unusual rates. With these tiny hand-held devices, one can measure their oxygen saturation levels at home. Self-monitoring and online reporting are not limited to COVID-19. They can easily encompass a host of other health conditions, including chronic diseases such as diabetes, hypertension, lung disease etc. With these self-monitoring tools in hand, patients can demand healthcare services that leverage these tools and help them manage their health.

With telehealth and self-monitoring being popularized among people, consumeristic healthcare post-COVID-19 will be heavily influenced by digital technology. It will involve the use of machine-learning algorithms and AI to predict prognoses, smartly distribute work to doctors and nurses and manage patient intake virtually.

Virtual consultations by doctors and clinicians are going to add to the patient experience immensely. It certainly addresses one of the major issues that patients find in their healthcare experience – a lack of sufficient interaction with their primary healthcare providers. Digital modes of healthcare dissemination will also allow for continuous contact with patients through simple text messages or video clips – modes that do not necessitate direct interaction but still improve the patient experience.

In this scenario, one element is fundamental: patients should be willing to share data to contribute to this transformation of healthcare and for the benefit of research. Availability of more data can help alter digital healthcare to better suit the patients' needs and expectations. Feedback is also very important so that future services can be better.

Can availability of patient data help in realizing the vision of intelligent home care?

We should analyze the benefits of the availability of patient data at two levels:

1. **Macro-level or population level care:** With the broad availability of patient data in a community, healthcare providers can better understand the prevalence and disease disposition patterns in the community. This information, in turn, can be used to develop the right community care plans like screening programs, awareness programs and wellness programs. Such programs could help in making the whole community healthier by preventing chronic conditions from occurring in the first place while ensuring adequate medical infrastructure is in place to treat the population. Additionally, having a broad patient data set from within a community could help train AI algorithms for better suitability and the removal of any biases in them.
2. **Micro-level or individual patient-level:** At an individual patient level, the availability of longitudinal personal medical data and history can truly enable better patient outcomes all through the care cycle. For example, continuous self-monitoring at home can enable patients to act in advance of any major medical episode and proactively reach out to their healthcare provider for timely guidance. Similarly, during the treatment phase, a patient's medical history combined with genetic data can help doctors customize care and treatment plans. Finally, during the recovery or maintenance phase of the disease, patient-level data from remote monitoring devices can enable caregivers to monitor recovery, treatment compliance, and timely intervention to ensure a proper return to health, thereby improving patient outcomes and experiences.

Virtual care will continue to be a leading strategy in healthcare. Do you think healthcare systems are ready for this change?

No doubt that this pandemic has been a major accelerator for virtual care model adoption for both patients and clinicians. However, in most parts of the world, we still have a long way to establish virtual care as a mainstream and robust care model. There are a couple of important aspects that need to be addressed at a health system level in a comprehensive way beyond implementing the required technological infrastructure:

1. **Setting up permanent and comprehensive reimbursement models for virtual care model:** While many healthcare payors instituted temporary reimbursement models for virtual visits, it is imperative to look at the reimbursement schemes more

comprehensively beyond just visits. Remote therapy and remote monitoring need to be included in the overall plans of healthcare payors and systems to enable a sustainable transition to virtual care both by physicians and patients in the short term.

2. **Adopting healthcare workflows through proactive care coordination:** This is one of the most difficult aspects of shifting from physical care to virtual care. Traditional healthcare workflows have been largely designed around a patient physically showing up at the healthcare facility and moving from department to department. However, this is not the case when a patient is remote. In this scenario, the healthcare system will have to take on more responsibility in ensuring care coordination and reach out to the patient for care. We would need to create roles like "care manager" whose sole purpose would be to "bring the hospital to the patient".
3. **Driving adoption through effective change management:** Shift to virtual care models involves driving effective change management around the adoption of new tools and workflows in both patients and clinicians. This requires consolidated efforts to familiarize, train and support them. Additionally, setting a short-term incentive structure to drive adoption would be key to enable this transition speedily. Finally, continually analyzing, measuring, and evaluating virtual care workflows and leveraging patient and physician feedback would help every healthcare institution find models best suited to their culture and needs.

Do you think changing the traditional model of healthcare will result in patients feeling disconnected from clinicians?

For as long as there have been doctors and nurses, the basic healthcare interaction has been a very human one. When a person feels sick or suffers an injury, they visit a

healthcare provider (Siemens Healthineers Insight Series Issue 19). This traditional physical way of providing care has served healthcare well for generations, but in today's world, the limitations of this system are becoming more and more apparent. Due to the increase in patient population, administrative workload and staff shortage, the doctors often find they don't have enough time to devote to patients for quality interactions. Long waiting periods in getting appointments and proper diagnosis result in delayed treatments, which often negatively impact patient outcomes and satisfaction. Hence, there must be broad-scale adoption of virtual care where doctors are supported by myriads of technological tools that help them increase their efficiency through automation of tasks, e.g. triaging chatbots or remote monitoring devices. Virtual care could truly improve patient outcomes and satisfaction.

Patients who receive home health services may still need assistance directly from clinicians/ care managers. What strategies can be used in such scenarios?

Having a proper "escalation management" system is key to the success of any virtualized process, and virtual care is not an exception to this requirement. Patients receiving virtual care services at home need to be continuously monitored to timely receive the attention of clinicians and care managers in case of adverse events. Digital technologies like AI and machine learning could play a big role here. Properly trained AI algorithms could identify and predict the occurrence of adverse health events of remotely monitored patients based on the trends from their vitals. With this information, physicians and care teams can trigger an appropriate care protocol which may include bringing the patient physically inside a hospital for intensive care (Siemens Healthineers Insight Series Issue 10).

To adjust to an innovative, virtual model, healthcare organizations will have to invest time and money. Do you think they are technically equipped and have sufficient expertise?

The digital transformation can only be successful and sustainable if healthcare leaders move beyond adopting technology solutions and begin transforming their institutions into learning health systems. This is a vital development for the future of healthcare and one that will prepare providers to respond to new COVID-19 outbreaks or other infectious disease events. How? By including data and technology that is easy to use and frees up caregivers' time, by establishing an organization committed to digital transformation, and by rigorously measuring and disseminating patient outcomes (Siemens Healthineers Insight Series Issue 12). Measuring outcomes is the basis for course correction and makes it possible to scale the right measures toward continually optimizing, expanding and advancing enterprise performance. The learning health system will be better prepared for both routine care and for extraordinary circumstances like the one we are living with COVID-19.

This transformation isn't easy; challenges to successful digital transformation include low quality of data, an inability to securely and conveniently access operational and clinical data, low interoperability of systems, and fragmented care systems in place in many countries. Enduring value-generating partnerships between healthcare providers and medtech companies can help provider organizations leverage technology to upgrade their organizations both in the near term, to better cope with the urgency of the pandemic, and in the long term, by investing in strategic digitalization efforts. In collaboration with medical technology partners, healthcare enterprises can create more value for stakeholders and deliver meaningful improvements in clinical and financial outcomes. ■

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CardioFollow.AI - A Digital Follow-up Service Expanded Beyond the Hospital Walls

An intelligent system to improve patients' safety and remote surveillance in follow-up for cardiothoracic surgery

Author: **Ana Rita Londral | Executive and Scientific Director | VOH.CoLAB I** Lisbon, Portugal
Author: **Salomé Azevedo | Head of Digital Health | VOH.CoLAB I** Lisbon, Portugal
Author: **Pedro Coelho | Senior Surgeon | Hospital de Santa Marta, Centro Hospitalar Universitário Lisboa Central I** Lisbon, Portugal
Author: **Jorge Pinheiro Santos | Cardiac Surgery Resident | Hospital de Santa Marta, Centro Hospitalar Universitário Lisboa Centra I** Lisbon, Portugal

CardioFollow.AI is a real-world pilot pushing forward the frontiers of follow-up care of cardiothoracic surgery patients to allow them to recover comfortably at home. This article briefly presents the work and principles undertaken for designing and implementing a postoperative digital telemonitoring service for patients submitted to cardiac surgery in Hospital de Santa Marta.

Key Points

- The design of a remote telemonitoring service must consider the diversity and variety of socioeconomic status of patients reducing the risk of inequity and inequality in the access to healthcare.
- Digitising a healthcare service requires a collaborative network of stakeholders that consider and perceive the value they add for the patient and the healthcare network.
- Digital healthcare service is the result of successive iterations of technologies and organisational models.
- Patients and healthcare professionals must be engaged from the beginning of the service design process to express their contexts, needs, fears, and motivations.
- Artificial intelligence can improve patients' engagement and support clinical decisions by using technology based on risk stratification.

Introduction

Academia and government experts emphasise that to reach a sustainable universal healthcare coverage, it is crucial to identify the optimal allocation of resources and improve the quality of healthcare delivery. Although there has been an intense, fast, and dynamic progression in science and digital innovation in healthcare, the benefits of these investments to the overall system are not clear. The effort to digitise the healthcare system is under constant scrutiny due to a fragmented system that cannot demonstrate its potential value to all stakeholders. Consequently, exciting times and opportunities emerge for technology and innovation to meet and give structure to achieve a higher-quality, lower-cost healthcare system. Besides providing improved capacity to treat patients, remote care services, and new treatments for diseases, technology has the potential to give helpful information and include a diversity of perspectives to enlighten on the actual value inherent to all healthcare processes (Gray et al. 2017).

Digital Follow-up Care in Cardiothoracic Surgery

The commitment to universal health coverage, and the emergence to control the damage caused by COVID-19, demand a transformation of the healthcare system grounded on appropriate care and efficient use of resources. Moreover, digital technology can be the best adequate venue for collecting evidence and supporting decision-making across all levels and stakeholders of the system. However, recent research demonstrates that technology adoption is not at its maximum potential. Even with imposed social distance due to pandemics, why were we not ready to tackle the population healthcare needs with so much technology in our hands? The importance of having remote access to healthcare and facilitating a digital experience to patients and clinical teams has never been so evident as during this pandemic.

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We designed and implemented a postoperative digital telemonitoring service for patients submitted to cardiac surgery in Hospital de Santa Marta. Hospital de Santa Marta, a central public hospital in Lisbon, Portugal, is a centenary and leading hospital in Cardiothoracic Surgery at both the national and international levels. With a successful phone-call-based follow-up service, the surgery team was motivated to improve the service to integrate vital signs and patient-reported outcomes collection to allow a better patient experience, earlier hospital discharge, and safer recovery at home. Furthermore, telemonitoring became particularly advantageous in the pandemic context, as it supports the continuity of care with minimal risk of transmission by avoiding unnecessary hospital visits and consultations.

The Relevance of Collaborative Networks to Deliver Value in Healthcare

Considering the European context and the values of societies committed to universal health coverage (UHC), a panel of experts (European Commission 2019) propose four values to healthcare systems, from previous contributions of Porter and Teisberg (2006) and Gray et al. (2017): Personal value, allocative value, technical value or utilisation value, and societal value. These four pillars require a transformation of the healthcare system by understanding what patients, healthcare professionals, healthcare providers, technology providers, payers, society and others value most.

The value-based healthcare paradigm has fomented the collaboration between experts from different fields to "fix the healthcare system". Shortell (2008) foresaw that a healthcare system based on value, derived by outcomes, will drive the reconfiguration of the healthcare system into a network-based structure. Academia, industry, government, and non-governmental organisations dedicate their time and resources to cope with challenges and opportunities to improve the healthcare system. There is an ultimate desire to provide high-quality products and services to people seeking healthcare. Different interests, motivations, and definitions on healthcare quality and access must be considered to drive stakeholders to develop high-value services; otherwise, they will self-organise and compete for individual goals compromising results (Rouse 2000). The increased workload due to this practice, however, may be challenging to manage and biparametric MRI may prove a valuable optimisation in terms of acquisition time and exam scheduling in busy radiology departments. A study conducted in the United Kingdom reported a 55% reduction in scan time, significantly increasing the number of scans performed weekly (Sushentsev et al. 2020).

To address the aforementioned systemic issues, CardiofollowAI implemented a network to guarantee a high-value digital healthcare service. This network was promoted by Value for Health CoLAB, joining Fraunhofer AICOS, Vodafone Portugal, Nova Medical School and the Hospital de Santa Marta. After gathering the stakeholder's motivations, expected benefits, and contributions, we defined a strategy that would leverage a value-based digital service.

- **Value for Health CoLAB (VOH.CoLAB)** is a non-profit research collaborative laboratory focused on developing and validating innovative methodologies to measure outcomes and costs that influence the health value of every person. The motivation to engage in the design of this new service was to advance knowledge in the design methodology of value-based, flexible, and low-cost remote digital healthcare services.
- **Fraunhofer AICOS** joined the project to enhance its investment efforts from their previous success in developing a digital health kit for remote monitoring of patients with chronic cardiac pathologies. The digital health kit consisted of a smartphone with SMARTBEAT app to collect data from a smartwatch (to measure steps and continuous heart rate), a sphygmomanometer (to measure blood pressure and heart rate), and a scale (to measure weight).
- **Vodafone Portugal** joined the project to promote the development of technological solutions that improve the quality of life of the community and develop new products and services in the health sector. Vodafone Portugal contributed with the 4G connection integrated into the kit to allow data exchange.
- **NOVA Medical School** and Hospital de Santa Marta support the clinical research and deployment of the digitised service. Hospital de Santa Marta as a university hospital has a strong background and motivation to collaborate with NOVA Medical School to train their medical students in new medical areas. These two organisations have been working to modernise existing services and prepare healthcare professionals to integrate cost-effective technology in clinical practice.

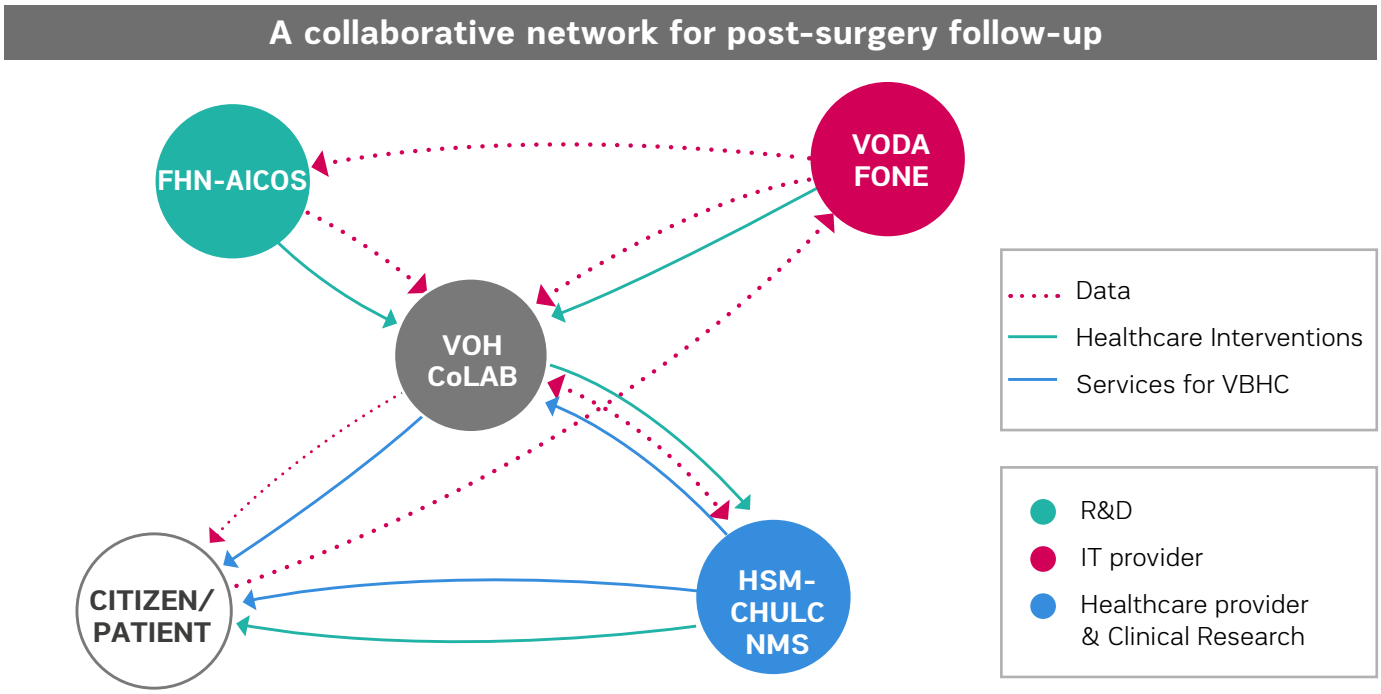

Figure 1 - Collaborative Value Network for post-surgery follow-up

A Digital Experience that Provides Better Access to Healthcare

Patient follow-up is essential in the recovery of cardiac surgery patients, as hospital readmission rates are 15 to 20% in the first 30 days and 30% considering the first year. To tackle the risk of readmission, the goal of the RPM service is to empower patients to report symptoms from home and actively engage them in recovery. Also, the service must empower the clinical team to follow patients effectively.

We mapped a patient pathway to allow data collection in different timestamps to monitor the patient and control the quality, experience, feasibility of service, and technology performance. The clinical team was fundamental in specifying use cases and scenarios for cardiothoracic surgery digital remote follow-up service. Throughout several in-presence meetings, the research and the clinical teams exchanged knowledge using process maps to design the care process, define the outcomes to be measured and the required resources to assess these outcomes. After an iterative process, the protocol was validated by all stakeholders.

The primary commitment was to design a digital remote monitoring experience to quickly demonstrate how the patient and the clinical teams would be involved in a 30-day telemonitoring period.

In CardiofollowAI, we developed a system where patients generate data, i.e., patients are instructed to perform a daily routine to collect data. The reason for this was to promote patients' engagement in recovery, making them aware of the process. Usability of the technology and literacy of the patients is a determinant factor in the success of such an approach. The daily remote monitoring routine of the patient consists of measuring the vital signs using a sphygmomanometer and a scale, using a smartwatch to count steps and measure pulse rate, answering five multiple-choice questions about symptoms, and taking a picture of the surgical wound to send via a chatbot. Every day, the nurses monitor this data in a web-based monitoring platform. In case of unexpected variations, the nurse contacts the patient to assess the patient's health status or discusses the clinical case with the surgery team.

As nurses must spend extra time analysing each patient's reported data, the high burden associated with more patients demanded an agile system that would allow an overview of all patients' health statuses with alerts to call for attention for specific abnormal parameters and allow a more detailed description of each patient. That was how Beatnik was created in co-creation with the clinical team — a web-based remote telemonitoring management system interoperable with the IoT devices and the chatbot.

After several iterations, Beatnik allows nurses and surgeons to quickly assess each patient's health status (vital signs, symptoms, and wound cicatrisation), take notes, and change therapy.

More recently, based on patients' and clinical team's feedback, another opportunity for development emerged: provide feedback to patients using a chatbot. As the chatbot integration was very successful, since most of the patients were using this channel for communication, nurses looked to the opportunity of interacting with patients more frequently. This chatbot sends automatic messages with health literacy content pre-defined by the nurses and triggered by specific events.

Figure 2 - Patient Zero learning how to use the digital health kit

Digital Health Literacy

Literature in digital health has consistently highlighted the importance of patients and their caregivers as active members in the development cycle. More specifically, they should be informed and involved in the design of new digital health services. Therefore, our approach to improving the digital health literacy of the patients started on the day of hospital discharge. An individual session with the patient, caregiver and nurse was organised to explain the project, assess the patient's will to participate and deliver the digital health kit. We simulated a daily routine, and the nurse discussed the relevance of the measures for a safe recovery.

A Further Step with AI: Supporting Decisions Based on Risk Prediction and Intelligent Interaction

After a successful pilot study, the telemonitoring service faces the challenge of optimising the follow-up process, with results from the telemonitoring pilot and the outcomes from the 1-year follow-up programme. Data integration would allow identifying patients at higher risk of complications or readmissions to support decisions on follow-up resources that maximise patient safety.

In the CardiofollowAI project, funded by the Portuguese National Foundation of Science and Technology, we are now working in machine learning algorithms to develop risk prediction models based on patients' data. These models will support decisions that are related to the telemonitoring needs and resources. We are posing the hypothesis that patients with a higher risk of complications during the first year after surgery are those who will most benefit from the digital remote telemonitoring service.

We are also developing intelligent interaction between patients and nurses, considering patient-reported outcomes, literacy, and other particular needs. Intelligent interaction implemented in the chatbot and the clinical telemonitoring platform will allow personalised support to each patient's recovery pathway.

Figure 3 – Cardiofollow.AI project illustration

Conclusion

Digital health services are an opportunity to cope with challenges related to lack of capacity, isolated population, and low access to high-quality healthcare. These services' inherent technological basis allows evidence-based, efficient, and more effective development and integration iterations. The work conducted so far motivated the collaborative network to apply for large-scale pilot project funding.

The main goals include developing an Artificial Intelligence-based decision support system for resource allocation to maximise long-term health outcomes and studying the service's macroeconomic impact. The proposal was granted funding, and all stakeholders are involved in a 2-year research project.

Based on Lean Startup's principles and Design Science Research Methodology, our approach to design and develop a new digital health service allowed all agents involved to be creative and give contributions without compromising resource and budget constraints. It also enabled the demonstration of value in short cycles of development and real-context validation.

To know more about the project, please refer to: beatnik.vohcolab.org

Conflict of Interest

None. ■

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Patient Safety As Gold Standard in the Era of Big Data

Author: **Alessandro Roncacci I Senior Vice-President I Chief Medical Officer I Affidea**

Affidea launches an innovative Business Intelligence Tool for real-time radiation dose monitoring to improve patient care.

Key Points

- The use of a new technology built on GE Healthcare's Applied Intelligence platform and imaging insights.
- Better data integration and analysis through the use of the Affidea Dose Excellence programme, a unique global programme for patient safety and radiation protection.
- The launch of a 3.2 version of DoseWatch in combination with a real-time business intelligence (BI) tool- Imaging Insight- for data dashboarding.
- Affidea becomes the first healthcare provider in Europe to install this innovative BI solution.

Healthcare is undergoing a digital transformation and at Affidea we are committed to leading this pathway, improving quality of care and patient safety, while driving operational efficiencies. The cornerstone of ensuring this across our diverse geographies is to leverage a new technology built on GE Healthcare's Applied Intelligence platform, Imaging Insights, which merges dose, technical and operational data from imaging machines. Better data integration and analysis is indeed key for driving our decisions in order to improve patient care.

Some of this vast amount of data is coming from the Affidea Dose Excellence programme, through which we analyse information from more than 75000 Computed Tomography (CT) scans each month.

This is a unique global programme for patient safety and radiation protection which brought Affidea international recognition. We are the most awarded healthcare provider for patient safety by the European Society of Radiology, where 50% of the total centres awarded with 5 stars for radiation protection on the Eurosafe Wall of Stars belong to the company.

As the leading European provider for advanced diagnostic imaging, outpatient and cancer care services, with 309 medical centres across 15 countries, we have always been a pioneer in our industry, looking for clinically proven methods to enhance clinical excellence and offer outstanding patient care.

With this in mind, we have taken our Dose Excellence programme to the next level with the launch of a 3.2 version of DoseWatch in combination with a real-time business intelligence (BI) tool- Imaging Insight- for data dashboarding. The BI is installed on Corporate Affidea Microsoft Azure Cloud and collects data, in a secure and compliant way, from all local DoseWatch installations, with Affidea Hungary and Spain centres being the first to implement it. Affidea thus becomes the first healthcare provider in Europe to install this innovative BI solution.

A Real Time BI Data Dashboard to Drive Operational Efficiency and Clinical Excellence Across the Group

The Imaging Insights Business Intelligence tool regularly updates and correlates multiple data sources into one consolidated view. It keeps the clinical teams well informed, allowing them to focus on optimising operational efficiencies, clinical excellence and patient experience.

Imaging Insights can help achieve operational efficiencies by optimising the exam duration and procedure scheduling to

increase throughput and reduce backlog. At the same time, it also helps benchmarking CT technologies at group level, identifying variations in practices across multiple centres and staff performance for training opportunities.

This is another proof of our strong compliance with 2013/59 Euratom Directive by identifying variations in real time and by standardising and optimising protocols, while maintaining the optimal image quality and increase safety for our patients.

notifications on clinical context and cumulative dose of iodine (risk factors, prior adverse events) as well as injection details (contrast media, volume, injection protocol). All these features will allow Affidea to manage contrast media data in order to strengthen the clinical protocols and track patient historical data in terms of radiation, iodine dose and contrast media adverse events, in this way offering enhanced standards of quality and safety in our premises. Thanks to the tracking and

The Imaging Insights Business Intelligence tool regularly updates and correlates multiple data sources into one consolidated view. It keeps the clinical teams well informed, allowing them to focus on optimising operational efficiencies, clinical excellence and patient experience

At the 107th RSNA Scientific Assembly and Annual Meeting to be held in Chicago starting on November 28th Affidea will report on preliminary results obtained with the implementation of the Business Intelligence Tool, during the scientific presentation "Towards Big Data And Visualization Analytics: Dose Management 3.0 In A Multi-center European Settings".

Moreover, a key feature of the new DoseWatch 3.2 version is the contrast media data management which allows optimisation of contrast media, the company will be able to personalise contrast injection to each patient, avoiding any unnecessary extra contrast injection.

Ultimately, it's all about patient safety. That's why we are taking Dose Excellence to a level that no one in Europe has ever seen before, with a significant impact on radiation protection, clinical excellence and education. After Hungary and Spain, we aim at rolling it out across other Affidea countries during 2022. ■

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The Next Normal of Healthy Cities

Building a Resilient City: Implementing technologies that help predict, prevent and respond to health risks

Author: **Massimiliano Claps I Research Director, IDC Government Insights, Europe I International Data Corporation (IDC) I** Milan, Italy
Author: **Nino Giguashvili I Research Manager, IDC Health Insights, Europe I International Data Corporation (IDC) I** Prague, Czech Republic
Author: **Louisa Barker I Research Manager, IDC Government Insights, Europe I International Data Corporation (IDC) I** London, UK

The COVID-19 pandemic has fuelled the adoption of data and digital technologies to improve the resilience of cities, regions and countries. These tools have been leveraged across each component of the sense-predict-respond model that underpins public health preparedness and risk management strategies. The lessons that cities learned from the pandemic on the applications of data and technologies to innovate public health can be extended to non-communicable diseases and can be leveraged to shape broader population health management strategies. This article highlights how cities, and their ecosystem partners, can enhance their resilience by leveraging data and digital technologies to predict, prevent and respond to health risks.

Key Points

- COVID-19 demonstrated more than ever the value of data and digital technologies to make cities more resilient to health emergencies.
- The feasibility and success of the digital solutions utilised during the COVID-19 pandemic depended on the availability and intelligent use of high-quality data, the interoperability of systems, and the workforce's digital skills.
- The pandemic has also amplified the challenges that already limited the ability of cities, and their ecosystem partners, to deliver digital public health initiatives.
- Going forward, cities will need to proactively manage challenges related to citizen's data privacy and trust, technical and organisational interoperability across the healthcare ecosystem and overcoming budgeting procurement and implementation bottlenecks that limit investment in data and technological innovation.
- If these challenges are overcome, cities and their ecosystem partners will be able to successfully collaborate to deliver a data-driven and value-based integrated service model.

The Next Normal of Healthy Cities

COVID-19 has demonstrated more than ever the value of data and technology to make cities more resilient to health emergencies. Data and technology have been at the forefront of the pandemic response, from early detection and contact tracing, to proactively coordinating services, organising resources, such as hospital beds, triage systems and long-term care centres, to optimising operations, such as directing ambulances to the hospitals with available and appropriate resources to ensure citizens' access to essential care. Actionable insights from data have helped city leaders coordinate with national health authorities, public and private healthcare providers, national and international health institutions and communicate with citizens to **prevent what is preventable and prepare for what is imminent.** The feasibility and success of these solutions have depended on the availability and intelligent use of high-quality data, the interoperability of systems and digital capabilities and skills.

The lessons that cities learned from the pandemic on the applications of data and technologies to innovate public health can be extended more broadly to diseases management and control, including to non-communicable diseases such as diabetes, cardiovascular diseases and cancer, or to manage everyday accidents and emergencies more efficiently. This can lay the foundation for the 'next normal' of healthy cities. More effectively and systematically utilising data and technology can help improve health operations and drive better and more inclusive health and social outcomes for citizens, thus empowering cities to achieve Sustainable Development Goals (SDGs), such as SDG #3 (Good Health and Wellbeing), and SDG #11 (Sustainable Cities and Communities) (United Nations 2021).

The Integrated Service Model Leading to Healthy Cities

City leaders that want to improve the health resilience of their communities must integrate competencies and capabilities across the continuum of the sense-predict-respond model that underpins public health preparedness and risk management strategies (Allocato et al. 2020).

- **Sense and enable** includes ongoing activities such as public health surveillance and disease monitoring, developing effective strategies and building resilient systems and infrastructure for emergency preparedness.
- **Predict and prevent** involves putting in place systems for effective disease management, prevention and control, and strengthening capabilities to produce proactive insights for early identification of diseases, epidemiological modelling and demand forecasting.
- **Respond and protect** entails emergency response management, real-time monitoring and surveillance, risk communication and community engagement, health promotion and public awareness raising and implementing integrated care service models.

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Data has been used to **sense** the causes of disease outbreaks and track its spread since the 19th century, when John Snow mapped cholera outbreaks in London in 1854, by tracking down the source of the infection to a water pump on Broad Street (Rogers 2013). Since those early days, the availability of health-relevant data has risen exponentially, providing information on patient health status, socioeconomic characteristics, clusters of diseases, patients' location and resource availability and other variables. This explosion of data has been fuelled by technological advancements and new data sources such as Mobile Positioning Data (MPD), online public health reports, wearable biosensors, and big data from social media. Combining multi-sourced data with advanced analytic capabilities such as Artificial Intelligence (AI) can provide valuable insights to help detect and track diseases in near real-time, swiftly spot the outbreaks of epidemic-prone threats such as the current coronavirus and inform and **enable** emergency preparedness systems. For example, the European Centre for Disease Prevention and Control (ECDC) has developed the Epitweetr social media monitoring tool that helps users monitor trends by time, topic, and location to capture early signals, such as an unusual increase in the number of tweets, to support early detection of public health risks ECDC (2020).

Data is essential to **predict and prevent** public health

risks, for example, to anticipate the transmission and spread patterns of infectious diseases or to model the progression and future burden of non-communicable diseases for specific population groups. Predicting which neighbourhoods are more likely to be vulnerable to the spread of viruses or identifying population segments with elevated health risks, such as ageing communities with long-term conditions and comorbidities, can help cities respond to the needs of those communities, and plan effective population health management and public health strategies. For instance, the German government is using big data, including anonymised county-level MPD as well as data on social, economic and environmental indicators, as part of a prototype project to identify successful counties with relatively low infection rates (positive deviants) and analyse their strategies and citizen mobility patterns during the pandemic (GIZ Data Lab and Teralytics 2021). The insights gained can help in the design of more effective strategies to prevent transmission.

City leaders that want to improve the health resilience of their communities must integrate competencies and capabilities across the continuum of sense-predict-respond model that underpins public health preparedness and risk management strategies

Respond and protect systems can be significantly improved by the intelligent use of data and digital technologies. Data and the capacity to learn from data, synthesise the information and embed insights into decisions can drive effective, efficient and sustainable response strategies. In turn, these strategies can be implemented by leveraging an array of tech-enabled tools for response and protection such as contact tracing applications and platforms to effectively manage the distribution of available resources. For example, the city of Cascais set up an operational COVID-19 control room and digital platform to efficiently manage its resource availability and have a real-time view of the situation and disease's spread (Claps and Dignan 2021). The city was able to manage the crisis in an integrated manner through real-time data visualisation and integrating information from the civil protection, firefighters, and other actors of the health system. The operational control room was also used to optimise COVID-19 test scheduling and result management and to monitor resources, as well as their capacity (total and available), and is currently being used to optimise vaccine distribution.

The emergence of the COVID-19 pandemic was also a pivotal moment for accelerating the use of digital technology for delivering health services. During lockdowns, telehealth and remote care became a crucial way of providing essential services to manage both COVID and non-COVID patients to preserve care continuity while containing infection spread. The pandemic accelerated the uptake and acceptance of digitally enabled services, leveraging telehealth and virtual care platforms and an array of technologies including mobile apps, Internet of Things (IoT) and AI-based chatbots and intelligent health assistants. It is expected that these digitally-enabled services will play an increasingly important role in healthcare systems going forward, including in the aftermath of COVID-19.

Cities across Europe have also used various digital tools, including web-based resources, mobile apps and AI-enabled chatbots, to communicate risks, engage with the public and deliver close to real-time information on the evolving crisis to raise awareness and protect city residents and visitors. For instance, the Valencia Smart City Office deployed a municipal website coronavirus.valencia.es that brings together data on the evolution of the health crisis including positive cases detected, fatalities, number of people hospitalised and discharged (from the regional health board), as well as critical updates regarding other services, such as mobility, urban waste management, pollution and water consumption (Smart City Valencia 2021).

The COVID-19 Pandemic and the 'Next Normal'

The 'next normal' of healthcare will become increasingly digital. In the new normal, building healthy and resilient cities will rely on multi-stakeholder collaborative digital ecosystems to support proactive, integrated and value-based care models and services. Several national and local governments have already started advancing efforts and developing partnerships to achieve this vision and COVID-19 is accelerating this paradigm shift. For example, since 2018, the National Health Service (NHS) in the U.K. has been working to strengthen its relationships with local councils, communities, and other key stakeholders to provide place-based coordinated healthcare and social services and develop integrated care

systems (ICSs) (NHS 2021). Data and technology, including data exchanges between partners, are at the core of these reforms and have been put in place to facilitate services that improve the population's health and create a more equitable and accessible healthcare system, including keeping people healthy and out of hospitals and close to their homes, families and communities.

Tackling the Open Challenges of Healthy Cities

The pandemic has accelerated the use of data and technology to improve the resilience of cities, regions and countries. However, it also highlighted the gaps and amplified the challenges that already limited the ability of cities and their ecosystem partners to deliver digital public health initiatives. Going forward, cities will need to proactively manage these challenges, including:

- **Data privacy and ethics –** citizen's data privacy came to the fore, particularly related to track and trace applications, as cities and countries across the world experimented with different uses of mobile positioning to track the movement of their citizens. Cities must develop ethical principles related to the use of citizen location data and around the fair and non-discriminatory nature of predictions, the accuracy of insights, and the understandability of algorithms (Cities for Digital Rights 2021).
- **Ecosystem collaboration and interoperability** – the pandemic highlighted the complexity and dynamic nature of the city health ecosystem, with siloed programs and technologies among health and social care agencies, between levels of government and across the private and public sector, making it difficult to align incentives to share data for the public good. Cities must establish governance mechanisms that bridge those gaps, like Aberdeen did with their Autism Strategy that brought together the local council, the NHS and community organisations (Aberdeen City Council et al. 2019).
- **Data quality and digital capabilities** - the feasibility and success of many of the solutions and services highlighted in this article depended on the availability of high-quality data, data integration and analytics capabilities and the workforce's digital skills. Cities should focus efforts and investments on enhancing these capabilities and consolidating and improving the quality and interoperability of the data they collect or procure.
- **Agile operations -** the pandemic also highlighted the need to speed up budgeting, procurement and implementation cycles to increase the ability of public health authorities to invest in data and technology innovation. In particular, the emergency resulted in national and international institutions issuing guidance on how to make procurement faster, while maintaining transparency (OECD 2021).

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Conflict of Interest

None. ■

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