5 Case study on the Internet of Things in healthcare

This chapter presents the findings from a case study on Internet of Things (IoT) adoption in healthcare. While data from information and communication technology (ICT) usage surveys provide information on the uptake of IoT health monitoring devices by individuals, limited information is available on the adoption of such devices by hospitals and general practitioners. Information on the effects of their adoption is also scattered. The case study's findings contribute to filling this information gap, particularly regarding the use of smart devices for remote patient monitoring.

This chapter presents the findings from a case study on Internet of Things (IoT) adoption in healthcare.[1] The case study is intended to complement data from the information and communication technology (ICT) usage surveys on the drivers of and obstacles to IoT diffusion in the sector as well as on the impact of IoT applications.

Main uses of the IoT in healthcare

Digital transformation in the health sector has been rather slow due to regulations, a lack of funding and low investment (Socha-Dietrich, 2021[1]). However, the COVID-19 pandemic has acted as an accelerator (The Economist, 2020[2]). Following the lockdowns imposed in most countries in response to the pandemic, several countries have lifted regulatory restrictions or overcome barriers, e.g. payment methods for telemedicine services, which have increased significantly as a result (OECD, 2020[3]).

From a healthcare perspective, the IoT comprises any device that collects health-related data from individuals and transmits them on a network, including computing devices, mobile phones, smart bands and wearables, digital medications, and implantable surgical devices (Table 5.1). While there are multiple digital tools and applications in the health sector (eHealth), the main uses of the IoT are remote monitoring, automation, nursing, and transportation (OECD, 2018[4]).

Table 5.1. Examples of IoT devices in the healthcare sector

IoT device	Brief description
Wearables	Technological infrastructure worn by the user that interconnects wearable technology with wearable sensors through wireless connections.
Digital (smart) medications	Ingestible sensors. Sensors made from copper, magnesium and silicon, in minute quantities, which communicate with an external body sensor such as a wearable sensor patch.
Vital sign patches	Designed primarily to wirelessly track and monitor heart rate, respiration rate, temperature, step count, sleep cycle, stress levels and falls or incapacitation.
Continuous glucose monitors and smart insulin pens	Track dose and time, and recommend the correct type of insulin dosage.
Therapeutic extended reality	Augmented, mixed and virtual reality can visualize data collected from IoT sensors. These create a sense of being transported into lifelike, three-dimensional worlds and can be applied as an innovative treatment modality to manage a broad range of health conditions.
Bluetooth-enabled inhalers	Use a Bluetooth sensor, mobile application (app), predictive analytics and feedback.
Smart voice assistants (conversation agents)	Installed in the home setting to provide support to users through conversations (e.g. Amazon Alexa and Google Home).
Smart cameras	Smartphone cameras that can capture changes in the environment.

Source: Kelly, J. et al. (2020[5]), "The Internet of Things: Impact and implications for health care delivery", https://doi.org/10.2196/20135.

At home, remote monitoring reduces the need for patients to see a doctor in person or go to a hospital. Simple consultations can be administered via online video systems, health data can be collected remotely via mobile health-specific wellness devices (e.g. to monitor heart rate or glucose level) and emergency situations can be identified via implantable electronic devices. Furthermore, personal wellness wearable devices, e.g. fitness monitors and calorie counters, can track a wealth of data that can be used to identify patterns and alert people of risk factors, potentially leading to predictive and personalised healthcare.

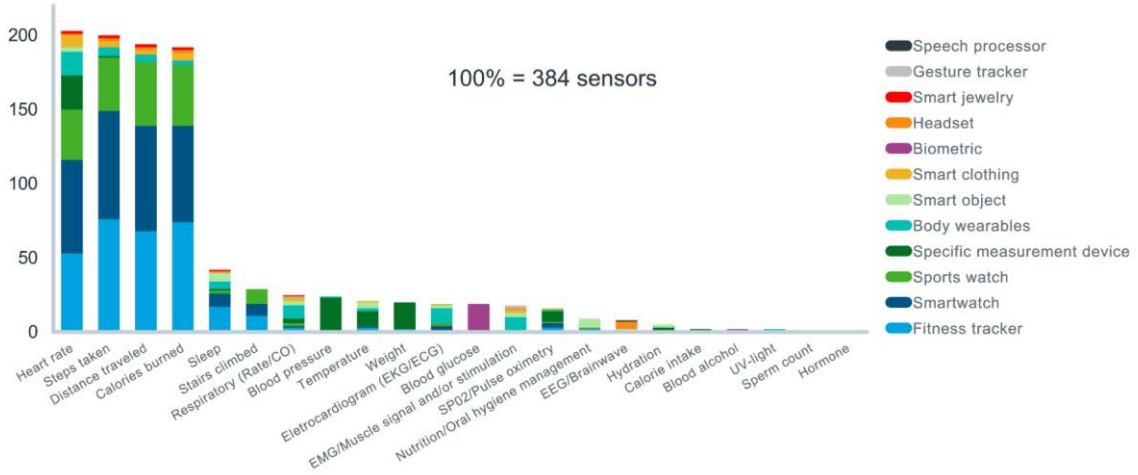
Outside the home, healthcare facilities can be equipped with the IoT to control all aspects of their operations, reduce operating and administrative costs and increase the quality of care. Hospitals can become more efficient while providing more information to patients and orienting them through the healthcare system. Potentially, these technologies would be able to exchange information with wearables and mobile health apps used by patients to generate a richer picture of the health condition and behaviour of users. However, health systems are still trying to figure out how to integrate data generated by these IoT devices into existing information systems (OECD, 2019[6]).

The IoT can also improve prevention and monitoring of chronic diseases, thus enhancing life quality and expectancy, enable patients and health providers to connect remotely and help reduce hospitalisation, thus leading to time and cost savings. Telemonitoring has been found to improve health outcomes, for instance, by reducing the mortality of patients with heart failure and improving the care of some chronic diseases (Oliveira Hashiguchi, 2020[7]).

Most IoT wellness and healthcare devices can be applied to the care of older people, helping to maintain them in their own homes rather than in residential facilities. Smart homes can have sensors that monitor movement and automatically calculate normal activities of daily living, reporting when an occupant deviates from the norm. Two promising areas of IoT application in this area are detecting falls and mitigating the effects of diminished cognitive function and memory loss (OECD, 2018[4]).

At present, most of the wearable devices on the market are of the like of smartwatches, sports watches and fitness trackers (Figure 5.1). They are linked to wellness and activity monitoring, such as heart rate, steps taken, distance travelled and calories burned. These account for 75% of measures tracked by wearable devices. Apps related to these wearables (e.g. Fitbit, Mi Fit, Huawei Health, Google Fit) have been downloaded more than 10 million times and, in aggregate, account for almost 50% of total app downloads. Wearable devices measuring specific health parameters, e.g. heart rate and blood pressure, account for about 15% of overall devices, showing the increasing importance of personalised health monitoring. Other body wearables, including electrocardiogram (ECG) devices and breathing monitors, represent 10% of all devices (IQVIA, 2021[8]).

Figure 5.1. Parameters measured by consumer health digital devices by type, 2021



Note: The chart includes data from 384 sensors. The total exceeds 384 due to multiple measures being tracked by a single sensor. Specific measurement devices include vital measurements.
Source: IQVIA (2021[8]), *Digital Health Trends 2021*, https://www.iqvia.com/insights/the-iqvia-institute/reports/digital-health-trends-2021.

COVID-19 has acted as an accelerator for IoT adoption in healthcare (Umair et al., 2021[9]). In the early phases of the pandemic, track and trace apps were used to monitor and control the spread of the disease (OECD, 2020[10]). Hong Kong (China), Israel, Korea and other countries (see below the results from the case study) used wearables and communication technologies to remotely monitor patients with COVID-19 at home, catching signs of possible deterioration and helping health researchers understand how the disease develops (OECD, 2020[3]). IoT technologies have also been used to track and monitor COVID-19 vaccines during shipment, help manage temperature and react to events with potential impact on the supply chain (Controlant, 2020[11]). Additionally, several countries have adopted emergency regulations to authorise the use of IoT devices for health purposes: for instance, the United States Food and Drug Administration (FDA) issued six Emergency Use Authorisation certificates for remote or wearable patient monitoring devices in 2020 (FDA, 2021[12]).

COVID-19 has also triggered faster changes in the national health systems: in Italy, for instance, telemedicine has been officially recognised and covered by the national health system since the end of 2020. Smart devices and apps for remote control and monitoring of vital and clinical signs are also covered. Italy's National Recovery and Resilience Plan (NRRP) foresees EUR 4 billion in investments for the policy objective "home as first place of care and telemedicine" (MEF, 2021[13]). France's NRRP also foresees investments of EUR 2 billion to strengthen digital health in the country (Ministère de l'Économie, des Finances et de la Relance, 2021[14]).

Results from the case study

While data from ICT usage surveys provide information on the uptake of IoT health monitoring devices by individuals, limited information is available on the adoption of such devices by hospitals and general practitioners (GPs). Information on the effects of their adoption is also scattered. The objective of this case study is to start filling this information gap, particularly regarding the use of smart devices for remote patient monitoring (RPM). RPM refers to the activities aimed at monitoring patients' health condition outside the hospital through connected devices. The data collected by such devices are then transmitted electronically to healthcare providers, who follow the patient's health status remotely and decide on any action to be taken.

A set of questions on the use of IoT devices at home for RPM in national health systems were included in the OECD ad hoc survey on telemedicine undertaken in the first half of 2022.

The following questions were included:

- This section focuses on the extent to which applications of the IoT and, especially, hospital-at-home are being deployed in OECD countries (If you do not have data or information at the national level, data and information at the subnational level are welcome).

1. To what extent do hospitals in your country use smart devices, systems and apps for RPM? If your response refers to a subnational territory, e.g. a region or a city, please provide details in the box below.
    - Most hospitals make regular use of smart devices for RPM.
    - The use of smart devices for RPM is in the testing phase or limited to a few hospitals.
    - No hospital currently uses smart devices for RPM but there are plans to introduce them in the near future.
    - No hospital currently uses smart devices for RPM and there is no plan to introduce them in the near future.

2. To what extent do your country's general practitioners or GPs (i.e. primary care physicians) use smart devices, systems and apps for RPM? If your response refers to a subnational territory, e.g. a region or a city, please provide details in the box below.
   - Most GPs make regular use of smart devices for RPM.
   - The use of smart devices for RPM is in the testing phase or limited to a few GPs.
   - No GPs currently use smart devices for RPM but there are plans to introduce them in the near future.
   - No GPs currently use smart devices for RPM and there is no plan to introduce them in the near future.
3. For what purposes are smart devices, systems and apps used to remotely monitor patients and what is the source of financing for such devices?

	Type of device (please report connected devices only)	Health condition monitored	Estimated number of hospitals covered	Estimated number of patients covered	Adoption stage (i.e. deployed, testing phase)	If available, please describe the financing model (multiple options are possible)
Pre-admission						
Post-discharge						
Ongoing chronic care management						
Other: non-chronic care						
Other RPM						

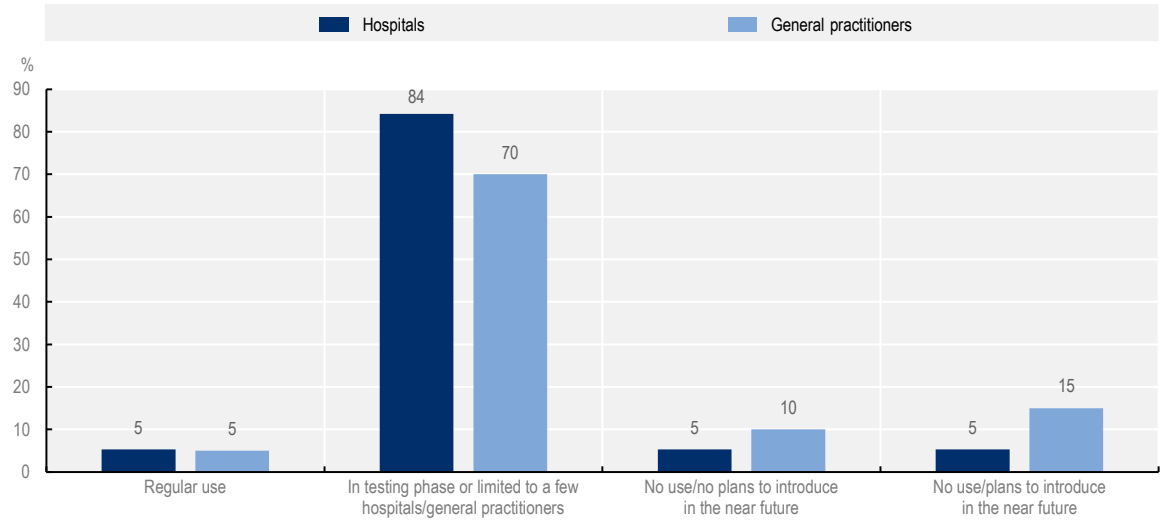
4. Does the ministry of health, a government agency or an academic institution have data or studies on the impact of RPM enabled by smart devices, systems and apps in your country, e.g. on clinical outcomes or healthcare costs? This can also refer to RPM of a specific disease/health condition (e.g. COVID-19 or health failure).
5. If hospitals/GPs do not use or make limited use of smart devices, systems and apps for patient remote monitoring, what are the main barriers to further adoption, both for hospitals/GPs as well as for patients?
6. The OECD would like to undertake a case study in your country on RPM enabled by smart devices, systems and apps. We would be grateful for your co-operation. Please provide the name and contact details of one or more experts in your country.

The responses from 25 countries show that using smart devices for RPM is still in the testing phase or limited to a few hospitals or GPs (Figure 5.2). Belgium is the only country reporting regular use of smart devices in hospitals, where RPM is undertaken in several fields, e.g. oncology, diabetes, sleep monitoring and cardiology. For instance, 11 000 patients with cardiac conditions are monitored through connected cardiovascular implantable electronic devices. England (United Kingdom) reported that a small number of hospitals are testing smart devices for RPM but they are not yet in regular use in the majority of hospitals.

Regarding GPs, Norway is the only country reporting regular use of smart devices, although no information is collected on their specific uses and effects. Several respondents commented that the decentralised administration of hospitals and GPs makes it difficult to obtain a general picture of the use of smart devices in their countries.

Figure 5.2. Use of smart devices for RPM in hospitals and by GPs

As a percentage of countries responding to the OECD Survey on Telemedicine, n = 23, 2022



Note: Response to the questions: "To what extent do hospitals in your country use smart devices, systems and apps for remote patient monitoring?" and "To what extent do general practitioners or GPs (i.e. primary care physicians) in your country use smart devices, systems and apps for remote patient monitoring?".
Sources: OECD ad-hoc data collection from the OECD Survey on Telemedicine and COVID-19, 2021-22; OECD (2023[15]), *The COVID-19 Pandemic and the Future of Telemedicine*, https://doi.org/10.1787/ac8b0a27-en.

Several countries reported further information on the RPM pilot projects. In England, between November 2020 and May 2021, 78 000 patients received home assistance for several medical conditions using remote monitoring technologies as part of the NHSX National Innovation Collaborative project. In Canada, Health PEI, which is responsible for the delivery of publicly funded health services in Prince Edward Island (PEI), has developed a free province-wide RPM programme spanning multiple care settings, including hospitals and primary care sites, for citizens living with heart failure or chronic obstructive pulmonary disease. In Latvia, P.Stradiņš Clinical University Hospital provides state-paid remote monitoring for people, including children, with heart rhythm disorders, while in Lithuania, smart devices are currently used in pilot projects for several conditions, such as blood pressure monitoring and glucose and pulse monitoring. In Belgium, a pilot project – involving 12 hospitals and about 280 patients – makes use of smartphones and a specific app (moveUP Coach App) to monitor knee and hip arthroplasty rehabilitation.

The respondents also reported that several RPM projects were undertaken during the COVID-19 pandemic to provide patients affected by the disease with home monitoring. England implemented the "COVID virtual ward" model in some areas of the country, a secondary-care-led initiative to support early and safe discharge from hospitals for COVID patients by monitoring them remotely via pulse oximetry. In Belgium, a pilot project for both the pre- and post-hospitalisation phases of COVID-19 was run in 19 hospitals, with about 500 patients monitored in each phase. Likewise, in 2021, in Latvia, a pilot project by the National Health Service developed a platform where doctors can monitor, treat and communicate with COVID-19 patients remotely. In the United States, the COVID-19 Telehealth Program by the Federal Communications Commission offers investment grants to improve hospitals' capacity to provide telehealth services, including home monitoring. The Office of Connected Care of the Veterans Health Administration also has an RPM programme (Home Telehealth), which was scaled up during the pandemic.

Results from these programmes show RPM's positive impact on several health outcomes. Canada Health Infoway conducted several studies to evaluate the impacts of RPM tools. A study published in 2015 (Gheorghiu and Ratchford, 2015[16]) found moderate-to-high evidence for a number of positive effects of RPM: increased patient satisfaction and compliance, improved quality of life, a lower caregiver burden as

well as a decrease in hospitalisation and per-patient costs. In 2018, Canada Health Infoway conducted an evaluation of RPM programmes in PEI and Newfoundland (NL). In PEI, the evaluation found an 80% decrease in hospital admissions, while 90% of participants reported an improvement in managing their own health (Canada Health Infoway, 2017[17]). In NL, the evaluation found a 58.5% decrease in hospital admissions while 82% of participants strongly agreed the programme improved quality of life (Canada Health Infoway, 2018[18]). The home-based telecare for complex chronic patients operated by the Israeli Maccabi Telecare Center was also found to have reduced hospitalisation days and costs (Porath et al., 2017[19]).

On the other hand, the Health Technology Assessment (HTA) in Belgium reported more nuanced outcomes, concluding that RPM was as safe and effective as traditional monitoring via hospital visits. The HTA found several advantages for the patients, such as a decrease in in-clinic visits, earlier detection of events, a reduced risk of inappropriate shocks and a lower burden of atrial arrhythmias. However, there was no evidence of significant effects on hospitalisations, patients' quality of life, mortality or the workload of healthcare practitioners (Gerkens et al., 2021[20]).

In Belgium, an evaluation of 12 projects receiving financial support by the National Institute for Health and Disability Insurance concluded that it was not possible to draw any firm conclusion on the quality and efficiency of healthcare services, mainly due to the heterogeneity of the RPM devices used and the lack of a control group (Cornelis et al., 2022[21]).

For hospitals, economies of scale are a significant advantage for innovation procurement relative to primary care settings. In the Netherlands, most hospitals have one or more departments using smart devices. However, RPM tends to be organised separately from daily healthcare service or in a pilot setting. The Czech Republic also reported that larger hospitals, e.g. University Hospital Ostrava, have the most advanced or extensive applications, as they can experiment with various technologies and rely on funds provided by local, national or European Union projects. In the Republic of Türkiye, a pilot app has been realised for remote monitoring of type 2 diabetes patients as a part of a Horizon 2020 project (EC, 2020[22]), while other pilot apps are planned for remote monitoring of hypertension and chronic heart failure, with the perspective of scaling up their use.

The use of smart devices by GPs is limited to a few functions, for instance, to monitor diabetes in Finland and Norway. Norway has also piloted projects for remote 24 hours a day, 7 days a week blood pressure monitoring or of different chronic diseases. The country reported that there are several bodies, e.g. municipalities, hospitals and the Norwegian Directorate of Health are exploring different remote monitoring solutions for patient care.

The respondents to the survey pointed out several factors that may hinder the adoption of smart devices for RPM. The lack of a specific framework for financing, e.g. reimbursement mechanisms, was frequently cited, together with patients' low health literacy and digital skills of both patients and the medical staff. Other factors include technical aspects such as poor Internet connectivity, a lack of infrastructure, low interoperability between remote monitoring and the e-patient records/clinical systems in place and, more broadly, a low degree of digitalisation of the healthcare sector. Countries also reported patients' preference for in-person consultation and concerns about privacy and digital security.

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Note

[1] The survey (OECD Survey on Telemedicine and COVID-19, 2021-22) was undertaken by the OECD Working Parties on Health Statistics and on Health Care Quality and Outcomes and the OECD Working Party on Measurement and Analysis of the Digital Economy. See OECD (2023[15]), Box 1.2.