



Akademik Eğitim ve Sosyal Bilimler Dergisi (AJESS Journal)

The Role of Smart Cities in Improving the Quality and Sustainability of Healthcare Services: Leading Experiences

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Article History

Received: 31/07/2026; Accepted: 28/09/2026; Published: 05/10/2026

Abstract

This study aims to highlight the role that smart cities play in improving the quality of healthcare services and strengthening their sustainability, through the use of digital technologies and artificial intelligence to respond to escalating health challenges. It examines the transformations that digitalization has brought to traditional health systems, particularly in light of the limitations of conventional care models exposed by the COVID-19 pandemic and the resulting need to move toward a smarter, more flexible and more efficient model.

Drawing on a number of leading international and Arab experiences — notably Singapore and the Kingdom of Saudi Arabia — the study finds that integrating technology into the health sector helps expand access to medical services, strengthens the management of health risks, lowers costs, and speeds up diagnosis and decision-making. The findings further confirm that digital transformation has become a strategic choice for achieving quality and sustainability in healthcare services within smart cities.

Keywords: Smart cities, smart health, digital transformation, healthcare service quality, sustainability, artificial intelligence, healthcare.

Introduction

Today's world is undergoing technological developments without precedent, to the point that this era has come to be known as the age of the digital revolution and artificial intelligence. The term “smart cities” is arguably one of the most significant products of this era: the deployment of digital solutions and technological innovations makes daily life easier for people and helps sustain resources, while generally improving residents' quality of life. This has been accompanied by radical shifts in numerous concepts, foremost among them urban development itself — the focus has moved beyond traditional physical infrastructure alone toward investing in technology, data and artificial intelligence to strengthen the effectiveness of public services, chief among them the health sector, and to develop healthcare services that are more efficient, equitable and responsive.

Traditional healthcare services face growing challenges today — especially since the COVID-19 pandemic — such as overcrowding, weak crisis response, limited resources and rising costs, compounded by the mounting pressures of global epidemics and population aging. Within this context, smart cities offer an innovative model for supporting digital transformation in the health sector through solutions such as telemedicine, smart sensor networks, electronic health records, real-time monitoring, and artificial intelligence for diagnosis and early warning, among others.

Leading international experiences have shown that integrating technology into smart health systems raises the level of response to health risks, facilitates access to medical services, and reduces operating costs, while also enabling disease surveillance, the management of large-scale health data, and decisions based on precise real-time indicators. Cities such as Singapore, Barcelona and Helsinki have made tangible progress in implementing digital health systems by adopting smart sensing technologies, telemedicine and electronic health records.

Alongside these international experiences, several Arab countries have also emerged in the field of smart health, most notably Saudi Arabia, which adopted the NEOM project and a national digital health system built on unified health records and telemedicine, contributing to improved healthcare quality and a narrower gap in remote areas. The United Arab Emirates has likewise stood out through the Dubai Health Strategy 2025 and the “Salama” smart health record system, alongside its advanced reliance on artificial intelligence and medical robotics. These experiences confirm that digital health transformation has become part of national smart-city policy across the Arab region.

On this basis, the following research problem can be formulated:

How do smart cities contribute to improving the quality and sustainability of healthcare services, in light of a number of leading Arab and international experiences?

This study aims to highlight the role that digital transformation can play in addressing the growing health challenges the world faces day after day, along with the improvements that digital methods and technologies can bring to turning traditional healthcare into a smart service that keeps pace with the demands of the times and responds effectively to individuals' evolving expectations and needs, while achieving the dual goal of quality and sustainability.

It also reviews a number of leading experiences in smart health in the Arab and international context, represented here by the experiences of the Kingdom of Saudi Arabia and Singapore.

The paper is organized around the following four axes:

- Axis One: Smart Cities – Conceptual Framework
- Axis Two: Health Service – From the Traditional Concept to Smart Health
- Axis Three: Digital Technologies and Smart Solutions in Health and Their Impact on Its Sustainability
- Axis Four: Analysis of the Saudi Arabian and Singaporean Experience in Smart Health and Lessons Learned

Axis One: Smart Cities – Conceptual Framework

1. Definition of Smart Cities

Definitions of smart cities vary given the diversity of approaches and components that make up such cities, and there is no single, universally agreed definition. The concept traces back to 1994, when the European Digital Cities conference was held, followed by the launch of the European Digital City project in 1996 in a number of cities. Amsterdam was the first city to implement a digital-city project, followed by Helsinki.¹

A smart city is a designation given to a city or urban area that incorporates information and communication technologies to raise the quality of services such as security, energy consumption, transport and other required facilities, by reducing resource consumption.

Smart cities are also understood as the use of network infrastructure to enhance economic and political efficiency and to enable social, cultural and urban development; they are viewed as a mechanism for achieving sustainable development, representing a development pathway for the city of the future capable of producing the best outcomes even amid worsening problems such as rapid urbanization and mounting competitive pressure.²

A smart city is further defined as a city that operates in an ambitious, innovative manner covering the fields of economy, population, governance, mobility, environment and living. This innovation rests on an intelligent mix of support and active participation from independent, informed citizens capable of decision-making.³

The International Telecommunication Union (ITU) defines it as an innovative city that uses information and communication technology to improve quality of life, the efficiency of urban operations and services, and competitiveness — while ensuring that these benefits reflect the needs of present and future generations across economic, social, environmental and cultural dimensions, conditions a city must meet before it can be considered “smart.”⁴

According to the International Data Corporation (IDC), a smart city is a bounded entity whose governing authority operates at the regional rather than the national level, built on a telecommunications and information-technology infrastructure that enables efficient city management and strengthens economic development, sustainability, innovation and citizen participation.⁵

Broadly speaking, a smart city can be described as an urban entity that integrates information and communication technologies, artificial intelligence, the Internet of Things and big data to improve the quality of public services and

¹ **Haffaf, Souad.** “Smart Cities in the Face of the COVID-19 Pandemic: A Reading of the Necessities of Transformation.” *Al-Naqid Journal of Political Studies*, Vol. 6, No. 1, 2022, pp. 233–254.

² **Derdar, Hadjer, and Amina Moulay.** “Digital Governance as an Aspect of Sustainable Smart Cities: The Experience of the Emirate of Dubai.” *Journal of Intellectual Excellence for Social and Human Sciences*, Vol. 3, No. 3, 2021, pp. 246–258.

³ **Kouache, Zahia, and Oum Kalthoum Ouakli.** “Experiences and Applications of Smart Cities in the Arab Region: The United Arab Emirates and Smart Dubai.” *Journal of Economics and Environment*, Vol. 2, No. 2, 2019, pp. 8–27.

⁴ **Bessiklal, Tayeb, and Ouahiba Aissaoua.** “The Reality of Smart Cities and the Achievement of Sustainable Development: Arab Experiences (Smart Dubai City – ‘Masdar’ Sustainable City).” *Journal of Social and Human Sciences*, Vol. 14, No. 2, 2024, pp. 45–63

⁵ **Chennouf, Djamel, and Mokhtar Merahi.** “Moving Towards Building Smart Cities as a Strategy to Achieve Sustainable Development: Dubai as a Model.” *Journal of Advanced Economic Research*, Vol. 10, No. 1, University of El Oued, Algeria, 2025, pp. 203–219.

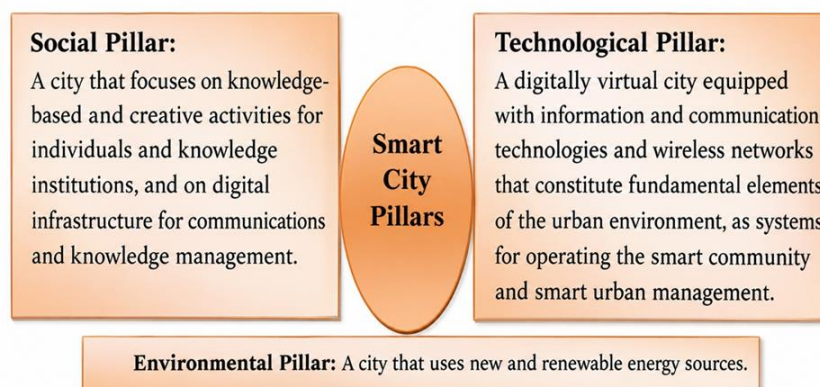
strengthen the efficiency of resource management. Such cities address urban and environmental problems through innovative solutions that reduce energy and resource consumption, develop transport, facilities and security and social services, and thereby achieve sustainable economic and urban development while enhancing residents' participation and quality of life.

2. Characteristics of Smart Cities

- **Smart economy:** built on the exchange of data and information across various communication networks, offering numerous applications that help develop different economic activities, which in turn helps identify the best means of preserving and developing essential resources in ways that ensure their continuity and sustainability for future generations — known as the green economy.⁶
- **Smart living:** the social dimension of smart cities in terms of quality of life, encompassing activities in culture, health, safety, tourism and social cohesion.
- **Smart environment:** whether natural or built, this is the physical environment of the city through which all of its activities take place.
- **Smart community:** the extent to which a city's community has absorbed information-technology applications and tools, and its capacity to move from an ordinary technology-using community to an innovative one able to reach creative solutions to its current problems and future development — one able to live within, and interact with, the information city: carrying out its activities, obtaining its services, and dealing with its administrative bodies through e-government, electronic cards, e-business and e-services.
- **Smart mobility:** the management of the transport and traffic system through a set of information-technology-based techniques. Smart mobility can be paired with sustainable smart infrastructure, so that the shift toward sustainable infrastructure underpins the shift toward a sustainable “green” city. This covers the components of a city's infrastructure (energy, water and sanitation, solid waste) and how they can be turned into environmentally sustainable elements, along with the extent to which information technology can contribute to their sustainability.
- **Smart governance / e-government:** the development of government operations through electronic means in delivering government services. The most important applications of e-government fall into three areas: information — making all activities and information related to the city's residents available; communication — the ability to exchange information and communicate between residents and government; and e-transactions — delivering services electronically.

The following figure illustrates this:

Figure 1: Characteristics/Pillars of Smart Cities



Source: **Kawach Zouhiya & Wakli Oum Kelthoum**, *Experiences and Applications of Smart Cities in the Arab Region – The UAE and Smart Dubai*, Journal of Economy and Environment, Vol. 02, No. 02, 2019, p. 11.

3. Importance of Smart Cities

⁶See, in this regard:

- **Chennouf, Djamel, and Mokhtar Merah**, op. cit., pp. 207–208.
- **Latreche, Samira, and Amna Lahmari**. “Smart Cities between Reality and Challenges: Smart Dubai as a Model.” *Economic Studies Journal*, Vol. 8, No. 1, June 2021, pp. 187–202.
- **Al-Qadi, Ahmed Naguib Abdel-Hakim, and Mohamed Ibrahim Al-Iraqi**. “Characteristics of Smart Cities and Their Role in the Transition Towards the Sustainability of the Egyptian City.” *International Journal of Architecture, Engineering and Technology*, Vol. 1, No. 1, 2018.

Smart cities contribute to improving economic conditions and raising the level of services, providing residents with a healthy, environmentally friendly setting, which makes them one of the most important factors in improving residents' quality of life. They are therefore a decisive factor in enabling future generations to live healthier lives, playing an important role in promoting health by providing advanced technology to collect and effectively analyze health data within the urban community in order to identify residents' health needs and trends. This helps in making sound health decisions and directing efforts toward disease prevention and public-health promotion, thereby improving healthcare services and supporting evidence-based decisions, and providing an advanced healthcare infrastructure and a healthier environment through the use of data technology and artificial intelligence — including easy access to hospitals and clinics, as well as the use of modern technology such as health apps and smart medical devices for health monitoring. Smart cities also help provide a healthier environment for residents by offering healthy public transport, promoting healthy lifestyles through green spaces and facilities, and using technologies that store medical information and provide easy, secure remote access to it.⁷

The importance of smart cities can also be summarized as follows:⁸

- **Practical importance:** smart cities help focus on the importance and quality of life, since their value lies in experiencing quality of life effectively and interactively, which is reflected in collective psychological well-being, with the aim of offering people the best possible outcomes.
- **Importance of self-reliance and experience:** every component must be consistent with individuals' characteristics and culture, and only the people of that environment itself are able to understand and keep pace with implementing smart digital cities.
- **Applied importance:** this rests on a universal design methodology that takes into account the capacities and characteristics of societies — Arab societies in particular — in the sense of what can translate into development outcomes, service quality and time savings, as well as training people and familiarizing them with the ideologies of smart living and their capacity to use the mechanisms for implementing digital-technology applications, so as to draw on them in developing individuals' positive potential.
- **Importance of an intellectual orientation toward developments on the international scene:** smart, digital-system visions that have been generalized across all sectors, intended to be embedded in every home and in every interaction individuals have in their daily lives.

Axis Two: Health Service – From the Traditional Concept to Smart Health

1. Concept of Health Services

Health services are a basic requirement for every human being, one that human societies strive to achieve regardless of differences in their political and economic systems. Various states likewise try to provide their health institutions with the appropriate human, technical and financial resources needed to raise the level of health-service performance.

Health services are considered an intangible economic good, like other service goods, but they are distinguished by a set of characteristics that affect demand for them, which makes it necessary to identify these characteristics.

Health services can be defined as all activities directed at preserving human health and safety by treating and preventing disease — meaning that health services comprise all activities aimed at caring for people and preserving their safety.⁹

They are also defined as everything health institutions provide in the way of curative, preventive or productive services: curative services relate to the individual, preventive services relate to the community, while productive services consist of manufacturing medicines, medical devices and the like — in addition to raising individuals' health standard and meeting the desires associated with this service.¹⁰

Health services can further be defined as all the services provided by the health sector at the national level, whether curative services directed at the individual, preventive services directed at the community and the environment, or productive services such as the manufacture of medicines, pharmaceutical preparations and prosthetic devices, aimed at raising the population's health standard and treating and protecting them from infectious diseases.

It follows from the above that health services encompass everything the health sector of a country provides, whether directed at the individual, the community or the environment. It is nonetheless important to distinguish between two concepts:

- **Medical care:** the services provided by health institutions relating to diagnosis, treatment and social and psychological rehabilitation, along with complementary specialized medical services such as laboratory tests and medical analyses, emergency care, outpatient clinics, radiology, ambulance services, nursing, and pharmaceutical and nutritional services, among others.

⁷ Abdelrahmane Mohamed El Hassan Ahmed, “The Role of Smart Cities in Promoting Health,” *Journal of Social Empowerment*, Vol. 4, No. 6, University of Ammar Thlidji of Laghouat, December 2024, p. 138.

⁸ Samira Latreche and Amna Lahmari, “Smart Cities between Reality and Challenges: Smart Dubai as a Model,” *Economic Studies Journal*, Vol. 8, No. 1, June 2021, p. 192.

⁹ Abdelrahmane Mohamed El Hassan Ahmed, op-cit, p. 138.

¹⁰ Lubna Snani, “Quality of Health Services: A Theoretical Introduction,” *Sociology Journal*, Vol. 7, No. 1, 2023, p. 59.

- **Healthcare:** the services provided by health institutions to society as a whole, aimed at providing health for all — such as family-planning campaigns, maternal and child care, prevention of endemic diseases, vaccination against infectious diseases, and elderly care, among others.¹¹

Health administration is characterized by a specificity derived from the particularities of the health sector and its institutions, as the largest and most complex sector compared with other sectors in any given society. Among the distinguishing characteristics of the health sector are:¹²

- The input into the health sector is the human being.
- The individual nature of the health service.
- The high degree of professionalization and specialization in the health sector.
- Demand for, and the need for, health services grows with a society's degree of urban development — the greater the degree of urbanization and progress, the greater the demand for health services, and consequently the greater the number and variety of health institutions required.
- Health services are not subject to the law of supply and demand, since demand for them generally remains higher than the available supply; health services are, by nature, generally urgent and cannot be postponed.

Figure 2: Components of the Health Administration System
Components of the Health Management System



Source: *Nidal Issa, op-cit, p. 3.*

The primary objective of every health system is to improve health, though this is not its only aim; the goal of good health encompasses two dimensions: the best attainable average outcome (quality), and the smallest possible gap between individuals and groups (equity).

2. Importance of the Health Service

The importance of health services can be assessed through the benefits and value they generate, namely:¹³

- Direct, tangible benefits that can be measured and calculated, represented in the costs that can be saved in the future as a result of the health services received.
- Direct, intangible benefits that are difficult to measure, represented in the reduction of pain suffered by the patient as a result of the health services received.
- Indirect, tangible benefits that can be calculated, represented in the increased output resulting from the healthcare services received by members of the workforce.

Additional reasons behind the growing interest in the health system in recent times include:

- Good health represents the ideal condition for properly enjoying life.
- Health is the one subject that concerns everyone without exception.
- Health services today constitute one of the largest and most complex industries, owing to their rising costs and increasing profitability.

3. The Shift to the Concept of Smart Health and Its Benefits

Improving the level of healthcare services is among the most important services for human beings, given its direct connection to their lives and to the life of society; it is also one of the measures of a country's progress in this field and has received considerable attention from governments and concerned institutions. It covers health facilities such as hospitals, health centers, public clinics, private clinics and pharmacies.

¹¹ **Fouad Ghadbane**, "The Concept of Health Services," article published on December 14, 2023, available at: <https://mail.almerja.com/more.php?idm=195417>

¹² **Nidal Issa**, *Health Systems Management*, Faculty of Health Sciences, Al-Manara University, pp. 2–3, available at: <https://fr.scribd.com/document/673321724>

¹³ **Amina Ben Ali**, *Lectures on Health Services Marketing*, intended for Second-Year Master's Students in Services Marketing, Department of Commercial Sciences, Faculty of Economic, Commercial and Management Sciences, Tahri Mohamed University, Algeria, 2020, p. 27.

In light of the tremendous progress achieved in numerous fields, healthcare organizations — hospitals foremost among them — have been driven to advance their healthcare services in order to benefit from recent technological developments, move toward digital transformation, and place greater emphasis on patients, as well as to adapt their health and medical practices so as to keep pace with the complexities emerging in the field of health services and with beneficiaries' needs and expectations. This has made it necessary for health organizations to undertake fundamental changes by designing services that rely on modern technologies, in a way that helps deliver services capable of achieving beneficiary satisfaction and organizational excellence, and of keeping pace with rapid, changing developments.¹⁴

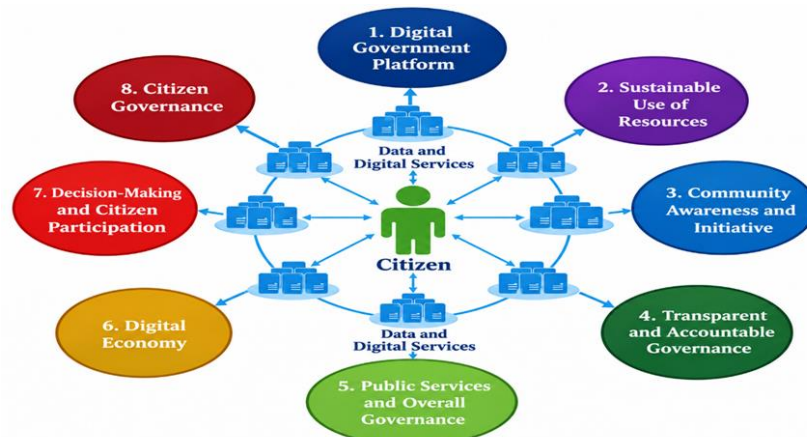
According to the World Health Organization, smart (digital) health — that is, the use of digital technologies in the health field — has become a prominent field of practice, employing innovative patterns of information and communication technology to meet health needs. This has been particularly true since the spread of the COVID-19 pandemic, which posed a global challenge that drew attention to the need to strengthen the trend toward improving smart health services, on the one hand, and to strengthen digital health communication between patients, physicians and the general and specialized public, on the other.

The term digital (smart) health is rooted in the term e-health, which the same organization defined as “the use of information and communication technologies (ICT) in support of, and to promote, health and health-related fields.”

Technological innovation, robotics and the Internet of Things (IoT) have also driven the growing use of various digital devices by healthcare professionals and hospital and clinic staff. Electronic health records have facilitated the treatment of many patient groups, and there is now a continuously growing body of digital data related to healthcare treatment and to patients.¹⁵

The simplification of technology has encouraged its wider use, enabling institutions to focus on system functions rather than becoming absorbed in the technical details of the technology itself — which shortens system-development periods and adds greater value for citizens by providing the ability to analyze numerous fields. This can be summarized in the following figure:

Figure 3: Health as One of the Areas in Which Citizens Benefit from Smart Cities



Source: **Talal Abu-Ghazaleh**, *The Inevitable Digital Future: The World of Smart Cities*, Talal Abu-Ghazaleh Translation, Publishing and Distribution, 2021, p. 14.

This shows that improving healthcare is one of the core areas smart cities aim to achieve, through the introduction of numerous innovative digital solutions.

The technological revolution has produced, in the world of medicine, a revolution of another kind, moving the hospital from a traditional facility to an advanced one, and then to a smart hospital that achieves outcomes in hospital care that earlier technologies were unable to deliver. This transformation has been accelerating recently, particularly in financially capable and technologically advanced countries — the Gulf states being not merely close to, but at the very heart of, this race, playing an active part in it. This progress is naturally being registered at the global level, from the United States to China, by way of Europe.

Figure 4: A Model of a Room in a Smart Hospital

¹⁴ **Mashari Mansour Warid Al-Otaibi**, “The Role of Digital Transformation in Improving Healthcare Services: An Applied Study on the Directorate of Health Affairs in Makkah,” *Future of Social Sciences Journal*, Vol. 20, No. 1, January 2025, p. 39.

¹⁵ **Nawal Wassar**, “Digital Health amid the COVID-19 Pandemic: Digital Health Applications via Smartphones as a Model,” *International Journal of Social Communication*, Vol. 19, No. 1, Abdelhamid Ibn Badis University, 2022, pp. 401–402.



Source: <https://www.thearabhospital.com>

A smart hospital can be defined as a hospital that uses information-technology tools to improve medical treatment — that is, advanced medical technology for modern healthcare. Artificial intelligence enables the rapid analysis of vast quantities of data, while automation simplifies processes and avoids wasting time on lower-priority tasks that might otherwise occupy healthcare staff's entire working day; the Internet of Things, in turn, turns various devices into tools connected to healthcare services and citizens' well-being. Integrating all of these elements requires a radical transformation in hospital management.

The adoption of smart hospitals is moving from the pilot stage into operational reality, achieving remarkable results and drawing wide attention for the accuracy of care, speed of service and safety in handling the health cases presented to them. From telehealth services that facilitate round-the-clock communication between patients and care providers, to breakthroughs in artificial intelligence, robotics and digital imaging, these hospitals are revolutionizing the delivery of healthcare. According to Statista, an estimated 116 million virtual medical consultations were expected to take place in 2024, underscoring the rapid shift toward technology-based care.¹⁶

Digital health can be said to offer important benefits and opportunities in terms of:¹⁷

- **Improving public health and healthcare institutions:** for example in hospital procedures, electronic health records and health information, with quality care becoming attainable through the rapid sharing of information and data among care providers and specialists across healthcare institutions.
- **Supporting physicians:** improving procedures and surgical operations, including remote surgery (in China, for instance, fifth-generation technology has enabled remote surgery involving the liver and the implantation of deep-brain stimulation devices).
- **Personal health and advanced devices:** sensors, screens, smartwatches and mobile phones for monitoring and feedback purposes.
- **Enabling improved analysis and prediction across health datasets,** through artificial intelligence and virtual-reality-based simulation, allowing data to be gathered from electronic devices and sensors for imaging, diagnosis and data analysis.

Smart health devices are already being tested in numerous capitals, enabling ordinary people to provide basic medical treatment to those who need it, connected remotely with specialist physicians on standby to provide support and guidance, through smart healthcare devices that enable specialists to deliver proactive healthcare to growing numbers of people, creating new telemedicine services, remote surgical procedures, and faster development of drugs resistant to diseases caused by emerging viruses.¹⁸

Axis Three: Digital Technologies and Smart Solutions in Health and Their Impact on Its Sustainability

1. Using Smart-City Technology to Build More Efficient Health Systems

Smart-city technologies can be used to improve healthcare systems and make them more efficient, by gathering health data from individuals and analyzing it using artificial intelligence, improving the delivery of health services and identifying health needs and trends. Tracking and analysis techniques can also be used to identify where diseases are spreading and to direct resources more efficiently. Smart cities have sought to build more efficient healthcare systems using the technologies available for this purpose; to achieve this, they draw on numerous modern technologies and solutions, employing the Internet of Things, artificial intelligence, big data and other emerging technologies to confront

¹⁶ **The Smart Hospital: How the Concept of Healthcare Is Leading to a Different World,”** *The Arab Hospital Magazine*, article available at: <https://www.thearabhospital.com>, accessed November 28, 2025, at 00:20

¹⁷ Nawal Wassar, “op-cit”, pp. 403–404.

¹⁸ Talal Abu-Ghazaleh, *The Inevitable Digital Future: The World of Smart Cities*, Talal Abu-Ghazaleh for Translation, Publishing and Distribution, 2021, p. 15

and manage urban challenges. Sustainable Development Goal 11 explicitly commits the world to making cities inclusive, safe, resilient and sustainable.¹⁹

1.1. Artificial Intelligence and Big Data

These are used in data analysis and virus-spread modeling, in helping develop vaccines, and in analyzing patterns for improved control purposes. The growing reliance on AI systems to analyze and process data in order to deliver better, faster information means that these systems themselves will need to be placed under scrutiny, to ensure they function correctly and transparently.²⁰

As artificial-intelligence capabilities expand, everything from internal operations to medical records benefits from the integration of predictive modeling, automated report generation and other AI features. Four specific use cases for AI in healthcare can be identified:²¹

1.1.1. Improving healthcare operations

Healthcare operations form a complex system comprising internal and external procedures that depend on the continuous exchange of data. These operations have moved from paperwork and phone calls, to email and digital files, and then to cloud databases and modern applications. Today, artificial intelligence helps streamline workflows across different departments — assisting human resources in managing staff data, supporting finance in cost analysis, automating patient procedures, and improving supply-chain management by detecting potential bottlenecks.

1.1.2. Improving the patient experience

Patients frequently encounter paper forms, especially since the COVID-19 pandemic. With the adoption of cloud-based solutions, data collection has become instantaneous, but artificial intelligence deepens the benefit by providing automatic updates and analytics for medical staff, saving their time, supporting a focus on preventive care, reducing administrative burdens, and contributing to more comprehensive, proactive care.

1.1.3. Artificial intelligence in healthcare finance

Given the complexity of the financial dimensions of the health sector, owing to regulations, confidentiality requirements and insurance obligations, the shift toward unified cloud-based systems represents an important step toward improved accuracy and efficiency. When artificial intelligence is integrated with these systems, financial operations become considerably more streamlined.

Through the use of artificial intelligence for financial needs and processes, a healthcare institution can benefit in the following ways:

- Root-cause analysis of both sudden and gradual problems.
- Predictive analytics regarding institution-wide trends that affect the bottom line.
- Modeling to improve operations, resources and supply-chain needs.
- Identifying and automating repetitive tasks to improve process effectiveness.

1.1.4. Advantages of Healthcare Data Management

Resource management is a vital element in hospitals and clinics, and its importance became especially clear during the COVID-19 pandemic because of the pressure on resources such as medical staff, vaccines and supplies. Moving this resource data to the cloud helped provide a single, unified source of information supporting decision-making. Artificial intelligence and machine learning have also added considerable value by generating automatic reports and metrics on resource use based on real-time data, reducing time and effort. Through predictive modeling, AI helps improve the balance of resource distribution and anticipate periods of increased demand, enabling health institutions to plan ahead and ensure better care for the community.

1.2 Internet of Things:

the Internet of Things contributes to gathering public-health data, monitoring air quality, transporting sensitive goods, and tracking various processes, thereby strengthening the effectiveness of healthcare services. Integrating digital technologies helps speed up emergency response, provides physicians with more accurate data for better decisions, and gives patients easier, more varied options. Robotics also supports public health by monitoring patients, delivering medication and food, and efficiently managing medical inventory, which raises the quality of health services, facilitates access to them and helps limit the spread of disease.²²

2. The Role of Smart Cities in Sustaining the Health Service and Improving Its Quality

Smart cities are increasingly viewed not only as engines of innovation and economic growth, but also as the level at which solutions can be produced for many of the problems threatening residents' lives; city administrations accordingly develop suitable, innovative approaches to such varied issues by pursuing technology. Among all the facilities smart cities offer their citizens are smart health services and care, helping to keep citizens balanced and healthy in every respect. There is

¹⁹ Abdelrahmane Mohamed El Hassan Ahmed, *op. cit.*, pp. 142–143.

²⁰ Talal Abu-Ghazaleh, *op. cit.*, p ; 24.

²¹ **“Artificial Intelligence in Healthcare Is the Future,” Oracle Cloud Infrastructure, Saudi Arabia**, article published on October 6, 2021, accessed November 28, 2025, at 00:30, available at: <https://www.oracle.com/sa-ar/artificial-intelligence/what-is-ai/ai-in-healthcare>

²² Abdelrahmane Mohamed El Hassan Ahmed, *op. cit.* p. 144.

no doubt that the health sector has made progress over the past few years, but with population growth and urban lifestyles it has become important to increase the speed and efficiency of citizen care; yet the sector's challenges are escalating so rapidly that health-related concerns are expected to account for more than 15% of urban-sector attention in cities.²³

The term digital healthcare technology refers to a field that uses information and communication technology to improve healthcare and deliver medical services, including the use of mobile applications, online assistance, hotlines and other digital technologies to improve the delivery of healthcare and the prevention of non-communicable diseases. The pace of digital innovation accelerated during and after the COVID-19 pandemic, enabling remote care such as telemedicine, digital therapeutics (DTx) and remote patient monitoring (RPM). Patients can now use apps to complete rehabilitation for certain conditions (such as neurological conditions, or undergoing cognitive behavioral therapy), as well as to track diabetes and chronic respiratory and cardiovascular disease, among others. International investment in technology-based healthcare reached around two trillion dollars after 2010, a rapidly growing market whose applications are expanding day by day.

The pillars of healthcare technology in urban settings can be summarized as follows:

- **Digitization of medical records:** among the earliest roles technology played in the health sector was the digitization of medical records. This step has considerable benefits: easy access, and the ability to store complete patient information that might otherwise be forgotten over time — such as a patient's allergy to a particular medication — along with the ability to follow a patient's condition and response to treatment, in addition to providing a vast database that researchers can analyze and use to predict disease.
- **Big data and the cloud:** the term “cloud” refers to storing information in large, secured databases accessible from anywhere in the world and analyzed by digital-data specialists. This data offers major benefits, most importantly lowering healthcare costs, predicting epidemics, avoiding preventable deaths, improving quality of life, reducing waste in healthcare, and developing new drugs and treatments for numerous diseases and helping control them.
- **Telemedicine technology:** this takes the form of two-way digital (video) medical consultations, or the transfer of healthcare data from patient to remote supervising physician via internet-based health applications. Telemedicine can be used in many fields, including cardiovascular care; remote-monitoring technology can track vital signs, symptoms and even blood levels from a distance, and thanks to this technology robotic surgical operations can also be carried out, with physicians in some cases not needing to be physically present in the operating room with the patient during surgery.
- **Wearable technology:** the round-the-clock data these devices gather on patients helps physicians monitor and assess the health of wearers, in addition to devices that alert authorities to serious medical problems in patients and enable rapid intervention before their condition worsens.
- **3D printing:** 3D printing has come a long way since it emerged, particularly in its healthcare applications; this technology helps manufacture prosthetics, repair damaged tissue, and produce realistic skin for burn victims.
- **Virtual reality for treating mental illness:** mental health is one of the emerging areas of healthcare benefiting from smart technology, with virtual reality seen as a promising avenue for combating depression and post-traumatic stress disorder, particularly for Alzheimer's patients.
- **Communication:** this technology enables a form of communication between physicians and their patients; statistics indicate that in 2015 nearly 80% of physicians used mobile devices and medical apps to communicate with patients — very useful for following up with rural patients without requiring them to travel to the city, while also allowing access to patient records, writing prescriptions and scheduling appointments directly with the patient.
- **Strengthening clinical decision-making:** clinical decision-making is strengthened through the processing of large patient datasets, which in turn helps automation identify disease patterns, predict outcomes and tailor necessary treatments; the correct use of artificial intelligence can also lead to the rapid detection of life-threatening diseases. One example is a model developed to predict acute kidney injury (AKI) in patients 48 hours in advance, helping physicians determine treatment options to prevent deterioration in critical cases.
- **Reducing infant mortality:** developing cities are experiencing rising infant-mortality rates, which has made healthcare technology more responsive through data-driven interventions focused on maternal and child health, using infectious-disease surveillance systems to stay ahead of fast-spreading epidemics, particularly in rural

²³ In this regard, see:

- Abdelrahmane Mohamed El Hassan Ahmed, op. cit , p. 144;
- *Digital Healthcare: The Leadership of Sustainable Smart Cities*, article published on the website of the College of Education and Human Sciences, University of Karbala, Iraq, accessed November 27, 2025, at 22:45, available at: <https://cohe.uokerbala.edu.iq/wp/>
- Abdelrahmane Mohamed El Hassan Ahmed, op. cit p. 144

settings — achieved through health applications on mobile phones connected to servers at the ministries of health of those countries.

Accordingly, smart wristbands and smartwatches — which are set to transform patients' health mapping and treatment pathways — represent a means of delivering proactive healthcare, through the real-time data they can provide to health institutions regarding patients' health; this will provide better diagnostics for early detection and allow elderly patients to live more independently. Vital readings and health conditions can be monitored remotely, allowing health professionals to take action in emergencies. These devices can even detect people with particular conditions and help combat outbreaks when a virus spreads, enabling the identification of an infected person in contact with healthy others.²⁴

Axis Four: Analysis of the Saudi Arabian and Singaporean Experience in Smart Health and Lessons Learned

The Middle East is undergoing a rapid transformation toward innovation in digital health. From national strategies focused on artificial intelligence and health-data governance, to growing investment in cybersecurity and connected care, countries in the region are working to build health systems that are more integrated, resilient and responsive to their populations' needs.

Within this framework, we review the experience of Saudi Arabia as a leading model in addressing health-related issues, alongside the efforts made by Singapore in the field of smart health.

1. The Saudi Arabian Experience

Several Middle Eastern countries — including the UAE, Saudi Arabia and Qatar — are moving rapidly to implement ambitious national visions for strengthening digital transformation in the health sector, such as Saudi Vision 2030, the UAE's health strategy, and Egypt's digital-transformation plan. These efforts focus on developing healthcare systems and harnessing data to improve health planning and patient outcomes, amid an unprecedented rise in investment directed toward digital health.²⁵

Saudi Arabia's health sector is undergoing an unprecedented qualitative shift, driven by an ambitious national strategy that places the individual at the heart of its priorities. Digital transformation in Saudi health is no longer merely a technical option; it has become a fundamental pillar for achieving the objectives of Saudi Vision 2030, which aims to build a vibrant society, a thriving economy and an ambitious nation. This digital revolution seeks to fully restructure the healthcare system by adopting the latest technologies to enhance service quality, raise operational efficiency, and facilitate access to integrated, innovative healthcare for all members of society.

The scale of investment the Saudi government devotes to this vital sector reflects a deep recognition that the health of citizens and residents is the cornerstone of sustainable development. From this understanding, the transformation drive was launched to enable hospitals, health centers and regulatory bodies to use data and digital solutions for more accurate decision-making, proactive personalized care, and a seamless, connected health experience for beneficiaries.²⁶

Healthcare spending is a top priority for the Saudi government. According to a report published by Mashreq Bank and Frost & Sullivan, Saudi Arabia plans to invest USD 66.67 billion in health infrastructure and to raise private-sector participation from 40% currently to 65% by 2030, targeting the privatization of 290 hospitals and 2,300 primary healthcare centers, with average life expectancy in Saudi Arabia expected to rise from 76.4 to 81.8 years by 2050.²⁷

1.1.Strategic Pillars Supporting Digital Transformation in the Saudi Health Sector

Digital transformation in Saudi health does not rest on isolated initiatives or scattered technologies, but on an integrated strategic framework led by the Ministry of Health in cooperation with all relevant public- and private-sector bodies. Its most prominent pillars include:

- **Alignment with Saudi Vision 2030:** the health-sector transformation program is one of the Vision's main executive programs, aiming to restructure the sector into a comprehensive, effective, integrated health system based on the principle of value-based healthcare and ensuring the prevention of health risks.
- **Development of digital infrastructure:** the Kingdom has worked to establish an advanced digital infrastructure able to accommodate and secure the vast volume of health data, including high-speed communication networks, national cloud data centers, and interoperability platforms that ensure information is exchanged smoothly and securely among different service providers.
- **Investment in human capital:** the Kingdom recognizes that the success of digital transformation depends primarily on qualified personnel; intensive training and qualification programs have therefore been launched for health-sector workers to strengthen their digital skills and enable them to use new tools and systems efficiently.

²⁴Talal Abu-Ghazaleh, *op. cit.*, p. 14.

²⁵Hal Wolf, President and CEO of HIMSS, “Why Is the Middle East Drawing Attention?”, *The New Center for Digital Health*, article available at: <https://www.thearabhospital.com>, accessed November 28, 2025, at 00:10.

²⁶“**Digital Transformation in Saudi Healthcare: A Technological Revolution Shaping the Future of Healthcare in the Kingdom.**” RMG (Renad Al Majd Information Technology), article published on July 17, 2025, available at: <https://www.rmg-sa.com>, accessed November 28, 2025, at 00:15.

²⁷ Linda Boulaassel, “Arab Initiatives for Digital Transformation in the Healthcare Sector: Saudi Arabia and the United Arab Emirates as Models,” *Journal of Economics and Business*, Vol. 10, No. 1, April 2025, pp. 232–235.

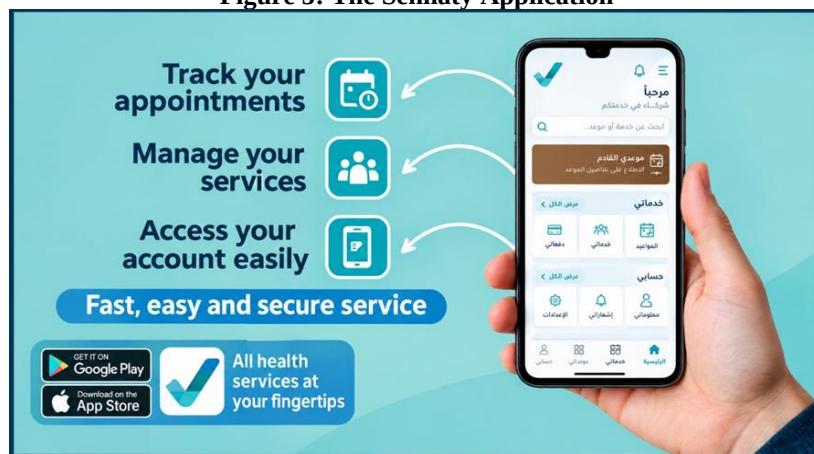
- **A supportive legislative and regulatory framework:** policies and legislation have been developed and updated to keep pace with the requirements of the digital age, with particular focus on data governance, ensuring the privacy of patient information, and setting strict cybersecurity standards to protect the health system from growing threats.

1.2.Key Digital-Health Initiatives and Applications in the Kingdom

National strategies have been translated into a set of concrete initiatives and applications that have made a real difference to the patient and provider experience. Digital transformation in Saudi health is today a reality lived by millions through innovative platforms, most notably:²⁸

- **The “Sehhaty” app:** the Ministry of Health's unified application, giving users access to health information and a number of health services provided by various bodies in Saudi Arabia's health sector. Sehhaty allows users to obtain audio and video consultations with healthcare specialists, book COVID-19 testing and vaccination, and receive immediate guidance on managing possible side effects.

Figure 5: The Sehhaty Application



Source: Saudi Ministry of Health website.

- **The Seha Virtual Hospital:** launched in 2022, the largest facility of its kind in the world, connecting more than 150 hospitals and offering more than 30 specialized health services and 73 sub-services, including neurology, cardiology, virtual lenses, and AI and robotics services, with a capacity of around 480,000 and more than 123,000 beneficiaries since its establishment.
- **The Unified Health Record (SHR):** one of the largest national projects, aimed at creating a unified digital health record for every individual in the Kingdom. It allows accredited healthcare providers immediate access to a patient's complete medical history, reducing repeated testing, preventing medical errors, and supporting well-informed treatment decisions.
- **The “Sheifa” platform:** a digital platform that facilitates access to health services such as booking appointments and medical follow-ups, which has served around 7,233 beneficiaries.
- **The “Mawid” service:** a centralized system enabling beneficiaries to easily book appointments at hospitals and health centers affiliated with the Ministry of Health, helping to organize patient flow and significantly reduce waiting times.
- **The “Wasfaty” e-prescription service:** a platform linking health facilities with community pharmacies, whereby prescriptions are sent electronically, ensuring accuracy in dispensing medication and sparing patients the burden of carrying paper prescriptions.
- **The “Family Doctor” service:** this service helps provide preventive and curative healthcare, increasing the role played by primary healthcare centers and their level of interaction with beneficiaries, which is reflected in individual and community health.
- **A healthy and sporting community:** the Kingdom has taken accelerated developmental steps to improve physical well-being and healthy lifestyles across all segments of society, contributing to greater sporting

²⁸ In this regard, see :

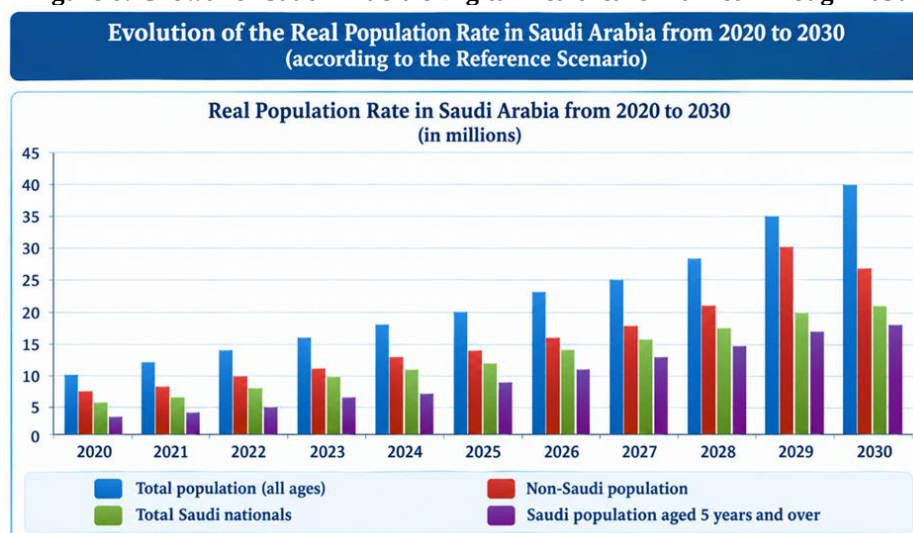
- **Abdullah Musa Ali Al-Shamrani et al.,** “The Role of the Sehathy Application in Developing Digital Health Services in the Kingdom of Saudi Arabia: An Analytical Study,” *Scientific Journal of Media Research and Communication Technology*, No. 18, 2025, p. 534.
- **Linda Boulaassel, op. cit.,** pp. 232–235.
- **“Digital Transformation in Saudi Healthcare: A Technological Revolution Shaping the Future of Healthcare in the Kingdom,”** op. cit.

awareness and a society characterized by physical-activity initiatives; an estimated 62.3% of adults engage in at least 15 minutes of physical activity.

- **Reliance on artificial intelligence and the Internet of Things:** one of the most important digital-transformation technologies for improving healthcare quality and strengthening service efficiency in smart cities. Among the most prominent uses of AI is analyzing medical images to detect potential diseases early, identifying suitable medications, predicting their effectiveness and improving their design and formulation, while the IoT enables the remote monitoring of patients in outlying areas and early surgical interventions, together with the use of robotics and similar technologies.

The following figure illustrates the evolution of the digital healthcare market in the Kingdom of Saudi Arabia up to 2030.

Figure 6: Growth of Saudi Arabia's Digital Healthcare Market Through 2030



Source: Linda Boulaassal, previously cited, p. 234.

The figure shows notable growth in the digital healthcare services provided by Saudi Arabia under its Smart Health 2030 program.

2. The Singaporean Experience in Smart Health

Singapore is one of the world's leading countries in relying on modern technology across various fields, which has made it the world's smartest city in sectors including education, health, transport and communications, among others. The city also uses artificial intelligence and cloud computing to analyze data and improve services; the Smart Nation initiative was launched in 2014 by the Prime Minister, and three years later it received government support of USD 1.73 billion, aimed at building a digital city based on innovation and technology to meet individuals' needs.²⁹

According to the PwC Cities of Resilience framework, the Singaporean government took decisive action to raise citizens' awareness of the impact of COVID-19, drawing on its strength in information technology and data analytics. The government runs a state-managed WhatsApp communication group for citizens, providing daily updates on confirmed cases, clarifications of circulating rumors, and government statements.

Singapore did not hesitate to make use of these capabilities from the very start of the pandemic, being among the first to activate digital surveillance and tracking systems. While Singapore takes pride in having one of the highest vaccination rates in the world — 80% of the population — its residents nonetheless remained subject to strict restrictions to counter new variants. Remote work became the reality for most of the population, easing congestion in public places and transport, while the capacity of tourist areas and commercial markets was limited, and gathering marshals were deployed throughout the city to ensure gatherings complied with safety standards, with heavy fines imposed on anyone who exceeded them. The public could also track crowd levels in shopping areas, stores and post offices using a dedicated app in order to avoid them.³⁰

All of this made Singapore's leading experience one of the most important examples in comprehensive healthcare, providing high-quality, reasonably priced — if not low-cost — care that ensures sustainability. This is not to claim that everything that works for this country can be applied elsewhere, since every country has its own particular circumstances; nonetheless, there are general characteristics that transcend borders.

Today Singapore ranks sixth in the world on key health indicators, ahead of countries such as the United States and other wealthy nations, despite spending, as a share of GDP, less than half of what these countries spend on health.

²⁹ Hamida Bouamoucha, "Singapore's Experience in Establishing Smart Cities," *Journal of Economic Research*, Vol. 17, No. 2, University of Blida 2, 2022, p. 188.

³⁰ Souad Haffaf, *op. cit.*, p. 242

The success story of the Singaporean experience began with the earliest seeds of the health system in the mid-1980s, when healthcare was treated as a national priority. A long-term strategic plan was then drawn up and implemented through a cross-ministerial, cross-institutional team that worked in close harmony, away from narrow calculations and the “silo culture” prevalent in many developing countries — noting that this culture of teamwork is not confined to the health sector but runs deep in Singaporean culture more broadly, with the permanent secretaries of relevant ministries meeting regularly to follow up on various strategies and remove obstacles to their implementation.

It was essential, at the start of the project, to achieve a “quick win” that would help win citizens over and earn their support and trust; primary healthcare proved the ideal arena for this achievement, since it could deliver tangible health gains at modest cost. This was accomplished by bringing health services close to everyone and within their reach, through clinics equipped with the basic means of diagnosis, treatment, prevention and education — clinics that formed the initial nucleus for establishing comprehensive health centers, which in turn eased the pressure on hospitals, freeing the latter to focus on the role for which they were established and which lies at the core of their specialization, leading to a tangible reduction in treatment costs.³¹

2.1. Achievements in the Field of Smart Health

Singapore did not become a global medical hub by chance, but through a carefully studied, precisely planned ascent to the top, built on solid foundations that inspire immediate confidence. Singapore's healthcare system is consistently ranked among global leaders such as Sweden and Switzerland, and is regularly rated as one of the best health systems in the world. Many of its highly skilled physicians trained at prestigious universities in the United States, the United Kingdom and Australia. The Ministry of Health oversees the system with an unwavering commitment to quality. Its leading hospitals include Gleneagles Hospital, Mount Elizabeth Hospital, Parkway East Hospital and Farrer Park Hospital, all of which have received international accreditation from bodies such as the Joint Commission International (JCI), ensuring they meet the highest global standards for patient safety and care.³²

2.1.1. Advanced Technology and Innovation

Entering Singapore feels like stepping into the future: patients have access to the latest medical technologies available on the market, including advanced genomic testing for personalized cancer-treatment plans, and robot-assisted surgical systems such as the Da Vinci Xi, which delivers unmatched precision in complex procedures. Thanks to this commitment to innovation, patients can now access treatments and tests that may not be widely available in their home countries, along with the latest medical technologies, including advanced genomic testing for personalized care.

2.1.2. A Multicultural, English-Speaking Haven

Language is among the most significant barriers to medical travel; in Singapore, this barrier is virtually nonexistent. English is one of the country's four official languages and the primary language of business and medicine. From surgeons and nurses to hotel receptionists and taxi drivers, communication is remarkably easy. Patients from around the world feel welcomed and understood, thanks to a deep respect for different customs, dietary needs and cultural sensitivities that pervades this global fabric.

2.1.3. Relentless Safety and Hygiene

Singapore is known as one of the safest and cleanest cities in the world, and this extends well beyond its clean streets to its healthcare facilities. Hospital-acquired infection rates are among the lowest in the world, thanks to strict hygiene protocols. For a patient with a weakened immune system, or one recovering from surgery, this ultra-clean environment is not a luxury but an essential element of safe recovery.

2.1.4. A Hub for Specialized, Complex Care

While Singapore excels across all medical fields, it has built a particularly strong reputation in several high-demand specialties:

- **Oncology:** providing advanced treatments such as proton therapy, immunotherapy and targeted therapies at comprehensive cancer centers.
- **Cardiology and cardiothoracic surgery:** a leader in minimally invasive heart surgery, transcatheter aortic valve implantation (TAVI), and complex bypass procedures.
- **Orthopedics and sports medicine:** pioneers in joint replacement (hip, knee and shoulder), spinal surgery, and cartilage restoration using advanced biomaterials and robotic assistance.
- **Neurology and neurosurgery:** expertise in treating brain tumors, cerebral aneurysms and spinal disorders using advanced surgical imaging and neuronavigation.
- **Women's health and fertility:** exceptional care in obstetrics, gynecology, oncology and IVF programs known for high success rates.

³¹ Asim Mansour, “Lessons from Singapore’s Experience in Healthcare,” 2025, available at: <https://asemmansour.io/>

³² “Medical Tourism in Singapore: Where World-Class Healing Meets a Futuristic Oasis,” article published on September 29, 2025, available at: <https://medigence.com/ar/blog/medical-tourism-in-singapore-where-world-class-healing-meets-a-futuristic-oasis/>, accessed December 1, 2025, at 22:10.

Singapore is itself a therapeutic environment: its unique blend of modern architecture, lush green spaces and tranquil water features creates a calming atmosphere ideal for recovery, alongside the therapeutic health services that make it a destination for medical tourism, foremost among them:

- **World-class accommodation:** from luxury hotels to fully equipped medical-recovery suites, ensuring a comfortable, suitable stay.
- **A food paradise for health:** Singapore's culinary scene is legendary, offering everything from Michelin-starred restaurants to hawker centers with countless healthy, delicious and clean food options to aid recovery.
- **Gentle rehabilitation:** recovery can include quiet walks through Singapore's Botanic Gardens (a UNESCO World Heritage site), a peaceful stroll along the Marina Bay waterfront, or a gentle ride on the Singapore Flyer. This is not mere tourism, but active, mindful recovery in a stimulating yet calming environment.

Conclusion

In conclusion, it is clear that automating the healthcare sector through reliance on artificial-intelligence technologies represents a fundamental pillar for the future of digital medicine, given its considerable potential to improve the quality of services and increase their efficiency and accuracy. While this transformation offers innovative solutions capable of strengthening disease surveillance, controlling epidemics and improving patient well-being, it nonetheless remains fraught with a range of technical, regulatory and ethical challenges, particularly regarding data management and governance, interoperability, the shortage of skilled personnel, and the growing risks associated with cybersecurity.

There is a pressing need in the Gulf states, and the Arab region more broadly, to accelerate the pace of digital transformation in order to address the mounting pressures on health systems resulting from population aging, the rise of chronic disease and growing patient expectations. This reality also calls for strengthening international cooperation and building partnerships with leading organizations such as HIMSS, to support the exchange of expertise and to develop the capabilities and leadership needed to manage digital transformation efficiently and with awareness.

International experience confirms that the responsible use of artificial intelligence — grounded in effective governance, precise regulation and equitable access to care — represents a promising path capable of bringing about a qualitative shift in the performance, resilience and effectiveness of health systems. Strengthening cybersecurity is likewise an indispensable pillar for protecting data and ensuring the continuity of services, given the growing wave of cyberattacks targeting the health sector.

In light of the above, the future of healthcare in the region depends on the ability to harness artificial intelligence in a balanced and responsible manner — one that enables the building of a health system that is more sustainable, equitable and innovative, that places the patient at the heart of its priorities, and that paves the way for a new stage of advanced smart health services.

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