HOW CONNECTIVITY WILL REMODEL HEALTHCARE

In this article, Marjorie Villien, PhD, and Jerôme Mouly, both Technology & Market Analysts at Yole Développement, provide a forecast of the place of connectivity in the healthcare market and the significant changes it is likely to bring to both devices and the market itself.

Healthcare is facing one of its most significant turning points in decades. After penetrating the consumer market, the digital revolution and the IoT (Internet of Things) concept are rapidly changing health models.

A confluence of factors is driving these changes. First of all, the prevalence of chronic diseases in modern societies; as an example more than 400 million people are suffering from diabetes (types 1 and 2). In addition to genetic factors, some diabetics' risk factors derive from behavioural causes, such as obesity, lack of exercise and bad eating habits. The incidence of respiratory diseases, asthma for example, is strongly increasing due to environmental issues in highly industrialised cities. The estimated cost of chronic diseases could soon reach US$1.5 trillion (£1.1 trillion) per year for global health organisations, therefore reducing the impact cost of these conditions is a matter of urgency.

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The second factor is a shift in the attitudes and expectations of patients, who are willing to manage their health in a manner similar to how they now monitor steps and calories via worn fitness bands connected to their smartphones. More than two billion people are using internet-connected smartphones around the world today, fostering the rapid adoption of connected medical devices. Such devices have already generated $9 billion to date, estimated to grow to $23 billion by 2022.[1]

THE CONNECTED DRUG DELIVERY DEVICE MARKET IS GROWING

The global connected drug delivery device market, including implanted drug delivery pumps, inhalers, insulin pens and insulin pumps, has already reached two million units, including over 45 million with the capacity for Internet of Medical Things (IoMT) connectivity (Figure 1). Diabetes and respiratory diseases are two major chronic medical conditions, patients of which require regular and accurate medication. Development of connected solutions will not only help patients to better estimate the appropriate dose of medication, but will also alert them should they forget medication and record their data, leading to better adherence and avoiding errors that may led to emergencies and hospitalisations.

Connected inhalers for asthma are changing patients' lifestyles. Built as a fully integrated solution or as an add-on to standard inhalers, patients record all their inhalations via a Bluetooth connection to their smartphone or tablet. As an example, 3M is developing its Intelligent Control Inhaler, expected in 2018. The inhaler will help patients with respiratory diseases to control flow rate and record data. Using an app, patients and physicians can remotely visualise records and patients are able to access feedback. 3M is currently looking for a pharmaceutical partner to gain access to the market. A strong increase is anticipated in the inhaler market, with a 75% annual growth rate forecast for inhalers from 2016 to 2022.

In the area of diabetes, connected insulin pens are also changing the lives

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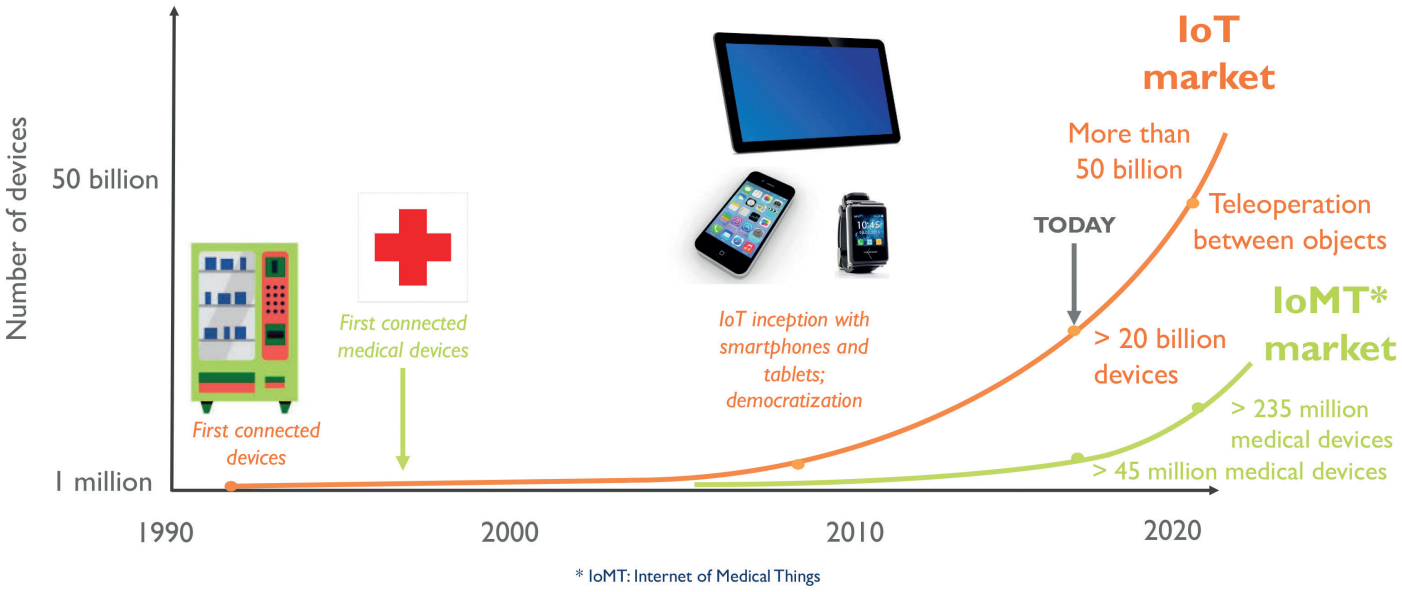

Figure 1: The number of devices capable of connecting Internet of Medical Things is increasing at a rapid, accelerating rate.[1]

of patients with diabetes types 1 and 2. Precise dosage measurements avoid under- and overdosing of insulin and patients could receive information from their smartphone to anticipate their needs more accurately, thanks to machine learning. Interest shown by pharmaceutical companies will likely boost adoption by patients. Novo Nordisk, the inventor of the insulin pen, has teamed up with Glooko, a developer of remote monitoring software, and is expected to launch the new generation of Echo-Pen imminently. Moreover, the development of the artificial pancreas, a (hybrid) closed loop system that communicates to automatically deliver the right dose of insulin, promises a less constrained life for type 1 diabetes patients.

ARTIFICIAL PANCREAS

An artificial organ is a device that is implanted or integrated into a human – interfacing with living tissue and/or fluid – to replace the functions of a faulty or missing vital organ. Hence, by this definition, the artificial organ has to be either wearable or implantable and replace an entire organ or function. Sometimes the use of an artificial organ is a temporary measure, a step in treating the disease process, acting as a bridge to a solution, while other times the artificial organ is a permanent solution. Moreover, some artificial organs are mechanical, such as an artificial heart or lung; based on biology, such as a bioartificial pancreas or liver; or delivering drugs, such as the artificial pancreas.

Presently, the only artificial organ operating as a drug delivery device is the artificial pancreas. The diabetes epidemic is truly global, affecting more than 8% of the world's population. Better management of diabetic patients is crucial, and this is where the artificial pancreas is playing a major role. The name "artificial pancreas" is something of a misnomer, however, as rather than mimicking an organic pancreas an artificial pancreas is simply a smart insulin delivery device. A more appropriate term is "closed loop system". Indeed, a closed loop system combines real-time continuous glucose measurement (CGM) with an insulin pump by using a control algorithm to direct insulin delivery. The aim of this system is to improve diabetes self-care by improving glucose control to mitigate the risk of hypoglycaemia. The systems coming to the market today are hybrid closed loop systems, since they employ a closed loop at all times but need manual-assist dosing at mealtimes and during exercise. The next generation will be fully automated insulin closed loop systems, (manual mealtime and exercise boluses will be eliminated) and the third generation will be fully automated multi-hormone closed loop systems.

It is worth considering that the performance of a closed loop system is limited by the speed of insulin absorption and glucose-sensing inaccuracies, and that the software has to take these limitations into account. In the near future, the next generation of artificial pancreas will have both myriad embedded sensors to monitor the status of the patient and greater intelligence to take changes in physiology into account (e.g. meals, exercise, sleep etc).

The software piloting an artificial pancreas using such technology must parallel engineering developments. A plethora of different algorithms exist, each with their own intrinsic advantages and disadvantages, but all with an internal control law. These span from very simple binary answers to fast, complex algorithms which take into account complicated combinations of multiple data from various sensors, physical laws and precise output calculations. Next generation algorithms are currently in development and major improvements are anticipated. New, fashionable methods like machine learning (and deep learning when the data is available) are entering research through fuzzy logic algorithms. These methods seem promising and will permit fully automated control of the artificial organ.

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Yole Développement expects the uptake of the artificial pancreas to be both high and rapid throughout the type 1 diabetic population, since the solution has been desired for years. As of 2017, only Medtronic has an artificial pancreas system approved by the US FDA and none have been granted a European CE mark. However, many companies' products are ready for approval and commercialisation. There are two collaborations of particular note: one between Diabeloop, Dexcom and Cellnovo and one involving TypeZero, Dexcom and Tandem. After decades of development, artificial organ products are now ready to enter the medical device market. For that reason, the artificial pancreas segment will experience massive growth, with a $CAGR_{2017\text{-}2022}$ of 49%.[2]

Historical artificial organs were made of mechanical parts, today they are based on electronics and tomorrow they will be smart. Sensors and software are playing major roles in the growth of the artificial organ market. If bioartificial pancreases and artificial livers are based on biology, most other devices are full of electronics, sensors, emitters and software. The part such technologies play can only increase as the healthcare industry moves towards more intelligent devices.

THE TECHNOLOGY IS READY

The dual challenges for medical device producers are to integrate sensors, electronics and connectivity into approximately the same footprint as equivalent, non-smart devices and to facilitate patient adoption. Most of the sensors integrated to connected medical devices are already available from other markets, such as consumer or automotive, and are already miniaturised, low cost, offering low power consumption, etc, but are not specific to the medical market.

After stabilisation and large scale adoption of connected medical devices, a second wave of innovation is expected. This wave will see the development of sensor solutions specifically dedicated to medical grade requirements in terms of reliability and accuracy, as well as new criteria, such as low invasive sensors, taking advantage of microelectromechanical systems (MEMS) technologies (Figure 2).

Connected inhalers benefit from the miniaturisation of flow sensors to evaluate the volume of medication inhaled. Sensirion, a Switzerland-based company, has developed a 5x8x5 mm differential pressure sensor, called SDP3x, that could be integrated in smart inhalers. Miniaturisation also enables the progression of systems from portable to wearable, making them ever more user-friendly.

NEW PLAYERS ENTER THE HEALTHCARE MARKET

The IoMT is at the crossroads of medical devices, telecommunications and information technology (IT). As such, an entirely new infrastructure needs to be set up, involving these new players in the medical area. Medical device companies like Medtronic and Johnson & Johnson have a great interest in this field. Naturally, pharmaceutical companies have an inherent interest in giving more value to medical devices associated with the medications that they are selling to patients.

Numerous companies are developing smart inhalers and insulin pens and are licensing their products to pharma companies (Figure 3). An example being the recent announcement of a development agreement between Dexcom, a manufacturer of continuous glucose monitoring devices, and Eli Lilly; the aim of this partnership being to combine knowledge and tools to simultaneously reduce complexity and improve disease management for patients with diabetes.

The IoMT also represents a huge opportunity for new players such as IBM's Watson augmented intelligence system to enter the healthcare market and to bring computing power to predictive medicine, as well as relevant infrastructure to interoperate connected devices from home, hospitals or anywhere data needs to be shared. Companies like Qualcomm Life, with its solutions 2net and Capsule, are dedicated to IoMT applications.

It is worth noting that security and data privacy are at the forefront of healthcare administration, to avoid

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Figure 2: The adoption of connectivity in the healthcare market will spur further, more creative innovation.[1]

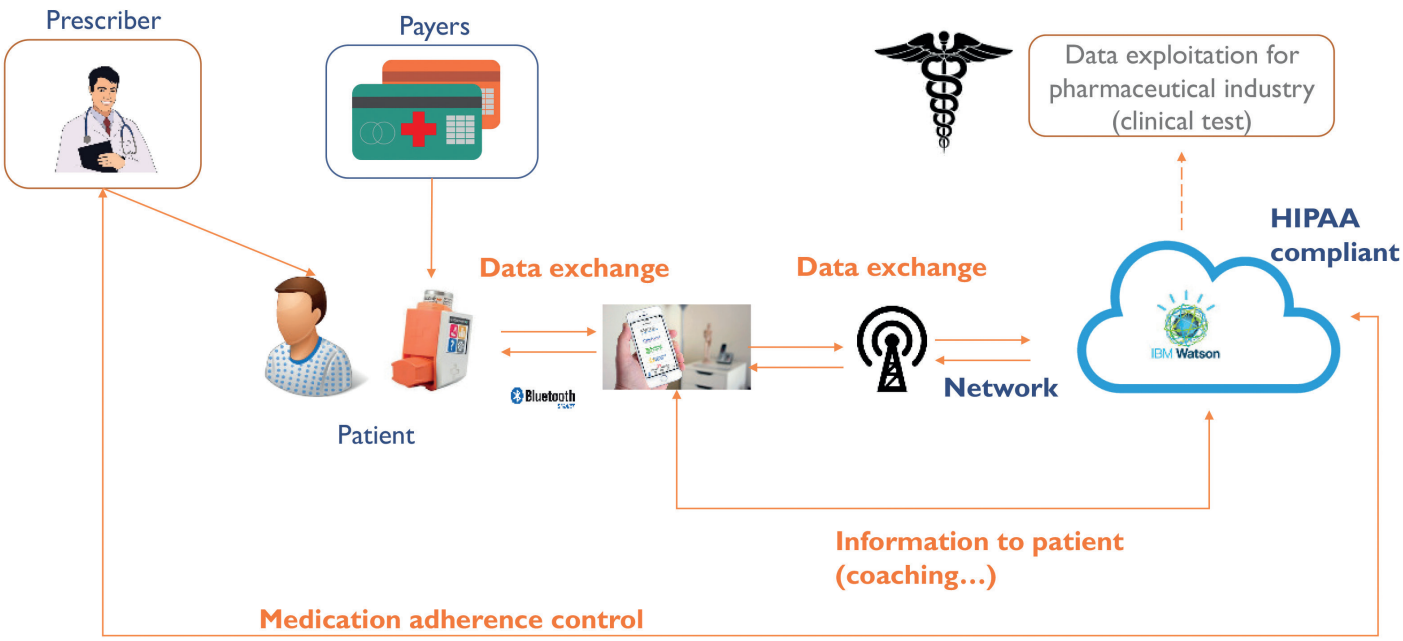

Figure 3: Example of a business model for a connected inhaler.[1]

unregulated use of information generated and also to guarantee the safety of patients (e.g. preventing hacking of implanted connected medical devices).

WHO PAYS AND WHO BENEFITS?

Current changes in healthcare require innovative business models to be realised. It is a fundamental change of paradigm for health administration, and the co-existence of two reimbursement models. From evidence-based medicine, connected medical devices enable the "P4" medicine concept: Preventive, Predictive, Personalised and Participatory. Innovative business models may well be being set up, but who will pay for prevention?

Health insurance companies are working with employers and telemedicine service companies to promote services to share the cost of connected medical devices (including architecture). Health insurance incentives or rebates are proposed for patients, should they participate in a programme increasing their adherence to medication by using a connected device that sends data to the patient, their physician and the insurance company.

This new shift in the healthcare landscape will require an evaluation of the performance of this new approach: will P4 medicine cost less than the evidence-based medicine concept? Ultimately, it is only long term analysis that will show the true impact. It is not only insurance companies which will benefit from connected drug delivery systems. Data generated could have great value, and pharmaceutical companies are looking to this precious information to analyse the impact of medication on patients more rigorously and accurately, enhance a personalised medicine approach, and accelerate clinical tests.

Monetisation of data is the next step after data storage in the cloud. Machine learning and artificial intelligence should help to process and analyse a large amount of data. What about Google, Apple and the other giants of the big data and analytics world? For several years the medical device market was far from their field of interest, with low volumes, strict regulations and long development times. The limits of healthcare devices as data generators are also a consideration; consumer well-being devices have fewer regulations on data privacy and data

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ABOUT THE AUTHORS

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transfer architectures, which provides more comfortable territory and generates much more data. The monetisation of data is key for these giants and regulations surrounding medical data are more constraining compared with those that apply to the regular consumer data they are more used to.

THE ERA OF CONNECTED DRUG DELIVERY IS TAKING OFF

The market share of connected drug delivery devices is expected to increase at a rapid pace, with a more than 75% CAGR over the next five years for systems used in the context of chronic diseases. A feedback of accurate information will help patients to better monitor their health with fewer constraints, reducing hospitalisations or unnecessary visits to the doctor's office. The impact on society should be significant, with lower costs for healthcare organisations as well as better therapeutic outcomes for patients, thanks to a participative approach to sharing health data. The challenges of data privacy and patient safety will be key, involving new players in the healthcare ecosystem. Consolidation of the market and the supply chain will occur later, with a series of mergers and acquisitions aiming to gather the most innovative products and regroup solutions with high synergies.

ABOUT THE COMPANY

Founded in 1998, Yole Développement is a market research & strategy consulting company that has grown to become a group of companies providing marketing, technology and strategy consulting and media in addition to corporate finance services.

Yole has a global vision and customer base. Yole, and its partners, System Plus Consulting, Blumorpho, Piseo and KnowMade, support industrial companies, investors and R&D organisations worldwide to help them understand markets and follow technology trends to develop their businesses.

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