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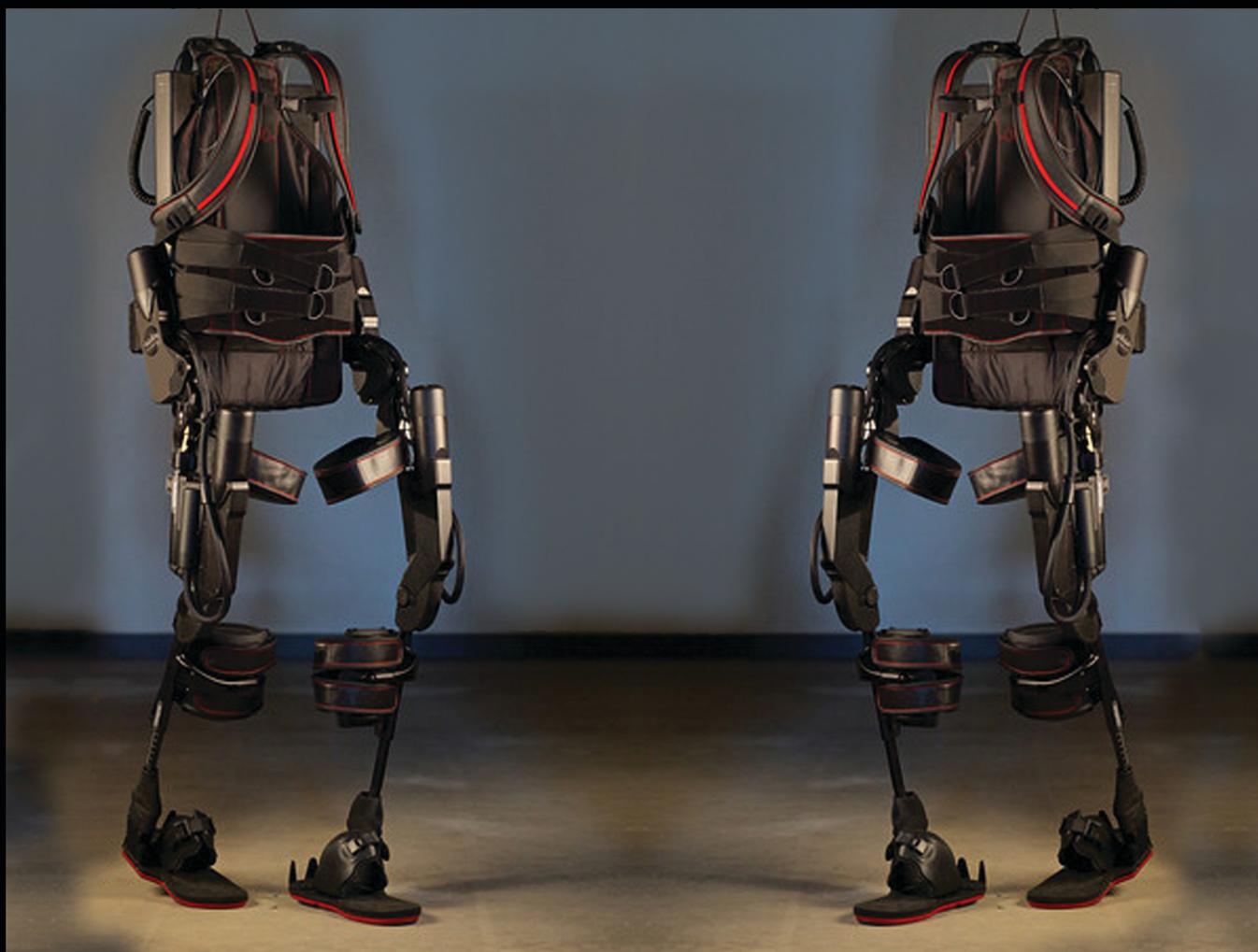
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# The consumerization of digital medicine

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## DISRUPTIVE DIGITAL TECHNOLOGIES

The past 25 years has witnessed some of the most profound changes to society as a result of the exponential development of digital technologies. There is scarcely any aspect of human life in the developed world that has not been impacted by the massive consumerization of hardware and software applications that empower citizens in unprecedented ways through on-line and ubiquitous access to information and services.

Traditional hierarchical relationships that have served society for centuries are being replaced by peer-to-peer networked relationships<sup>[1]</sup> that depend on connectivity and collaboration between multiple discipline “equals” rather than the transfer of knowledge from experienced professional “domain experts” to inexperienced nonprofessional citizens. The impact of this on-line, ubiquitous access to information and services is causing major disruption to long-established and traditional practices in all areas of life. It creates opportunities for innovative new service providers to seriously challenge existing dominant players in ways that were not possible in the predigital age.

Companies that began their existence selling music to teenagers now run international airlines, offer banking, and insurance services and are moving into the health and well-being space,<sup>[2]</sup> unhindered by the lack of a track record or proven experience in delivering these services. Digital technologies consumerize and democratize the provision of professional services of all kinds, bringing challenges to existing markets and introducing new levels of competition.

## IMPACT OF DIGITAL TECHNOLOGIES ON MEDICINE

Medicine is one of the oldest and most respected disciplines. China has arguably been the most influential

birthplace and cradle of medical knowledge and practice in the world and it should, therefore, come as no surprise that it demonstrates leadership in its adoption and exploration of the latest digital technologies for the science and practice of medicine. The union of one of the oldest and most established disciplines, medicine, with one of the latest and most rapidly developing, that of digital communications technologies, is generating an explosion of new practices, insights, opportunities, and challenges. Understanding and predicting the likely impact of this union is extremely important to all medicine, health, and well-being stakeholders because the future of the human race depends to a very great extent on ensuring the sustainability and effectiveness of medical and health provision to a growing population.

The difficulty in predicting the consequences of applying digital technologies to medicine, health and well-being should not be underestimated. Medical practitioners have been required to undertake years of training to develop the knowledge, skills, and experience needed to serve their profession. Medicine is, quite literally, a matter of life and death. The outcomes of medical judgments profoundly affect every citizen in ways which no other professional practice experiences. Consequently, an enormous amount of trust and responsibility is placed in the hands of clinicians and all those who research, develop, and provide services in the health sector.

For centuries, the tools available to doctors and specialists to diagnose and treat patients with medical conditions have changed little. The basic doctor’s toolkit to measure the key parameters of health would likely be still familiar to a doctor from the past century. This toolkit has been supplemented by increasingly sophisticated proprietary technologies designed to detect what these basic tools, combined with a doctor’s wisdom and judgment, have been unable to determine. As the complexities of the human body have been slowly unraveled by developments in digital medicine, the precision and accuracy of diagnosis and treatment have improved. The consequences of these improvements in diagnosis and treatment are very visible

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in the shape of increased longevity and the eradication of many of the traditional causes of mortality. Today, lifestyle related conditions such as obesity, diabetes, cancer, chronic obstructive pulmonary disease (COPD), and cardiovascular conditions are a primary cause of death<sup>[3]</sup> rather than many of the communicable diseases of the past centuries.

Despite all this progress in diagnosis and treatment, health services all around the world are in crisis and under a real threat of collapse. In the USA, health spending per capita is at record levels<sup>[4]</sup> and in the UK the dream of a healthier population envisaged by the founding fathers of the NHS has not been realized with regular news headlines bringing into focus examples of inadequate care provision.

All of this amounts to a paradoxical situation in which improvements in our understanding of the human body and our ability to diagnose and treat clinical conditions co-exists with a growing the incidence of chronic medical conditions that threaten to overwhelm the public and private finances that the national health services depend on.

The questions that this editorial seeks to explore are:

- What is the role of digital technologies in the future of medicine, health, and well-being?
- What significant digital technologies are emerging in medicine, health and well-being?
- What is the likely impact of future developments in digital technologies?
- How can the study and practice of digital medicine shape a sustainable future for medicine, health and well-being?

## THE DIGITAL MEDICINE IMPACT MATRIX, HEAT-MAPS AND ROAD-MAPS

The approach adopted in seeking the answers to these questions uses an adapted version of a technology roadmap developed for the creative industries as the part of a European-funded project called Creative Industries Adaptive Roadmap (CRe-AM).<sup>[5]</sup> The CRe-AM project was designed to examine the impact of disruptive digital technologies on different creative industry sectors including architecture, design, publishing, art, and video games. While all of these sectors are quite different from the medical profession, the roadmap approach might offer some answers that explain both the existing situation and help to forecast future trends and their impact on health stakeholders.

## THE DIGITAL MEDICINE IMPACT MATRIX

This proposed three-dimensional (3D) matrix shown in Figure 1 is designed to analyze the characteristics of digital technologies, the applications they are being applied to and the clinical conditions they seek to address. In this way, emerging digital technologies can be analyzed, their impact assessed and future trends predicted.

In the CRe-AM project, only a two-dimensional (2D) grid was used and the data to assign technologies to a creative process was ascertained from interviews with a wide cross section of stakeholders in each creative sector who were asked to give their views on:

- Digital technologies currently used in daily practice and what they are used for
- Digital technologies seen as important in the medium term (3–5 years)
- Desired digital technologies for the longer term future (crystal ball gazing).

These interviews were recorded and analyzed to extract key words and phrases that could be assigned to a specific technology and/or application, together with their dependencies on other technologies.<sup>[6]</sup> This approach, even with a modest (around 40) number of in-depth interviews produced a remarkably consistent insight into the impact of digital technologies and the likely future direction of technology.

To produce an equivalent analytical tool for digital medicine, it is proposed to conduct a similar analysis for the medical, health and well-being sector which identifies:

- The digital technologies in use today, what they are being used for and what types of clinical condition they target
- The digital technologies envisaged as being significant in 3–5 years
- The “wished-for” digital technologies that might emerge in the future as “silver bullets.”

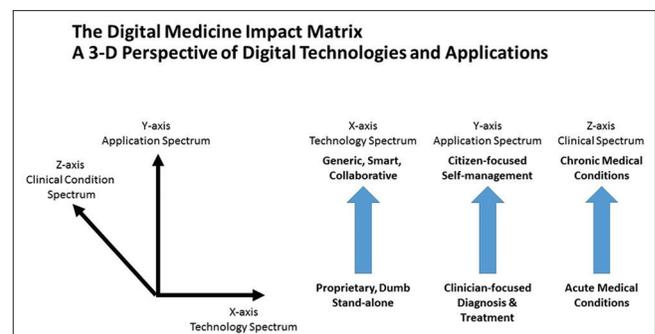


Figure 1: The three-dimensional digital medicine impact matrix model

This matrix is at present a theoretical model that could be researched and validated but, for the purpose of this editorial and to stimulate discussion and academic exchange, I will use the 3D approach to share my own observations drawn from the many digital health conferences, seminars, workshops, and meetings that I have attended in Europe over the last few years.

### THE TECHNOLOGY SPECTRUM PERSPECTIVE

The X-axis of the digital medicine impact matrix (DMIM) relates to the characteristics of any particular technology. At one end of the spectrum are proprietary, stand-alone, “dumb” technologies that perform basic measurements and calculations for an individual and are primarily used to help that individual use their human skill, insight and experience to make judgments and take action. Examples of such technologies would include a thermometer and stethoscopes.

At the other end of the spectrum are generic technologies that have multiple applications, and are connected, smart and intelligent. The characteristics of the technologies this end of the spectrum enable autonomous decision making by those technologies which do not require the skill, experience and judgment of a human being to initiate action. Examples of technologies at this end of the spectrum would include robots and artificial organs.

### THE CLINICAL APPLICATION SPECTRUM PERSPECTIVE

The Y-axis of the DMIM relates to the context in which the technology is being used and who is the primary user. At the bottom end of the Y-axis are the most fundamental medical practices involved in the understanding of the workings of the human body, clinical diagnosis, and treatment. This end of the spectrum is characterized by uses of technology by clinicians and medical professionals involved in prescribing and/or managing patients. It is also characterized by medical interventions to solve a clinical problem as opposed to patient-managed preventative medicine. Examples of applications at this end of the spectrum might include magnetic resonance imaging scans and radiotherapy.

At the other end of the Y-axis spectrum are applications used by nonprofessionals to manage personal health and well-being with a focus of citizen self-managed health and well-being with a greater emphasis on preventative practices. Examples at this end of the spectrum might

include consumer wearable devices, smart health monitors, and mobile applications.

### THE CLINICAL CONDITION SPECTRUM PERSPECTIVE

The Z-axis of the matrix represents the type of clinical condition or care ranging from acute and/or short-term clinical conditions that can be addressed immediately to chronic, long-term conditions which need constant monitoring and intervention.

### THREE-DIMENSIONAL HEAT-MAPS AND ROAD-MAPS

Using the approach developed within the CRE-AM project and adapted for digital medicine, it becomes possible to assign individual key words and/or phrases to positions within the 3D matrix that reflect the characteristics of the technology, how it is being applied and by whom and the type of clinical conditions the technology seeks to address.

A couple of examples of emerging technologies and their assignment in the matrix are shown below. In Figure 2, which unfortunately has to be expressed in 2D format, I have shown the mapping of two technologies within the matrix to illustrate how a 3D “heat-map” could be created from the type of analysis of interviews, articles, and publications described earlier. The examples shown are based on a couple of clinical case studies that use innovative, largely generic digital technologies in different contexts to address different clinical problems.

The virtual reality (VR) tools for treatment “bubble” is based on the “Snow World” VR game<sup>[7]</sup> trialed in the USA to help patients with severe burns limit the pain experienced when dressings are changed. The patients in

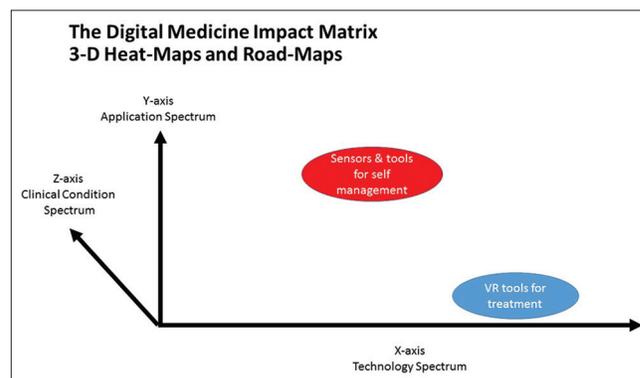


Figure 2: Example matrix assignments for emerging digital technologies

the trial used a VR headset with 3D sound and a games controller to knock over snowmen in a frozen landscape. The immersive environment and the distraction of the video game demonstrably reduced the pain felt by patients having their dressings changed. The position within the matrix reflects an interactive smart technology used by a clinician to treat an acute condition.

The second bubble relates to a trial involving COPD patients using smart monitoring technologies at home to self-manage their condition, supported by a remote clinician. Again, the position of the bubble in the matrix reflects a patient-centric, smart technology used to address a chronic condition.

### OPTIMIZING THE VALUE OF A DIGITAL MEDICINE IMPACT MATRIX

The DMIM could be used for multiple purposes by a variety of stakeholders who could both extract from and add value to such a model. An analysis of the current uses of existing technologies would highlight, through the heat-maps generated, where digital technologies are being used, by whom and to address what clinical conditions. By comparing this heat-map against a cost-benefit matrix showing where the greatest costs of clinical conditions are incurred would highlight where investment in digital technologies is likely to produce the greatest impact.

Similarly, by comparing the heat-maps of current technology usages with those predicted for the medium and long-term future, it would be possible to produce a technology road-map that would be of use to a broad range of stakeholders including health policy makers, investors and technology developers.

### A PERSONAL PERSPECTIVE ON DIGITAL MEDICINE FUTURES THE “CONSUMERISATION” OF MEDICINE, HEALTH, AND WELL-BEING

It has been a great honor to be invited to act as President of the first ISDM Chapter to be established outside China. With such honor comes a duty of responsibility to make every effort to uphold the objectives of ISDM in its mission to act in the best interests of society to improve global health and well-being. It is my belief that the International Society of Digital Medicine can play an important role within an ecosystem of international partners from many different disciplines, all sharing this common vision of shaping the future use of digital technologies in medicine, health, and well-being.

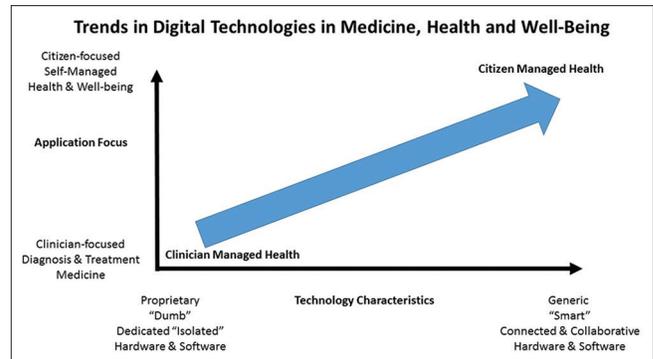


Figure 3: A subjective assessment of technology trends

Since the launch of ISDM in Nanjing in June 2016, I have attended many conferences, seminars, workshops and meetings with health and technology stakeholders of all sizes in both public and private sector. The extent of innovation and growth in digital technologies applied to medicine, health, and well-being is awe-inspiring. The conclusions that I have drawn from many meetings and discussions is that the development of digital technologies in medicine, health, and well-being is following the same trajectory as for other sectors in society such as education, finance, and the creative industries.

This trajectory is expressed in Figure 3 which shows that the consumerization of generic, smart devices is creating a shift in emphasis from clinician controlled health to citizen managed health and from the use of human experience, skill and insight to the use of artificial intelligence, machine learning and big data in delivering more precision and personalization into medicine, especially in the area of chronic disease management.

It is my observation that this shift in emphasis (and funding) is seen by some clinical practitioners as a challenge and threat to their traditional role but, as with other sectors, it will be the empowered consumer that will determine success or failure of emerging health service provisions in medicine, health, and well-being.

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## Wortley: The consumerization of digital medicine

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