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User Experience, IoMT, and Healthcare

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Abstract:

In this paper, we discuss current trends in how health professionals and patients are using wearables, connected devices, and software tools to deliver care and health monitoring purposes. We emphasize the importance of considering users' experience through understanding user workflows, their needs, and their limitations when creating connected health ecosystems (CHES). We discuss both the patient and the provider as "users" in the ecosystem. We note both barriers to using the Internet of medical things (IoMT) to create CHES and efforts to overcome them. The increasing penetration of the Internet and the availability of connected health devices along with changes in reimbursement policies provide an environment for CHES to grow.

Keywords: Healthcare, IOT, IoMT, User Experience, Care Delivery, Patient Monitoring, Connected Health.

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1 Introduction

Designers need to design positive experiences when developing products and services that users receive well (Djamasbi, 2014). The increasing frequency with which both patients and health professionals can access and use connected devices for clinical care and for monitoring patients has created abundant opportunities to deliver health and wellness services. In this context, we need to pay close attention to designing positive end user experiences. Building connected health ecosystems (CHES) that comprise tools that one can easily use, workflows that one can easily follow, and guide interactions that provide value to every user can have significant positive implications for patient safety and health outcomes. As an example, in a CHES for diabetes management, an easy-to-use smart glucometer would transmit a patient’s blood glucose readings seamlessly to a central monitoring system where staff members would monitor the data and send appropriate insulin and dietary recommendations to a smart insulin delivery device. Such a system could help patients (especially individuals who risk overdosing on insulin and sustaining organ damage due to suboptimal diabetes control) better manage their diabetes and avoid complications associated with inadequate or excessive insulin administration. An optimal CHES would also include a tool, potentially a mobile app, through which the healthcare provider and the patient could communicate regarding the readings and any changes needed in the care plan. Connected healthcare ecosystems such as this diabetes-management example continue to become more and more prevalent in the industry.

In this paper, we discuss the current state of health information technology (HIT) adoption, which includes the extent to which the general population uses smartphones and smart health devices. We also discuss the extent to which healthcare institutions and care providers use electronic medical record systems. With trends toward a focus on population health and changing reimbursement models, we discuss opportunities that have emerged from new developments in technology such as increasing access to Internet and smart devices and increasing interest among payers to use technology-based solutions to deliver care and monitor diseases. While acknowledging existing barriers that battle the technology trends, providing optimal CHES can enhance quality and control cost in the long term.

2 IoT and Current State of IoMT Adoption

The Internet of things (IoT) refers to a network of devices with sensors and software that connect to the Internet and enable devices to exchange data. Healthcare practitioners and organizations have commonly used IOT in the healthcare industry (sometimes called the Internet of medical things (IoMT)) to remotely monitor patients and manage assets (e.g., CT, PET, X-Ray machines) (Farahart, Tolba, Elhoseny, & Eladrosy, 2018). The IoMT expands also to equipment inventory tracking in individual hospitals and even to sensor-enabled hospital beds and other medical supplies. Some institutions now use sensors to track patients and staff. In this paper, we focus on how healthcare practitioners use IoMT to deliver care and monitor patients.

Various industries have increasingly begun to adopt the IoT, though the manufacturing and warehousing, transportation, utilities, consumer electronics, and automotive industries have led the way. Smart home devices such as smart refrigerators, dishwashers, security cameras, and lights bulbs continue to grow in popularity among consumers. The IoT global market reached US$726 billion in 2019, and sources expect it to grow to US$1.1 trillion dollars in 2023 (Desmond, 2019). Frost & Sullivan found that the global IoMT market amounted to US$22.5 billion in 2016 and predicted it to reach US$72.02 billion by 2021 (Alliance of Advanced Biomedical Engineering, 2017).

An integral part of IoT, smartphone apps continue to play an increasing role in our lives. We can take populations’ access to smart phones as a good proxy for the IoT’s potential impact, which includes its impact in healthcare.

A 2019 Pew research study found that 81 percent of American adults owned a smartphone (Pew Research Center, 2019). The same report also found that 53 percent of American individuals older than 65 years had access to a smartphone (up from 18 percent in 2013) (Pew Research Center, 2019; Anderson & Perrin, 2017). While the report did not find a racial difference in smartphone access, it did find significant difference when education and income were taken to consideration: 91 percent of college graduates had access to a smart phone compared to 66 percent of those who did not graduate from high school (Silver, 2019). Additionally, 95 percent of individuals with an annual household income more than US$75,000 had a smartphone versus 71 percent of individuals with an annual household income under US$30,000 (Silver, 2019). Despite these gaps, we can see that individuals overall have increasing access to smartphones irrespective of their age, race, education, income, or location.

Wearable devices, which connect to smartphones, constitute another important component of the IoT and the IoMT. The healthcare environment has used these devices for a long time, for example, to monitor patients' heart rate, monitor their brain electrical activities, and to monitor fetal activity in pregnant women. However, smartphones' ubiquity along with the increasing availability of wearable devices and remote monitoring devices in the market has led to growth in consumers' interest in these products for themselves and/or their loved ones. Consumers now use consumer-grade wearables such as pedometers, smart watches, and smart devices such as glucometers, scales, and sleep trackers that monitor activity, heart rate, blood glucose, weight, and sleep to monitor their overall health and disease conditions. In a survey of 2,300 adult Americans conducted by Accenture found that the use of wearable devices had increased from nine percent in 2014 to 33 percent in 2018. The same survey also found that use of mobile and tablet health apps had increased from 16 percent to 48 percent over the same period (Accenture, 2019).

3 Current Healthcare Landscape: Burden of Disease and Cost, Growing Elderly Population, and Access to Care

According to the latest CDC report, 60 percent of adults in the United States have one chronic medical condition (CDC, 2019a), and more than 40 percent of the U.S. adult population have two or more chronic conditions (Buttorff, Teague, & Bauman, 2017). The latest CDC report notes that heart disease, cancer, chronic lung disease, stroke, Alzheimer's disease, diabetes, and chronic kidney disease are the leading chronic conditions in the United States and account for approximately 85 percent of the US$3.3 billion dollars in healthcare spending. Additionally, caring for the sickest five percent of patients accounts for 50 percent of total healthcare spending (Peterson-Kaiser Health System Tracker, 2019). Another 2016 report showed that individuals older than 65 years constituted 15 percent of the total population in 2015 and will grow to 22 percent by 2050 (Federal Interagency Forum on Aging-Related Statistics, 2016). This population accounted for 34.5 percent of the total healthcare cost in the United States in 2014 (Peterson-Kaiser Health System Tracker, 2019).

Access to care constitutes another important issue for patients. In their study, Kullgren, McLaughlin, Mitra, and Armstrong (2012) found that 18 percent of the study's population had difficulty paying for healthcare services, which prohibited them from obtaining proper care. Additionally, 21 percent had non-financial barriers to access care, which included accessibility (long commute time or lack of transportation), availability (long wait time), and scheduling (conflict with work schedule) that led to an unmet need or delay in care (Kullgren, McLaughlin, Mitra, & Armstrong, 2012).

4 Electronic Health Record (EHR): Adoption, Patient Empowerment, and Changing Payment Model

The Health Information Technology for Economic and Clinical Health Act (HITECH) of 2009 led healthcare organizations across the US to adopt the electronic medical record system. A 2017 national electronic health record survey showed that 86 percent of office-based physicians in the US used an electronic health record (EHR) (CDC, 2019b). Another study showed that 80 percent of hospitals in the US used an EHR (Alder-Milstein et al, 2017). Traditionally, healthcare practitioners have used EHR to document clinical findings, view results, and enter orders. Healthcare providers across the care continuum can share these electronic health records. For example, the primary care physician (PCP) can almost instantaneously access lab results from another facility, or a specialist can review the PCP notes and vice versa all with just a few clicks in the EHR. Adoption of EHR systems which use common health information exchange standard has made sharing of patient data easier for healthcare providers. This has also made it easier for patients to share, and for healthcare providers to collect patient health data for monitoring and care delivery.

With the advent of electronic medical record systems that include patient portals, patients can better access their health information and take control of their own health in ways not possible in the past. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) provides individuals the right to see and receive their medical information in addition to protecting the privacy and security of individuals' identifiable health information. Lawmakers implemented the HITECH act to help patients and their family better engage in their health through access to their health data through staged meaningful use of EHR and through the Centers for Medicare & Medicaid Services (CMS) Quality Payment Program (QPP) (CDC, 2019c).

Additionally, the “quantified self” movement and the increase in the number of wearable devices have contributed to the growing number patients and families who have an interest in accessing and tracking their health data and, thus, becoming active participants in medical care (Quantified Self, 2019). Health activists such as e-Patient Dave (e-Patient Dave, 2019) and the Society for Participatory Medicine lead the way in bringing patients to the medical decision-making table (Society for Participatory Medicine, 2019).

On the reimbursement front, payment models have begun to change gradually from fee for service (where healthcare providers receive payment for each unit of service they deliver) to value-based model (where healthcare providers receive payment based on improving health outcomes and reducing cost). Bundled payments pay a provider/facility for an entire episode of care such as a heart surgery or a joint replacement (NEJM Catalyst, 2018). Payer-provider risk sharing represents a tool to control rising healthcare costs while improving the care’s quality (Lockner & Walcker, 2018). As a result, we have seen an increase in interest among payers and healthcare providers to use technology and patient health data to improve care and reduce costs.

5 Developments and Opportunities Facilitating Increase Use of IoMT Devices in Healthcare

The increasing availability and decreasing cost of Internet access, cloud computing, advances in wearable technology such as smart contact lens (Writer, 2019), sensor-enabled vests (MobiHealth News, 2017), stick-on wireless sensors (Stanford University, 2019), and connected devices like smart pills, medication boxes, glucometers, EKG devices, and video monitoring systems (MobiHealth News, 2017) have increased the application of IoMT to deliver care and monitor patients’ health.

On the policy front, the U.S. Department of Health and Human Services (HHS) has proposed a new rule to help healthcare providers and patients securely access, exchange, and use electronic health information (EHI) by giving them better access to health information and new tools to help deliver care through standardized application programming interfaces (APIs). These APIs allow individuals to securely and easily access structured EHI using smartphone applications (Centers for Medicare & Medicaid Services, 2018). The Food and Drug Administration (FDA) also recently published guidelines to clarify its position on the scope of its oversight of clinical decision support software intended for healthcare professionals, patients, and caregivers. These guidelines focus on helping organizations that develop clinical decision support software to do so in a safe and secure manner through appropriate clearance and FDA approval requirements when necessary (U.S. Food and Drug Administration, 2019).

Reimbursement for the care that healthcare providers provide through these connected systems plays an important role in whether they adopt IoMT. As more reimbursement shifts from fee-for-service to value-based payment models, both payers and healthcare providers have become increasingly interested in using information technology to care for and monitor patients. Payments for telemedicine-based services for clinical care and patient monitoring now exist, and some states even provide reimbursement similar to face-to-face visits courtesy due to “parity laws” (Yang, 2016). The Centers for Medicare & Medicaid Services (CMS) has now established billing codes for remote patient monitoring and for management of chronic conditions (Centers for Medicare & Medicaid Services, 2018), which has created opportunities to develop and integrate appropriate tools to provide these services (mHealthIntelligence, 2018).

6 Care Experience in IoMT Ecosystem

Patient experience encompasses various interactions that patients have with the healthcare system, including their care providers and institutional staff. We know patients highly value this experience when seeking and receiving care, and it represents an integral component of healthcare quality and patient-centered care.

With an increase in the frequency with which healthcare providers use technology (which includes IoMT devices) to deliver care, we need to understand both patients’ and providers’ needs to provide an optimal experience for both. Many experts have noted that electronic medical record systems contribute to physician burnout (Foster, 2019; Gardner et al., 2019) and poor system design to patient harm (Committee on Patient Safety and Health Information Technology, 2011). We need to understand the clinical context, patient and clinician workflows, and to recognize their needs and their limitations when designing connected health ecosystems using IoMT devices. A connected system to monitor and prevent falls at home will have different patient requirements compared to a connected system that monitors and manages heart failure. While the general principles for developing a connected ecosystem may be same, the nuances relevant to the clinical context will determine the extent to which users engage with a system and how much impact it will have on patients' health. A well-designed connected system for monitoring of heart failure may comprise a central cloud-based monitoring system that has appropriate algorithms to provide decision support, a smart weighing machine, and a smart app connected via a secure and reliable Internet connection that collects and shares relevant information with patients. Additionally, this system would also have a clinical team who monitor patient data and support the patient virtually or in person when required. Note that such a complex system has many different parts with many different user groups (patients, physician, nurses, etc.). Ensuring that the system operates successfully as a whole requires successful user experiences for its different user groups for each single part of the system. Thus, one needs to consider the *entire* care process and deeply understand the needs of *all* the user groups when developing a connected ecosystem. In doing so, we have the ability to create meaningful experiences and positively affect health outcomes.

7 Barriers and Challenges

Developing positive experiences for connected health ecosystems relies on seamless data exchange between all unit devices or subsystems. Despite health information exchange (HIE) being a priority and significant work being done to establish common standards for health information exchange such as HL7 and Fast Health Interoperability Resource (FHIR) (HL7, 2019), healthcare institutions and health information technology (e.g., EHR and device) vendors have not universally adopted these standards. Therefore, exchanging data between disparate systems will continue to face challenges, and this disjointed integration remains a barrier to streamlined workflows.

Concerns for privacy and security represent another important barrier that prevents one from developing positive user experiences. Given the accelerating pace of data breaches in the healthcare domain (Davis, 2019), data security has become increasingly important. The FDA has cleared software tools and smart devices such as smart EKG devices (AliveCor, 2019), thermometers, glucometers, and more for clinical use (MobiHealthNews, 2017). As increasing numbers of smart devices become available in the marketplace, we will need appropriate regulations and monitoring systems that address device safety and data security when integrating these tools and devices in the connected health ecosystem. Provider concerns about data overload represent another barrier to using these systems. We will need to develop tools to transform large volume patient data into meaningful information to help clinicians act on the data to help them use connected systems to deliver care. Finally, even though Medicare, Medicaid, and private payers have increased reimbursement for telehealth services, we still lack uniformity in coverage policies, requirements, and restrictions, which has limited the growth in adoption of IoMT-based solutions for delivering care and monitoring patients (CCHP, 2019).

8 Conclusion

All user groups (e.g., patients, doctors, administrators) require positive user experiences to ensure they successfully adopt smart and connected healthcare technologies. As we see continued increase in access to Internet and availability to smart health devices in the market and an increase in individuals' interest in accessing their health data for monitoring and managing their health, the opportunity to create connected health ecosystems grows as well. While several barriers have emerged (lack of standards for interoperability prohibiting seamless data exchange, patient privacy and security concerns, and payments to support investments in smart health ecosystem), encouraging developments have emerged as well, such as efforts to improve health information exchange, the FDA's work on guideline development and device clearance, and changes in payment models (i.e., a shift from fee for service to value-based care). We will need to emphasize user experience to gain users' acceptance and demonstrate the value of IoMT-based connected health ecosystem in improving health and potentially reducing costs. Further, user experience experts, caregivers, healthcare institutions, technology vendors, engineers, healthcare researchers, and policy makers will need to collaborate to build appropriate technology solutions that meet patient and caregiver needs and deliver value.

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