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The Internet of Medical Things (IoMT) at the Heart of Digital Healthcare

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Contents

Introduction

The use of digital tools spiked across industries during the coronavirus pandemic. Digital trends can take years to build up and several waves to reach ubiquity, but COVID-19 changed that pattern overnight.

Healthcare, traditionally a heavily regulated and consequently slow-moving industry, was one area where COVID-19 had a profound impact, accelerating the path to Digital Transformation and creating new perspectives on how digital tools could handle the incredible surge in demand for healthcare services. Digital technologies became vital in the face of disrupted supply chains and helped to alleviate the pressure on an overloaded global healthcare environment.

> *"Efficiency, connectivity and security are at the forefront of that push for digital transformation."*

At the same time, it proved to be a catalyst for evolving how healthcare is practiced and delivered to users more cost-efficiently, taking a more proactive approach to Remote Patient Monitoring (RPM), Proactive Health Management (users monitoring their own health), Clinical Efficiency (more efficient use of healthcare resources), Personal Care (for ongoing treatment of chronic conditions) as well as Assisted Living (for ageing populations).

This whitepaper is designed to help companies navigate the new digital healthcare landscape, to understand the key trends, developments, and technologies that are shaping the industry and how it is changing the way healthcare will be practiced and delivered in the future. In particular, how the push for efficiency, connectivity and security are at the forefront of that push for digital transformation.

Healthcare Challenges and Investment

COVID-19 had a significant impact on healthcare investment, necessitating massive investment in a short period of time, but also highlighting many fundamental shortcomings in the healthcare system, such as outdated processes, a lack of interoperability, and supply chain inefficiency.

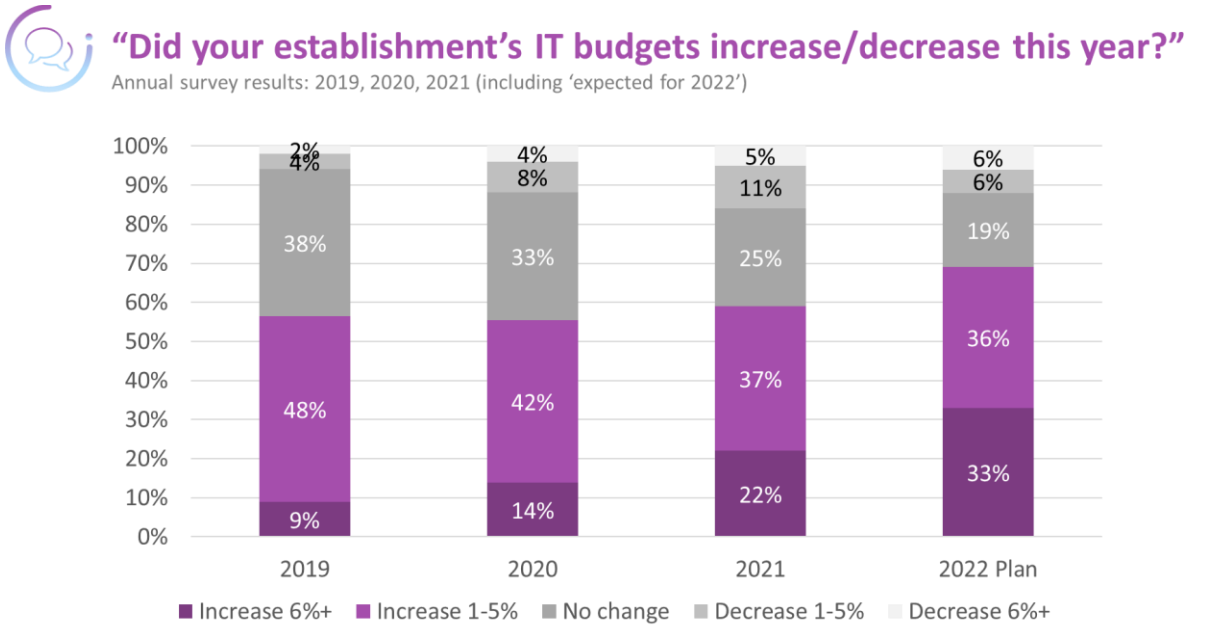
Many factors have increased the need for hospital investment. The AHA (American Hospital Association) for example, highlights a number of serious challenges that have arisen through and following the pandemic:

- **Rise in acutely ill patients.** Hospitals are seeing more high acuity, inpatient cases—including COVID-19 patients—requiring longer lengths of stay. While these cases contribute to revenue increases, any gains are offset by higher care costs for treating patients with more severe conditions. COVID-19 has also delayed acute treatment for serious conditions, placing greater strain on the healthcare system.

- **Rising expenses:** Expenses are rising across the board, as hospitals face increasing costs for labor, drugs, purchased services, personal protective equipment (PPE), and other medical and safety supplies needed to care for higher acuity patients.

- **Fewer outpatient visits.** Hospital outpatient visits—which tend to have lower expenses and higher margins—continue to grow but remain depressed compared to 2019 levels. They have yet to fully recover after plummeting with nationwide shutdowns and COVID-19 mitigation efforts in the early months of the pandemic in 2020.

Figure 1. Change in global healthcare budgets



Source: Omdia

According to Omdia, the proportion of global healthcare facilities significantly increasing their healthcare IT budget (6% or more) has grown exponentially since the beginning of the pandemic (see Figure 1).

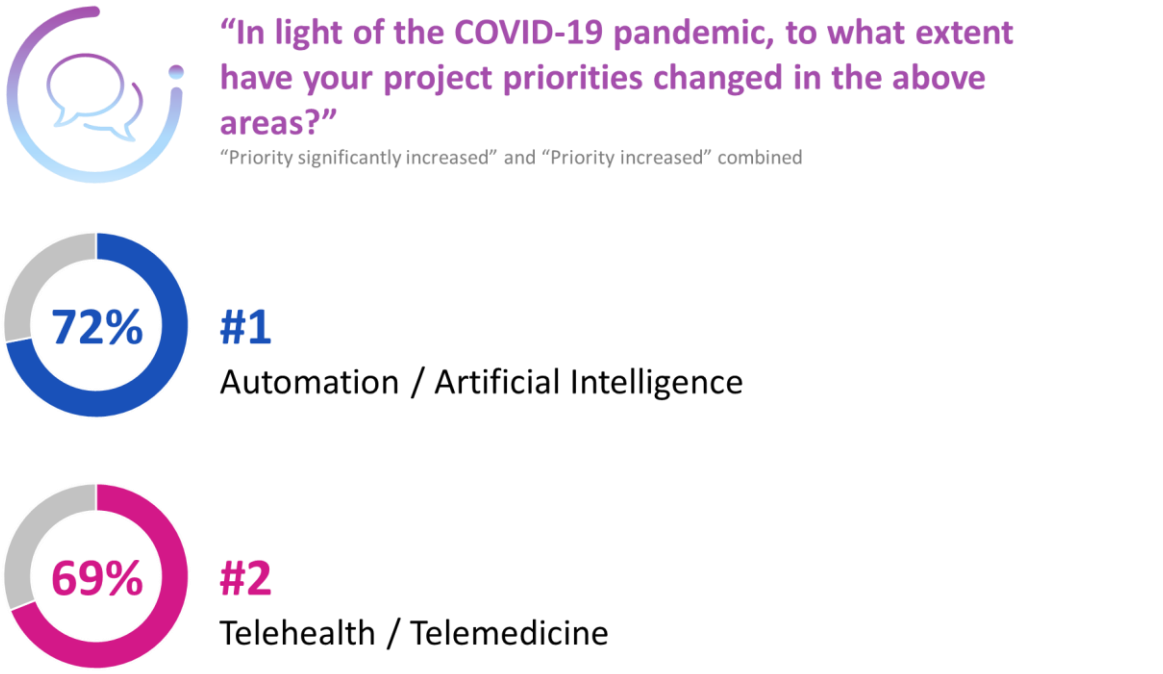
Larger healthcare establishments tend to invest more (relative to size) in digital transformation initiatives –driven by large volumes of patients and health data.

> *"The challenges presented by COVID-19 have led to a broader review of how to rapidly improve efficiency in healthcare through investment in digital tools..."*

Increased pressure and rising costs therefore drive the need for greater efficiency, creating a rise in digital technology investment. The challenges presented by COVID-19 have led to a broader review of how to rapidly improve efficiency in healthcare through investment in digital tools, such as Artificial intelligence (AI) to increase automation (and processes like dispensing prescriptions), and growth in Telehealth to monitor patients on an ongoing basis without the need for regular face-to-face contact (see Figure 2). The capabilities that these tools can bring will improve the relationship with users/patients and vastly improve efficiencies around appointment scheduling, hospital

admissions, portal access for EMR (electronic medical record) access and other contact between caregivers and patients.

Figure 2. COVID-19 impact on project priorities



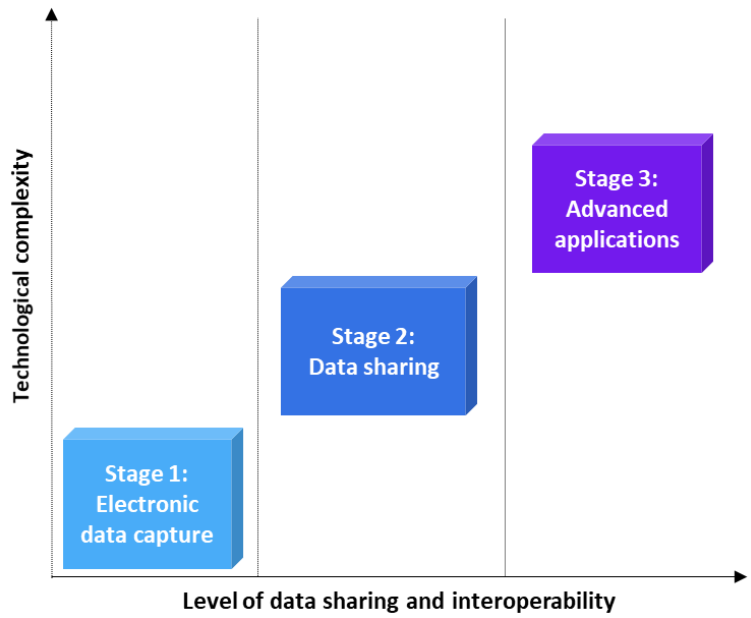
Source: Omdia

Digital Transformation in Healthcare

The opportunity for digitalization in healthcare exists with contributions from the healthcare IT ecosystem, non-IT healthcare budget diverted to digital healthcare, and medical devices. However, some fundamental challenges exist for healthcare establishments:

- Rapidly increasing medical demand, driven by a combination of factors. These pressures include growing patient expectations and ageing populations, leading to a greater prevalence of chronic illnesses.
- A shortage of healthcare professionals worldwide.
- Large health expenditures globally. Healthcare accounted for 9.8% of global GDP in 2019: 11% of GDP in Japan, 12% in Germany, 16% in the US, and 7% in China.

Figure 3. The 3 stages of digital healthcare transformation



Source: Omdia

Digital transformation will facilitate new technologies such as Telehealth and AI, which will help tackle many of these challenges. But this is an evolutionary process, with three stages (as shown in Figure 3):

Stage 1: Electronic data capture

- Electronic health data capture, such as patient demographics or clinical records, in a standardized format is the jumping-off point of the entire digital transformation project.

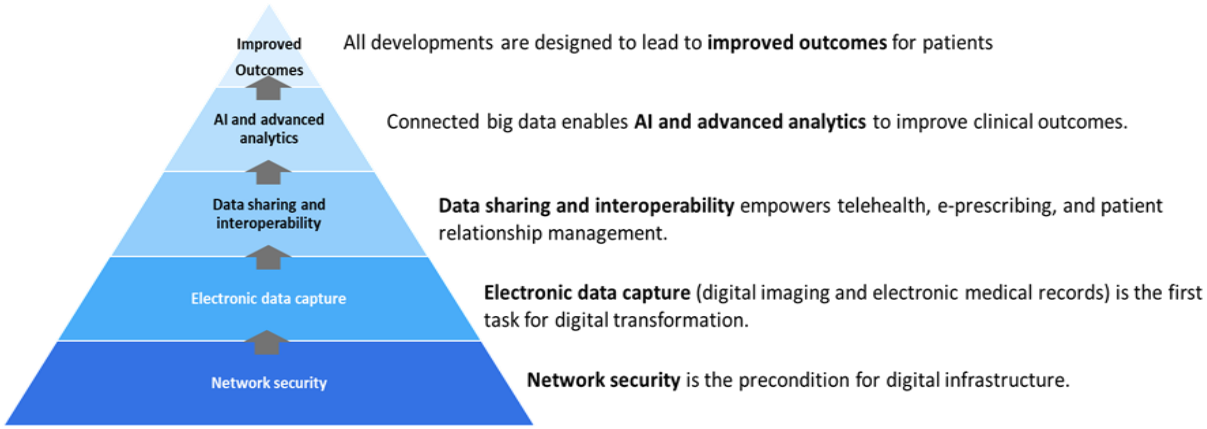
Stage 2: Data sharing and interoperability

- As electronic health data evolves, data sharing with other healthcare professionals and establishments will be enabled.
- Empowered by data sharing, new service models, such as Telehealth and e-prescribing, and advanced technology adoption, such as medical AI, will become possible.

Stage 3: Advanced applications of technologies and analytics based on connected data

- With clinical, financial, and operational data converging, healthcare practitioners are empowered to improve the quality, safety, and efficiency of clinical care.
- AI, business intelligence, and analytics can predict health outcomes within a population, which helps healthcare systems improve population health outcomes, and ensure their financial sustainability.

Figure 4. How Digital Transformation leads to improved healthcare outcomes



Source: Omdia

Digital technologies such as IoT and AI will help the industry push forwards in this journey and to deliver real benefits in patient care, especially as populations grow. In particular, the technology needs focus around three key aspects:

- **Efficiency –** The beneficiaries of digitalized healthcare will firstly be the patient, for whom it can deliver an experience which is less intrusive, less stressful, more accurate, and faster. Medical facilities such as hospitals and Doctor Offices will be able to operate with greater levels of efficiency through better knowledge of what is happening in real time with equipment (Asset Management), professionals (Clinical Efficiency), and patients (Remote Patient Monitoring).

- **Connectivity –** A huge variety of different care locations, regional differences, cost budgets, challenges and device types mean a flexible approach to the connectivity technology charged with transporting the patient data.

- **Security -** A raft of challenges will need to be addressed and overcome, including the security and privacy of patient data, fragmentation, and implementation.

Global variations in healthcare funding (public, private, and hybrid models of the two) also add a layer of complexity for IoT suppliers that will have to engage with both government and private healthcare bodies. Where vendors can meet the growing need, the digital investment in healthcare presents growth opportunities for:

- IT technology suppliers
- Semiconductor suppliers
- Hardware and software vendors
- Telecommunications providers
- Service and support providers

Those suppliers with flexible, open, and comprehensive offerings will be best placed to capitalize on this major new initiative that offers great potential for the global healthcare industry.

Telehealth and AI Healthcare Expansion

When asked about IT spending plans for the next 18 months, telehealth and AI were the areas with the highest growth in investment, across establishment sizes and types, according to Omdia.

- 71% of surveyed establishments will increase spending on Telehealth. 36% of the total respondents (compared to 23% in the 2020 survey) said that they will increase spending by more than 6%.
- 62% of surveyed establishments will increase spending on AI. About 25% of them (compared to 21% in the 2020 survey) will increase by more than 6%.

Telehealth

This improves the experience for both patients and healthcare professionals – for example by lowering costs, increasing efficiency, and addressing health resource disparities. Ramping up telehealth capabilities, higher acceptance by both patients, and regulation support from governments will drive the continued growth of Telehealth – but without reimbursement from health insurers, this adoption could stall. Government support is critical to normalize Telehealth in the wake of COVID-19. For example, healthcare establishments and insurers in the US have been calling for the maintenance of the telehealth policy that was implemented temporarily during the initial outbreak. On January 26, 2021, 336 establishments sent a joint letter to Congress urging advance permanent telehealth reform after the COVID-19 pandemic ends. Meanwhile, the Chinese government has taken gradual steps to expand reimbursements for Telehealth services in the wake of COVID-19.

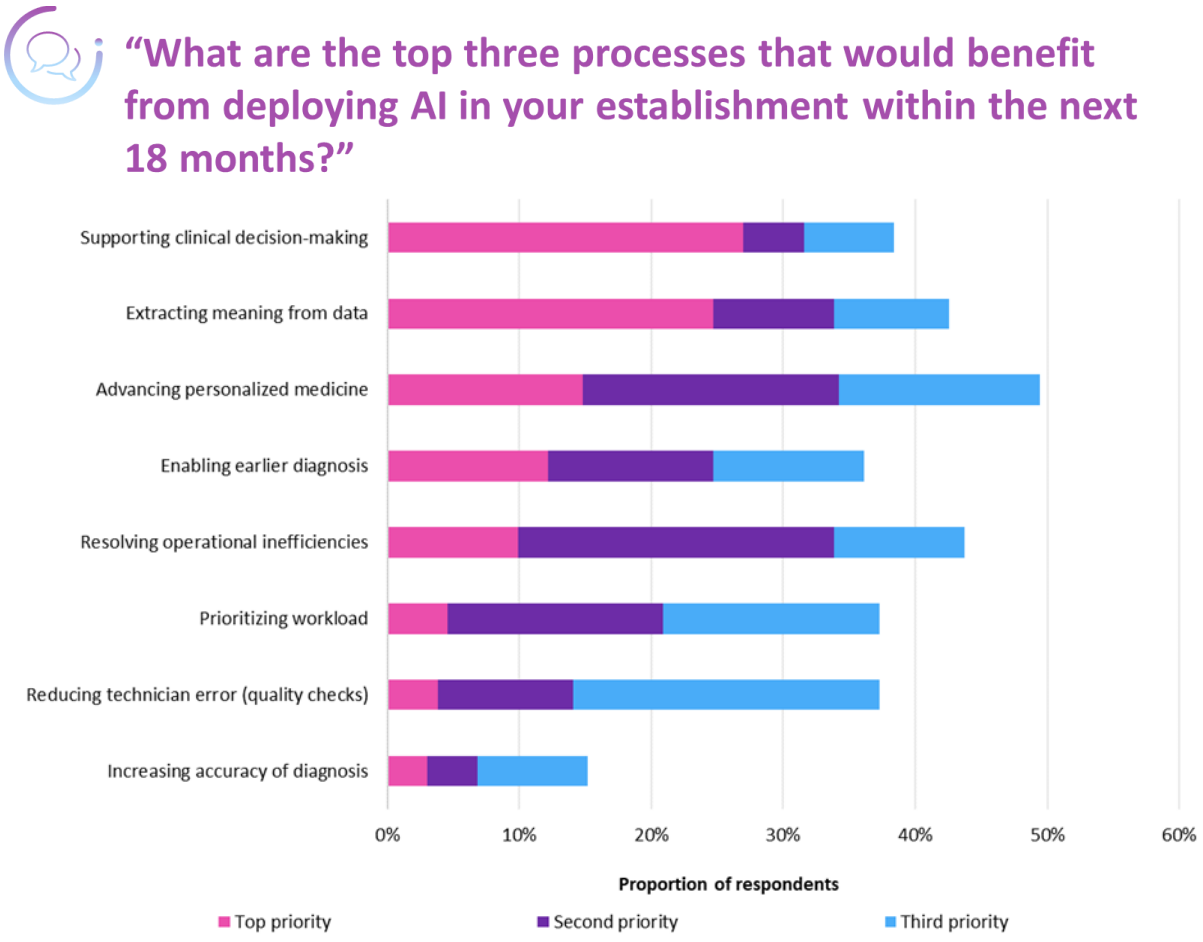
The COVID-19 pandemic prompted an increase in Telehealth adoption across the world. This has driven efficiencies in patient monitoring, both in terms of triaging patients and monitoring their conditions remotely to reduce in-person medical appointments.

Artificial Intelligence

AI deployments can potentially benefit many areas of healthcare – with improved clinical outcomes (such as personalized medicine and improved diagnosis) particularly important according to Omdia survey data (see figure).

This is particularly true for large establishments, as they have huge but high-quality databases with which to build AI tools. AI deployments also help with repetitive administrative tasks, such as scheduling and admissions.

Figure 5. How AI benefits healthcare



Source: Omdia

IoMT (Internet of Medical Things) Devices at the Heart of Telehealth

"In order to deliver the goals of improved efficiency and better medical outcomes, much relies on the infrastructure and devices for IoT."

A growing number of healthcare IoT devices are being used in remote patient monitoring applications to send and receive data, such as automatic pill dispensers, blood glucose monitors, continuous positive airway pressure, conventional health hubs, medical tablets, mobile cardiac telemetry, mobile personal emergency response systems and many others.

These IoT devices are at the heart of Telehealth for several reasons:

- **IoT devices are used to manage chronic illnesses:** Connected healthcare IoT devices that can help manage chronic illnesses (e.g., diabetes or cardiovascular diseases) are becoming more popular. Most healthcare IoT devices still use smartphones as gateways to connect to the cellular network and transmit data. However, a growing number of high-end patient monitoring IoT devices (e.g., blood glucose monitors, heart rate monitors) now include a dedicated connectivity within the device or connect via a dedicated gateway that may connect to a home router.

- **IoT is ideal for adherence and compliance verification:** IoT technologies can be used to supply data on medication adherence (e.g., connected pillbox) or therapy usage (e.g., CPAP). Healthcare professionals can utilize the patient adherence data to treat their patients more effectively while insurance companies can use the therapy usage data to verify the use of therapy before reimbursing the patient.

- **Remote patient monitoring is receiving more attention:** Although the healthcare industry has also been experiencing a negative impact from COVID-19, the industry has been receiving more attention and investments.

Patient Treatment Journey Improvement through IoMT Devices

The range of IoT medical devices can serve a variety of purposes, both in home and clinical environments. The proliferation of accessible consumer devices, from smartphones to smart watches and other wearables, in tandem with the pandemic, has lowered barriers to adoption in terms of users monitoring their own healthcare as well as driving the growth in telehealth services.

Increased adoption of wearables has resulted in people monitoring their exercise more effectively, while devices such as Continuous Glucose Monitors (CGMs) are now commonly used to help many of the 463 million people living with diabetes manage their condition. Moreover, devices such as pulse oximeters (used to monitor the oxygen saturation in the blood) have made people more aware of how to monitor their own health due to COVID-19.

The table below highlights key areas where the Internet of Medical Things (IoMT) are playing a key role in healthcare and the patient treatment journey.

Figure 6. IoMT device use cases and their role in the patient journey

 PROACTIVE HEALTH	 CLINICAL EFFICIENCY	 REMOTE MONITORING	 PERSONAL CARE	 ASSISTED LIVING
Wellness, Fitness, Wearables	**Smart Hospitals**	**Patient Monitoring**	**Personal Health**	**Elder Care**
Motivates people to keep up good health and productivity at work and avoid sickness proactively, reducing burden on hospitals.	Enables hospitals to elevate efficiency, safety, and patient experience while streamlining processes and eliminating the need for human intervention, saving cost.	Allows monitoring of post-acute or chronic patients remotely at home, reducing the burden on hospitals.	Enables people with chronic diseases to actively monitor and care for themselves while living a normal life, without costly clinical care.	Aided living applications allow the elderly to live longer at home, reducing the load on public services.
Example applications include Biometric wearables, Exercise trackers, Digital thermometers, Covid tests, Weight scale, body mass composition, Massage chairs and devices, Alt devices (Breathe analyzer – CO2 and other, smart toilet seat, posture trainer).	Example applications include Real-time asset tracking, Patient tracking, Staff workflows, Wireless portable. See deep dive below.	Examples applications include ECG, Gastro, Endoscopy Pill	Example applications include pulse-oximeters, heart monitors, Diabetes Management (CGM, BGM, Insulin Pump/Pen), Asthma Inhaler / Medicine Delivery, Wound Care	Example applications include Dementia tracking, Fall detection, Digestion assistance pill, Smart Pill Box

Source: Omdia and Silicon Labs

Clinical Efficiency in Focus

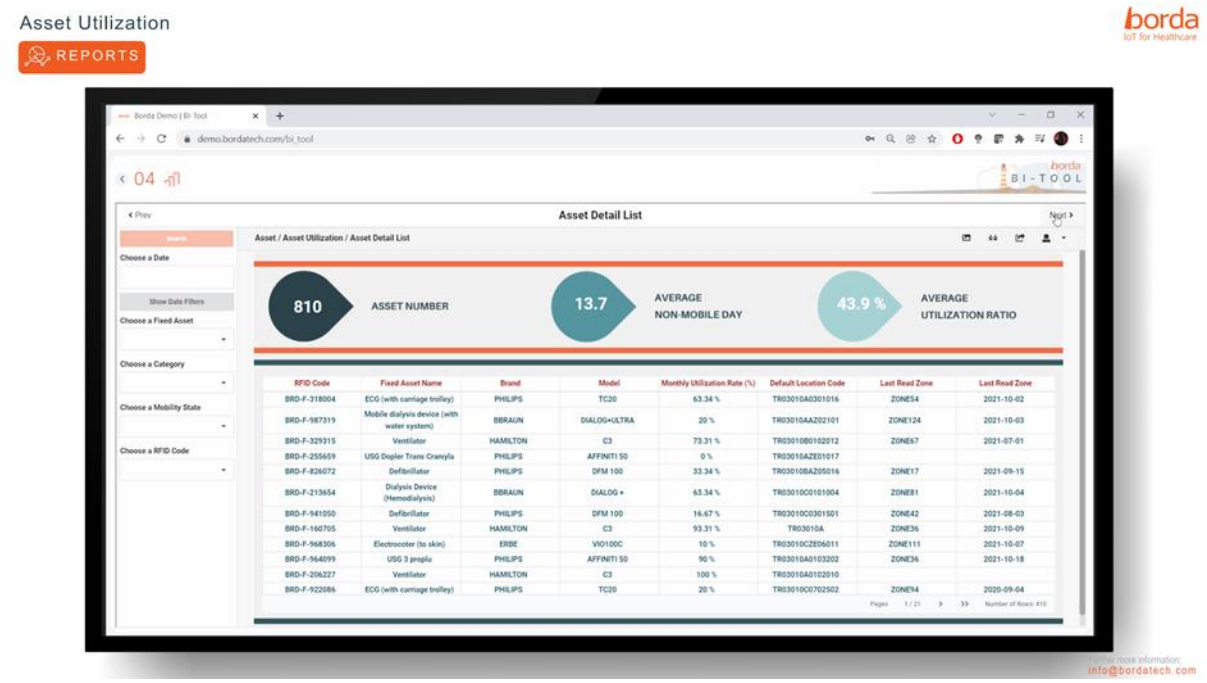
Again, more efficient usage of healthcare facilities e.g., hospitals, improves through having the right patient at the right time, minimizing unnecessary trips for patients, and treating less demanding and non-acute cases remotely. Knowing what equipment is where and in what condition the assets are, is equally vital in ensuring maximum utilization and more satisfactory patient outcomes.

It is estimated that $140 Billion is lost every year in US hospitals due to inefficient management of operations. An average asset in a hospital remains unutilized for more than 50% of its lifespan, while nurses waste a valuable portion of their time searching for the right equipment.

There are several ways in which IoT can assist improve clinical efficiency (through improved facility and asset management) and smooth the patient and staff experience:

- **Real-time asset tracking.** Improve hospital asset inventory management with increased asset efficiency and utilization. Optimize the time spent in localizing critical assets, identify lost or misplaced assets, and eliminate over-purchase.
- **Patient tracking.** Gain a holistic view into patient movements and patient vital signs from hospital check-in to check-out. Deliver better patient care and reduce idle waiting time with connected patient journeys.
- **Staff workflows.** Take control over staff operations and improve the overall performance.
- **Wireless portable.** Enable easy access to key vital signs and wellness information from connected bed-side devices are easy to move from one room to another.

Figure 7. Example of a clinical asset utilization dashboard



Source: Borda Technology

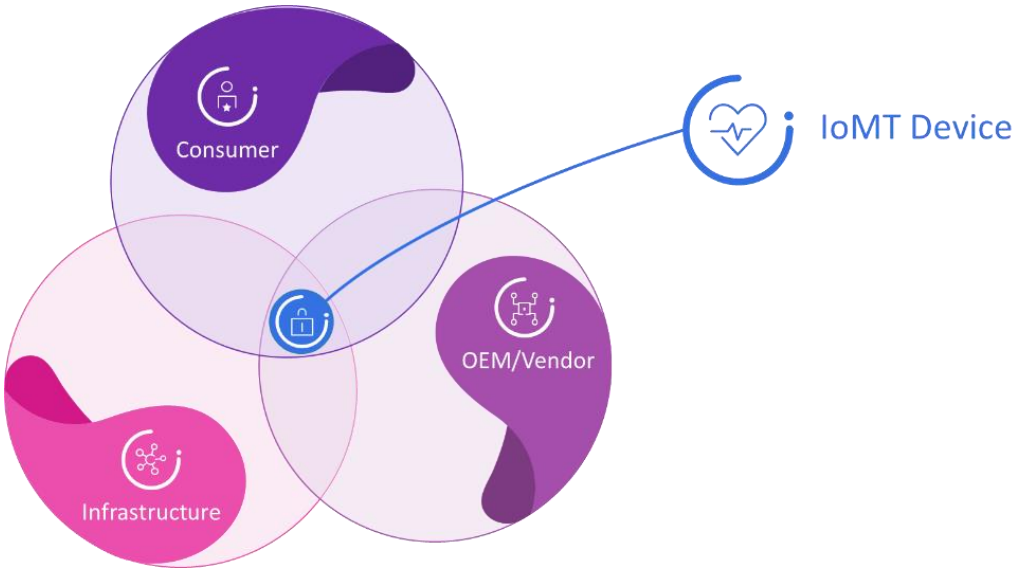
Requirements for IoMT Devices

While IoMT devices are the bedrock in the future of digital healthcare, both for both personal use and in clinical environments, they need to adhere to specific requirements given the importance of the data they are collecting. There are several criterial that are fundamentally important – namely Security, and Connectivity (both in harsh environments, and in interoperability).

Security

The rapid growth in the IoMT is transforming Telehealth. While most medical IoT devices are designed primarily with usability in mind, most fail to consider the importance of vital security aspects. Irrespective of the sophistication of the medical device, security is typically an afterthought. This presents a risk with medical IoT devices in any instance when they connect to a healthcare network, such as a hospital or EMR database; Data is at risk of being intercepted or stolen.

Figure 8. IoMT devices as an attack vector



Source: Omdia

COVID-19 saw an exponential rise in ransomware attacks on hospitals, and healthcare is the 3rd most attacked sector after Government and Education. Hospitals no longer worry solely about x86

PC environments, but rather the growing number of mobile devices, such as smartphones and tablets, along with a rapid uptake in medical IoT devices for managing conditions such as diabetes, epilepsy, and heart disease, among many others. Many of these are also used in home environments, meaning less control over security too.

The attack surface is increasing significantly, and on-device security is essential to protect consumers, the wider health industry/infrastructure, and the IP of the device manufacturers themselves.

> *"More than half (53%) of the IoT (internet of things) and internet of medical things (IoMT) devices used in healthcare contain critical cybersecurity risks."*

Vulnerabilities are present in multiple scenarios, such as mobile health clinics transmitting patient information to a database, or in-home telehealth devices transmitting data to healthcare providers, or accessing EMR (Electronic Medical Records). Security is only as strong as its weakest link, so secure and hardware encrypted medical IoT devices are vital.

Accessing a hospital network or healthcare database can provide cyber criminals with access to thousands of personal medical records, which fetch a far higher price on the black market than even credit card details.

When devices become connected, security attacks and exploitations become a severe threat to users – from real and perceived risks such as hacks and ransomware. IoT devices must be trustworthy throughout the entire product lifecycle, protected from silicon to cloud. Security is not a point in time, but rather lives through the life of the solution – meaning underlying security platforms in the hardware, software, network, and cloud, all able to be updated and patched in the field.

IoMT devices must adhere to the most stringent security controls to ensure medical devices are not subject to attacks. This has moved sharply into focus since the vulnerabilities highlighted in Medtronic insulin pumps, that could have had potentially fatal consequences.

Healthcare has become a key target for cybercriminals offering Ransomware-as-a-Service-which coupled with the availability of low-cost tools, saw a ramp in attacks throughout the pandemic, which means that without sufficient protection, medical devices are subject to serious security risks.

In summary:

- IoMT devices must be able to be securely identified and authenticated on the network.
- IoMT devices also need FDA approval, while new IoT Security Legislation, regulation, and new certifications in IoT are in development are very relevant to devices used for healthcare e.g.
  - California Consumer Privacy Act (SB-327), followed by other states
    - California Senate Bill 327, “Information privacy: connected devices” took effect on January 1, 2020. It requires all Internet of Things (IoT) devices sold in the state to be equipped with “reasonable security.”
  - Cyber Shield Act, NISTIR 8259
    - The Cyber Shield Act will specifically establish an advisory committee of cybersecurity experts from academia, industry, consumer groups, government, and the public to create cybersecurity benchmarks for IoT devices. NISTIR 8259 is the National Institute of Standard and Technologies standard, "Foundational Cybersecurity Activities for IoT Device Manufacturers." NISTIR 8259 recommends cybersecurity activities that manufacturers should perform before they sell their IoT devices to customers
  - DTSec and IEEE 2621
    - The Diabetes Technology Society (DTS) launched DTSec (DTS Cybersecurity Standard for Connected Diabetes Devices project). Devices for diabetes are increasingly able to communicate wirelessly with smartphones, the cloud and with each other.
    - IEEE 2621 is a framework for a connected electronic product security assurance evaluation program, with specific requirements and guidance relating to digital diabetes devices and solutions, such as insulin pumps is described in this standard
  - PSA Certified, SESIP
    - PSA Certified is a security certification scheme for Internet of Things (IoT) hardware, software, and devices. It was created by seven stakeholder companies as part of a global partnership. The security scheme was created by Arm Holdings, Brightsight, CAICT, Prove & Run, Riscure, TrustCB and UL.
    - Security Evaluation Standard for IoT Platforms (SESIP) is an optimized security evaluation methodology, designed for IoT devices

OEMs developing medical devices must ensure that devices comply with minimum security requirements, including PSA Certified Level 3 – the highest level of IoT hardware and software security protection.

Ability to operate in harsh RF environments

Wireless devices must be able to operate in any environment, including ones with thick walls, lack of line-of-sight and clinical environments with many connected devices. In addition to the environment, if the device requires a mesh connection, the end device needs to be able to adapt to nodes going down, new ones being installed, or a spotty connection to certain nodes. If the wireless network goes down, the device must use the best possible combination of hardware and software to maintain reliability. This requires a robust protocol, transmit medium, and software stack that can handle these situations.

Clinical environments are often extremely harsh wireless operating environments with lots of equipment operating at different frequencies. It is critical that device performance is not degraded by congested RF environments and that vital connected equipment is not subject to unnecessary downtime. Even consumer home environments are often subject to interference, for example in 2.4Ghz spectrum used by household appliances as well as Bluetooth.

RF performance should meet +20 dbm transmit, multiprotocol, and extreme sensitivity requirements to ensure that device data is transmitted, and connections remain stable, no matter the obstacle, distance, or noise.

Interoperability

One of the challenges facing companies developing IoMT devices are interoperability challenges and fragmentation in healthcare. Wearables, smart home products and services and dedicated healthcare devices often operate within their own ecosystems, forcing OEMs to make decisions about what ecosystems to support.

It also presents a challenge for consumers, who may want to measure different parameters with different devices e.g., blood glucose monitoring on a dedicated device, heart rate monitoring on a smart watch or blood oxygen levels via a pulse oximeter, there is very little guarantee that the ecosystems will be interoperable. Moreover, they are faced with a bewildering array of applications and there is no consistent approach in terms of how user data is managed.

Connected devices must be able to connect it to other IoT devices in their environments. OEMs face a challenge as there are a variety of IoT protocols and ecosystems to choose from and the end location or operating environment is not necessarily known. In addition, because technology standards and specifications change, products need to be updatable so they don't become a legacy device that can't connect to newer devices. End products must be flexible and able to connect and communicate with anything else, even standards that have not yet been defined.

It is important for device OEMs to work with partners who support multiple protocols and perform extensive interoperability testing with all common mobile devices and gateways

Case Study: Silicon Labs Helps Bring New IoMT Solutions to Life

Clearly the security, operation, and interoperability requirements for IoMT devices are rigorous. Further, when moving a product from the realm of consumer health wearables into medical monitoring, regulatory bodies such as the FDA require evidence of efficacy and safety. In fact, the complexity goes up by an order of magnitude, which puts further pressure on entrants into the market, who typically are more focused on solving medical and not technology issues.

In order to navigate this complex journey, most innovators of IoMT devices will require partners that are experienced in wireless and other enabling technologies. Working with such partners ensures that the time and cost for bringing these devices to market is minimized while helping to guarantee they meet the highest performance requirements.

The following real-world examples illustrate how Silicon Labs has helped trusted partners in this process, in turn allowing potentially life-altering medical solutions come to the market.

Portable Cardiac Monitoring: Bardy Diagnostics

The WHO estimates that cardiovascular diseases (CVDs) are the leading cause of death globally, taking an estimated 17.9 million lives each year. Heart rhythm disorders account for a large proportion of these deaths. Accurately and rapidly identifying those at highest risk of arrhythmias and ensuring they receive appropriate and timely treatment can prevent premature deaths.

Diagnosis of cardiovascular diseases starts with an accurate ECG tracing. While personal-use cardiac monitors have been available for years, there are issues with the practicality and accuracy of these devices. For instance, traditional Holter monitors require multiple wires and are meant to be worn for just 1-2 days and only providing simplistic heart rhythm analysis.

In recognition of the limitations of devices available in the market, Bardy Diagnostics developed the CAM (Carnation Ambulatory Monitor) patch, a new type of ambulatory cardiac monitor designed for continuous operation for up to 14 days. Based on Silicon Labs' EFM32 architecture, the small and lightweight CAM patch is a complete re-imagining of traditional cardiac monitors. It uses a combination of advanced technology and semiconductor miniaturization to overcome the cumbersome design as well as accuracy concerns of traditional ECG devices. The CAM patch is

designed to detect even the smallest, most nuanced electrical signals from the heart. This in turn allows healthcare provides a better diagnose abnormal heart rhythm and get patients the treatments that help prevent serious consequences cardiac arrest, stroke, or loss of consciousness.

> *"What appears to be a small shift in signal clarity can prove critical for helping people get the specific treatment they need to improve their health and manage serious disease."*

At the heart of CAM patch is Silicon Lab's EFM32TG210 MCU which connects to the patient interface sensor and provides the critical integrated peripherals (ADC, SPI, ASYNC serial interface and timer functions). An essential aspect of the EFM32TG210 is its ability to operate at extremely low power. This allows for a smaller battery in the CAM patch, which translates into a device that is lighter, smaller, and altogether more comfortable – all critical factors in reducing noncompliance in use by patients.

These low power attributes are due in large part to the Cortex-M3 microcontroller's power management which offers exceptional power savings compared to other architectures. By transitioning into and out of sleep extremely fast, offering autonomous operation of peripherals, and with low power clock generation the CAM Patch can reach up-to 14 days of continuous ECG recording with just an 48mAh CR1225 battery.

Even more importantly, this low power consumption does not come at the expense of accuracy, ensuring the CAM patch is effective at "seeing" those minute cardiac details that distinguish it from other available monitors. Specifically, the EFM32 architecture contains high-performance ADCs that allow capture of those precise readings while keeping an electromagnetically quiet emissions profile so that small details are not obstructed by interference.

The CAM patch has the capability to revolutionize ambulatory cardiac monitoring and diagnostics. The device is a great example of how leaders in the medical and technology can collaborate to create the next state-of-the-art medical devices that can help patients around the world.

Conclusions

Healthcare costs are rising…but digitalization can drive efficiency and improve outcomes

The healthcare industry represents a significant opportunity for digitalization, including IoT, Telehealth and technologies such as AI. This opportunity exists with contributions from the healthcare IT ecosystem, non-IT healthcare budget diverted to digital healthcare, and medical devices.

The proportion of global healthcare facilities that have (and are planning to) significantly increase their healthcare IT budget has grown exponentially since the beginning of the pandemic.

A direct impact of increased pressure and rising costs is the need for greater efficiency, which has seen a real rise in digital technology investment, especially Telehealth.

The Internet of Medical Things (IoMT) is at the heart of Telehealth

At the heart of growth in Telehealth and AI investments are the infrastructure and devices that can securely and efficiently capture data on patients and devices that leads to better medical outcomes (e.g., detecting critical medical episodes, reducing in-person visits, ensuring medication adherence etc.) as well as greater efficiency (broad process automation, reducing the cost of inpatient visits, improving workflow scheduling, allowing for ongoing patient status monitoring etc.).

Using IoT technologies is an increasingly popular technology choice for remote patient monitoring applications. A growing number of healthcare IoT devices in remote patient monitoring applications to send and receive data. The healthcare IoT devices that most widely use IoT technologies are CPAPs, mPERs, blood glucose monitors, and heart rate monitors.

New technologies are transforming IoMT device development

IoT medical devices can serve a variety of purposes, both in home and clinical environments. The proliferation of accessible consumer devices, from smartphones to smart watches and other wearables, in tandem with the pandemic, has lowered barriers to adoption in terms of users monitoring their own healthcare as well as driving the growth in telehealth services.

Increased adoption of wearables has resulted in people monitoring their exercise more effectively, while devices such as Continuous Glucose Monitors (CGMs) are now commonly used to help many of the 463 million people living with diabetes manage their condition. Moreover, devices such as pulse oximeters (used to monitor the oxygen saturation in the blood) have made people more aware of how to monitor their own health due to COVID-19.

IoT technologies are transforming multiple areas of care, including:

- **Proactive Health:** Motivates people to keep up good health and productivity at work and avoid sicknesses proactively, reducing the burden on hospitals.
- **Clinical Efficiency:** Enables hospitals to elevate efficiency, safety, and patient experience while streamlining processes and eliminating the need for human intervention, saving cost.
- **Remote Monitoring:** Allows monitoring post-acute or chronic patients remotely at home, reducing the burden on hospitals
- **Personal Care:** Allows monitoring post-acute or chronic patients remotely at home, reducing the burden on hospitals
- **Assisted Living:** Aided living applications allow the elderly to live longer at home, reducing the load on public services.

Recommendations

While IoMT devices can be transformative in terms of delivering greater clinical efficiencies and improving patient outcomes, choosing the right technology partners is critical, as there are many things to consider in building medical devices.

Choose technology partners who understand the challenge of building IoMT devices.

Portable medical devices offer a wealth of opportunities to help patients receive/clinicians deliver superior outcomes and save considerable money at a time of exponentially rising healthcare costs.

When moving a product from the realm of consumer health wearables into medical monitoring, bodies such as the FDA require evidence of efficacy and safety. In fact, the complexity goes up by an order of magnitude, which means that partners need to meet very high standards in security, operation, and interoperability.

As evidenced from the case studies, it is vital that technology can meet the high bar of requirements that medical devices require, to ensure

- **Security:** OEMs developing medical devices must ensure that devices comply with minimum security requirements, including up to PSA Certified Level 3 – the highest level of IoT hardware and software security protection.
- **Operational Excellence:** RF performance should meet +20 dbm transmit, multiprotocol, and extreme sensitivity requirements to ensure that device data is transmitted, and connections remain stable, no matter the obstacle, distance, or noise.
- **Power:** Despite the high RF transmission power required on portable medical devices, ultra-low-power wireless SoCs and modules are critical for maximizing battery life, extending battery replacement and re-charging intervals, or minimizing the battery size, depending on the device type.
- **Interoperability:** It is important for device OEMs to work with partners who support multiple protocols and perform extensive interoperability testing with all common mobile devices and gateways
- **Intelligence:** The level of intelligence in portable medical devices is increasing to such a high level that artificial intelligence and machine learning (AI/ML) capabilities will be crucial even on battery-powered devices. AI/ML hardware acceleration on wireless chips becomes a fundamental enabler for increasing ML processing power while minimizing energy consumption.

Inclusive design is vital for diversity.

Cultural diversity is a significant challenge for medical device makers (especially so when hoping to enter international markets). Social context, familial preferences, and expectations can influence the uptake of wireless medical devices. Not to mention anthropometric characteristics and language barriers. Personalized care and privacy are especially emotive topics when caring for children.

It's human nature to question the consequences should the device be hacked, used improperly, or report bad data that might cause a dangerous condition to go unnoticed, especially when trialing a new technology on a loved one. Today's technology seeks to address these concerns in the design stages. Beyond the technology application itself, what is sometimes more difficult to address is the human interaction with the data thereafter.

Co-creation is pivotal: It takes a village

Case studies such as Bardy Diagnostics highlight how combining the capabilities of clinical experts and IoT technologists from Silicon Labs can deliver holistic, transformative solutions for the treatment of severe medical conditions. By combining clinical and technological expertise, it is possible to build inclusive, transformative, minimal medical devices that can transform patient outcomes and significantly improve efficiency in healthcare.

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Appendix

About Omdia

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We combine the expertise of more than 400 analysts across the entire technology spectrum, covering 150 markets. We publish over 3,000 research reports annually, reaching more than 14,000 subscribers, and cover thousands of technology, media, and telecommunications companies.

Our exhaustive intelligence and deep technology expertise enable us to uncover actionable insights that help our customers connect the dots in today's constantly evolving technology environment and empower them to improve their businesses – today and tomorrow.

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About Silicon Labs

Silicon Labs (NASDAQ: SLAB) is a leader in secure, intelligent wireless technology for a more connected world. Our integrated hardware and software platform, intuitive development tools, unmatched ecosystem, and robust support make us an ideal long-term partner in building advanced industrial, commercial, home, and life applications. We make it easy for developers to solve complex wireless challenges throughout the product lifecycle and get to market quickly with innovative solutions that transform industries, grow economies, and improve lives. Silabs.com

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Omdia consulting

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Our unique combination of authoritative data, market analysis, and vertical industry expertise is designed to empower decision-making, helping our clients profit from new technologies and capitalize on evolving business models.

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