Digital Healthcare Innovation in Morocco Leveraging Telemedicine, Internet of Medical Things, and Artificial Intelligence for Chronic Disease Management

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Article

Digital Healthcare Innovation in Morocco Leveraging Telemedicine, Internet of Medical Things, and Artificial Intelligence for Chronic Disease Management

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Abstract

Morocco, facing a growing prevalence of chronic diseases such as diabetes, hypertension, and cardiovascular diseases, must overcome significant challenges to modernize its healthcare system. In this context, the integration of digital technologies, including telemedicine, the Internet of Medical Things (IoMT), Artificial Intelligence (AI), and healthcare system interoperability, represents a promising solution to improve the management of chronic diseases. This article examines how these technologies can be utilized to transform the Moroccan healthcare system into a more accessible, efficient, and patient-focused model of care. The paper reviews recent pilot projects and initiatives, focusing on infrastructure development, remote monitoring, AI and IoMT integration, public health campaigns, and national health programs aimed at improving access to treatment. Building on these observations, the paper explores the potential of an integrated digital health system for managing chronic diseases and proposes a national integrated care architecture that connects Morocco's public and private healthcare providers. These insights highlight the significance of digital health in Morocco and provide a framework for improved, more patient-centered, and more efficient advanced healthcare. Future perspectives focus on developing an adapted digital transformation approach to further enhance chronic disease management.

Keywords: digital healthcare model; telemedicine; internet of medical things (IoMT); artificial intelligence (AI); interoperability gap; chronic disease management; Morocco

1. Introduction

Chronic diseases (CD) represent a growing threat to global public health, particularly in low- and middle-income countries. According to the World Health Organization (WHO), these medical conditions are responsible for over 70% of deaths worldwide, an increase which is caused by aging populations, physical inactivity, fast urbanization, and lifestyle changes. (1) (2).

Non-communicable diseases (NCDs), also known as chronic diseases, are the leading cause of death in Morocco, accounting for 85% of total mortality and a premature mortality rate of 24% among individuals aged 30 to 70, primarily due to cardiovascular diseases, cancer, diabetes, and chronic respiratory illnesses (3).

Globally, the prevalence of chronic illnesses is rising, putting enormous strain on healthcare systems, especially in emerging economies like Morocco. What innovative solutions to these expanding challenges may digital health technologies provide? How could the integration of telemedicine, the Internet of Medical Things (IoMT), artificial intelligence (AI), and interoperability enhance the management of chronic diseases and increase diagnostic accuracy? (4) (5) This study

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adopts a descriptive review and conceptual approach to explore the potential of digital health technologies for chronic disease management within the Moroccan healthcare context. This article attempts to give a thorough overview of the Moroccan healthcare sector in relation to chronic disease management, examine the potential and implementation of digital health technologies, and highlight key pilot projects and national initiatives already underway. Finally, it proposes a strategic, digitally integrated care model designed to enhance health outcomes and promote equity within the Moroccan health system.

2. Overview of the Moroccan Healthcare Context

2.1. Prevalence of Chronic Diseases

Chronic diseases are a major public health issue in Morocco, particularly as the population ages. The World Health Organization (WHO) states that a significant amount of the nation's health burden is caused by non-communicable diseases (NCDs) such diabetes, hypertension, and cardiovascular conditions. (1).

In Morocco, diabetes is among the most prevalent chronic conditions, contributing markedly to morbidity and healthcare burden. Hypertension is similarly widespread and remains a major determinant of cardiovascular complications. Together, cardiovascular diseases, diabetes, cancers, chronic respiratory disorders, and chronic kidney disease constitute a substantial share of premature mortality nationwide.

These diseases significantly strain the nation's healthcare system and economy in addition to affecting people's quality of life. (6).

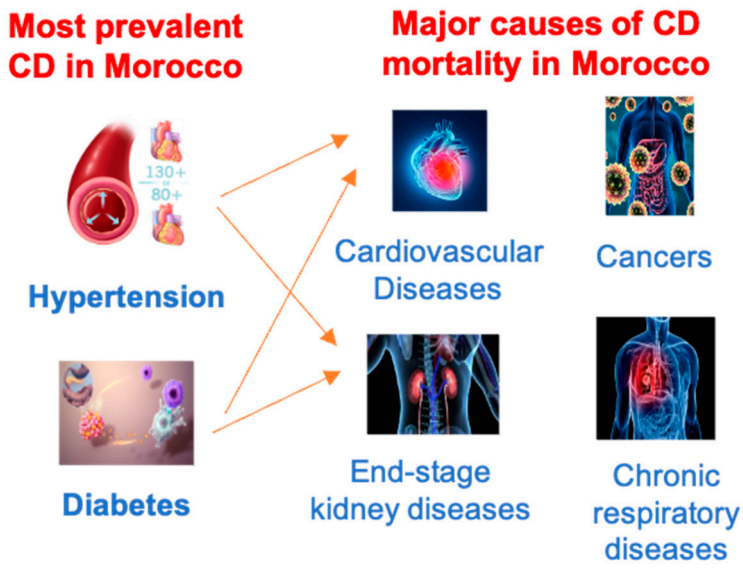

Figure 1. Prevalence of Chronic Diseases in Morocco.

2.1.1. Diabetes

Diabetes represents a growing global public health challenge, affecting 11.1% of adults, with more than 40% undiagnosed. By 2050, International Diabetes Federation (IDF) projections estimate a 46% increase, reaching 853 million adults (or 1 in 8). Type 2 diabetes accounts for more than 90% of cases, mainly due to urbanization, population aging, sedentary lifestyles, and rising obesity rates (7).

According to latest WHO estimates, the prevalence of diabetes in Morocco is continuously rising, affecting 12.4% of the adult population (8). The study by K. Rais et al. highlights a significant spatial interaction between this prevalence and the distribution of healthcare infrastructure, emphasizing the need to rethink territorial policies to enhance prevention and reduce inequalities in access to care (9).

However, patients' quality of life can be significantly enhanced and problems can be significantly decreased with the help of adequate care, early diagnosis, and preventive measures.

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2.1.2. Hypertension

Recent research reveals a troubling prevalence of hypertension in Morocco, affecting about 32.4% of the adult population (10). M.Aarrad, F.Laamiri, M.Hilal, et al. conducted a study in rural Settat and found that 53% of hypertensive patients had uncontrolled blood pressure, with factors such as male gender, low income, diabetes, poor medication adherence, and stress contributing to this lack of control (11). Additionally, the research by S.Belayachi, F.Z Boukhari, F.Essayagh, et al. in Marrakech reported a high prevalence of non-adherence to antihypertensive medication, with 82.4% of patients not adhering to their prescribed treatment (12).

In 2024, more than 1.2 million individuals with hypertension received care and follow-up services through Morocco's primary healthcare system, as reported by the Minister of Health and Social Protection, Amin Tahrawi (13).

These results highlight the urgent need to enhance diagnosis, improve treatment compliance, and implement effective management strategies for hypertension in Morocco.

2.1.3. Cardiovascular Diseases (CVD)

In Morocco, cardiovascular diseases, including heart disease and stroke, are the leading causes of mortality, accounting for approximately 38% of all deaths. Specifically, ischemic heart disease contributes to 31.0% and stroke to 22.5% of these fatalities (14) (15).

The findings of I.Talha, N.Elkhoudri, & A.Hilali, highlight the profound influence of inadequate dietary practices and insufficient physical activity on the advancement of cardiovascular diseases (16).

In fact, the research by R.Elyamani, A.Soulaymani, & H.Hami, found that the main risk factors in the population were tobacco smoking (45–50%), physical inactivity (21.1%), hypertension (25.3%), and depression (5.47%) (15).

According to the World Heart Federation, Morocco reported 134,920 deaths attributable to cardiovascular diseases in 2021, with age-standardized mortality and incidence rates of 463 and 235 per 100 000 population, respectively (17).

These statistics underscore the significant burden of cardiovascular diseases in Morocco and highlight the urgent need for comprehensive public health strategies focused on prevention, early detection, and effective management of cardiovascular conditions.

2.2. Challenges in Managing Chronic Diseases

The management of chronic diseases in Morocco is hindered by several factors:

2.2.1. Limited Healthcare Access in Rural Areas

A significant portion of the Moroccan population lives in rural areas where access to healthcare services is limited. There are few medical personnel and frequently inadequate funding for rural healthcare institutions. (5) (18).

2.2.2. Lack of Early Detection and Screening Programs

Diabetes and hypertension are examples of chronic illnesses that sometimes go misdiagnosed until they are quite advanced, leading to complications and increased medical costs. (19). Early screening and preventive measures are still underdeveloped in many parts of the country (20).

2.2.3. Health Education and Patient Awareness

Many patients struggle to adhere to treatment programs and lifestyle recommendations because they lack sufficient knowledge about their issues (21). Campaigns for public health education on managing and preventing chronic diseases are crucial.

2.2.4. Healthcare System Strain

Morocco's healthcare system is under pressure due to the country's growing population, limited medical resources, and rising incidence of chronic disorders. The system is further strained by

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managing the long-term requirements of patients with chronic illnesses, and clinics and hospitals are overcrowded. (22).

2.3. Approaches to Managing Chronic Diseases in Morocco

Chronic disease management in Morocco has traditionally relied on a curative, hospital-centered model focused on specialized care. National initiatives to prevent NCDs help this system, but it still confronts a number of obstacles, such as inconsistent patient follow-up, limited access to care in rural areas, and inadequate coordination across healthcare levels. Furthermore, community-based strategies are being developed that involve medical professionals in local monitoring, therapeutic patient education, and prevention (5). These initiatives aim to enhance patient autonomy and reduce the burden on hospital infrastructure. More recently, Morocco has begun a digital transformation of its healthcare system through the introduction of digital health technologies. These developments offer encouraging chances to enhance the effectiveness, customization, and continuity of care. (4).

Morocco's healthcare system has lately advanced significantly, and going forward, efforts will concentrate on incorporating international best practices and following global standards.

3. Digital Health Technologies

Digital health, also known as e-health or connected health, refers to the use of information and communication technologies to enhance the experience of both patients and healthcare professionals. It also empowers patients to take part in managing their own health by providing access to reliable medical information (23) (24).

In Morocco, managing chronic illnesses necessitates a comprehensive strategy that includes technology integration, health education, healthcare system improvements, and better access to care. While there are significant challenges, including limited healthcare access in rural areas and the growing burden of chronic diseases, there are also many opportunities for improving care. Telemedicine, IoT, AI, and more robust public health regulations could help Morocco manage CD more successfully and enhance the overall quality of life for affected individuals (25) (26) (27).

The following is an overview of how these technologies could be leveraged to improve CD management in Morocco.

3.1. Telemedicine

Telemedicine allows healthcare providers to offer remote consultations, diagnoses, and follow-up care to patients, especially in rural or underserved areas (5) (24).

Numerous studies have examined the effectiveness of telemedicine in managing chronic diseases, often focusing independently on the perspectives of patients and healthcare professionals (26).

In Morocco, telemedicine is being utilized to overcome geographical barriers, enabling patients in remote regions to receive timely medical advice without needing to travel long distances to healthcare facilities.

3.2. Artificial Intelligence (AI) in Healthcare

AI applications in healthcare, including diagnostic tools, predictive analytics, and personalized treatment plans.

Artificial Intelligence is used to analyze medical images, predict disease progression, and support clinical decision-making. (5) For example, AI can assist radiologists in diagnosing conditions from medical images such as X-rays or MRIs more accurately and efficiently (25) (28).

Ethical AI in Healthcare

Given the growing adoption of AI in Morocco's healthcare sector, future research should explore the ethical challenges related to patient data privacy (Law. 09-08 on the Protection of Individuals with Regard to the Processing of Personal Data), AI driven diagnostics, and equitable access to healthcare services (5) (29) (30).

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3.3. IoMT (Internet of Medical Things)

IoT devices such as wearable health trackers, connected medical devices, and remote monitoring tools.

IoMT enables the real-time collection of patient health data such as blood pressure, glucose levels, and heart rate. This data can be monitored remotely by healthcare providers, allowing for more personalized care and early intervention in case of complications (28) (27).

3.4. Interoperability Platforms

These platforms enable the seamless exchange of health data across different healthcare systems, improving coordination between hospitals, labs, pharmacies, and other healthcare providers (31).

Interoperability ensures that healthcare providers can access comprehensive patient data across various systems, improving coordination and continuity of care (23). This is crucial for improving healthcare delivery in Morocco, where healthcare services are often fragmented.

3.5. Healthcare IT Solutions

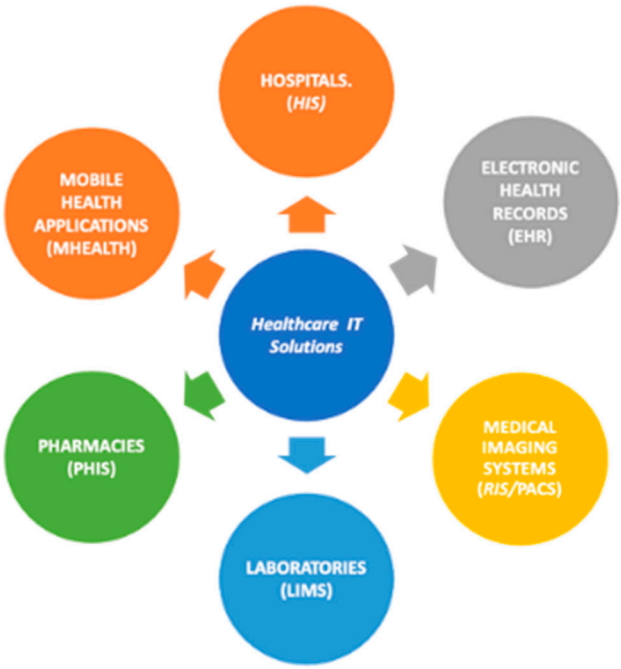

Figure 2. Healthcare IT Solutions in Morocco.

3.5.1. Hospital Information System (HIS)

A comprehensive digital system designed to manage the administrative, financial, and clinical aspects of healthcare institutions like hospitals and clinics.

Benefits: HIS helps streamline processes like patient registration, scheduling, billing, and managing medical records, improving both hospital operations and patient care. In Morocco, the HIS modernizes the health and social protection sector by centralizing medical, administrative, and financial data to enhance management and efficiency (32) (33).

3.5.2. Electronic Health Records (EHR)

Description: EHR systems store digital records of patients' medical history, diagnoses, treatments, and medications (34).

Benefits: EHRs improve the accessibility and security of patient records, making it easier for healthcare providers to access and update a patient's health information. In Morocco, EHR systems are gradually being implemented to improve the quality of care and reduce medical errors (18).

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3.5.3. Radiology Information System (RIS)

Description: A specialized system that manages medical imaging data, such as X-rays, CT scans, and MRIs.

Benefits: RIS allows for the efficient storage, retrieval, and sharing of radiological images. This system helps radiologists improve diagnosis and reduce the time needed for image access, especially in remote areas. In Morocco, the integration of Radiology Information Systems (RIS) and Picture Archiving and Communication Systems (PACS) has been pivotal in enhancing the efficiency and quality of radiological services (35).

3.5.4. Laboratory Information Management System (LIMS)

Description: A system used to manage and track laboratory processes, including sample testing, result recording, and reporting.

Benefits: LIMS increases the accuracy of lab results, reduces errors, and facilitates quicker access to test results for both patients and doctors. In Morocco, integrating Laboratory Information Management Systems with Quality Management Systems (QMS) in medical laboratories enhances the reliability and quality of laboratory results, ensuring more accurate diagnostics and improved overall laboratory performance (36).

3.5.5. Pharmacy Information Systems (PhIS)

Description: These systems manage inventory, prescriptions, and medication dispensing in pharmacies (37).

Benefits: Pharmacy information systems reduce medication errors, improve productivity in pharmacies, and guarantee that patients receive the right prescriptions. By improving inventories, prescriptions, and resource allocation, PhIS in Moroccan hospitals enhance pharmaceutical service management. Additionally, they facilitate strategic decision-making, increasing patient safety and healthcare efficiency. (38).

3.5.6. Mobile Health Applications (mHealth)

Description: Mobile applications that enable patients to track their health, schedule appointments, and access medical advice remotely (39).

Benefits: mHealth apps allow patients to monitor their health in real-time and communicate with healthcare providers, improving patient engagement and adherence to treatment plans. They are becoming more widely used in Morocco, which improves care coordination, increases access to healthcare services, and makes it easier to provide individualized health interventions (40).

3.6. Digital Transformation in Morocco

As part of the country's broader effort to modernize its healthcare system, a range of digital solutions is being implemented to address persistent challenges such as limited access to care, uneven resource distribution, and the growing burden of chronic diseases (34) (41).

As illustrated in Figure 3, Morocco is deploying telemedicine, the Internet of Medical Things (IoMT), artificial intelligence, interoperability platforms, and integrated healthcare IT systems (HIS, EHR, RIS, LIMS, etc.) to expand the country's health system's capacity, streamline clinical workflows, and enhance patient outcomes nationwide.

By integrating these technologies with strengthened governance frameworks and robust data security measures, Morocco aims to achieve a resilient and effective digital health transformation (42) (43).

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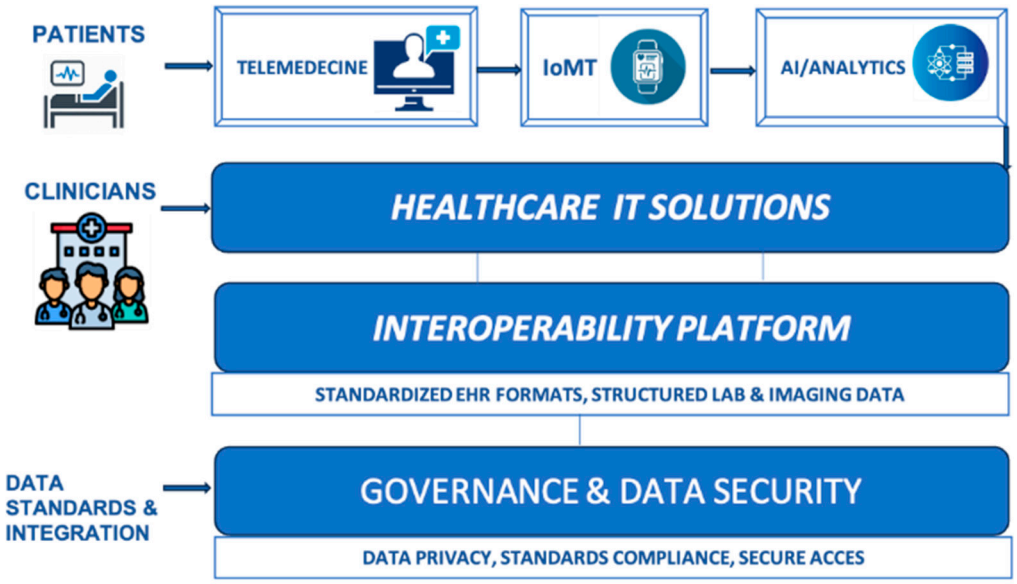

Figure 3. Digital Health transformation Ecosystem in Morocco.

However, sustained investment, strong infrastructure, and focused training initiatives for healthcare providers are necessary for the successful adoption of these advances.

4. Pilot Projects and Initiatives in Morocco

In recent years, Morocco has launched several pilot projects aimed at integrating digital health solutions, particularly telemedicine, into its healthcare system. These initiatives are part of a broader national strategy to improve healthcare access, especially in rural and underserved areas where specialist care remains limited (44).

In 2024, the Ministry of Health and Social Protection, the National Social Security Fund, and the Digital Development Agency signed an agreement to unify the Shared Medical Record and the Electronic Care Sheet through a common interface (45). This initiative aims to facilitate the integration of digital tools in healthcare facilities and support the digital transformation of the sector. It enables better access to health data, strengthens governance, and simplifies procedures for both patients and healthcare professionals.

4.1. Development of Healthcare Infrastructure: Progress in Hospital and Primary Care Facility Projects

The Minister of Health and Social Protection announced that 64 new university, regional, and provincial hospitals are currently under construction (46). These projects are part of a national strategy aimed at strengthening access to specialized care and ensuring the provision of high-quality medical services across the country (33).

At the same time, under the program for the construction, rehabilitation, and equipment of primary healthcare facilities, more than 1,000 health centers have already been rehabilitated. The objective is to reach a total of 1,439 centers in both urban and rural areas (46).

This program aims to consolidate basic healthcare coverage, improve accessibility and the quality of services, and reduce regional disparities in access to healthcare.

Improving primary healthcare services is key to the management of chronic diseases in Morocco (22) (47). Enhancing access to general practitioners and nurses, especially in rural areas, would enable early diagnosis, treatment, and ongoing management of chronic conditions.

In order to achieve a structural change of the healthcare sector, Morocco is dedicated to carrying out these significant projects in compliance with the highest international standards. The goal of this initiative is to create a high-performing, sustainable, and integrated healthcare system that can satisfy the needs of the general population while keeping up with international advancements and requirements in public health.

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4.2. Telemedicine and Remote Monitoring

The Ministry of Health and Social Protection has supported multiple telemedicine pilot programs in collaboration with public hospitals, universities, and international partners (48).

Telemedicine has the potential to significantly improve chronic disease management in Morocco, especially in remote and underserved regions (44). Healthcare professionals can currently monitor patients' illnesses in real-time because of the introduction of digital health technologies like wearable technology and smartphone apps. This reduces the need for physical visits and enables early intervention (49).

The Moroccan Society of Telemedicine, in collaboration with the Ministry of Health, launched a nationwide telemedicine pilot program in October 2018 (50). Through organized teleconsultation platforms, the program aimed to improve healthcare access in underserved areas by connecting rural health facilities with urban hospitals. During the initial deployment phase, several pilot sites—such as Anfgou, Imilchil, Zaouïat Ahensal, Ait Tamlil, Taliouine, and Talsint—were established to assess feasibility and operational effectiveness (51).

Furthermore, Morocco has adopted a legal framework for telemedicine since 2018, which has facilitated the development of regulated, secure, and ethically sound practices (10). However, the large-scale deployment of these solutions still faces challenges such as technological infrastructure, digital literacy, and interoperability among health information systems (48).

For example, telemedicine platforms for diabetes or hypertension management can help patients track their blood glucose levels or blood pressure and share this data with healthcare providers for personalized care and timely adjustments (52).

The nephrology department at Hassan II University Hospital in Fez uses telemedicine to remotely monitor 50 patients diagnosed with end-stage chronic kidney disease undergoing peritoneal dialysis, enabling real-time treatment adjustments through automated dialysis devices and a hospital-based monitoring station (50).

4.3. Integration of AI and IoMT in Healthcare

AI and IoMT are increasingly being integrated into the healthcare system in Morocco to assist in the monitoring and management of chronic diseases (53).

Artificial Intelligence (AI) can be used to analyze health data, detect early signs of complications, and suggest personalized treatment plans.

In Morocco, Artificial Intelligence (AI) is progressively applied in hospitals, and research centers for diagnostics, data management, epidemiological prediction, telemedicine, and hospital administration. AI enhances diagnostic accuracy, especially in medical imaging, and supports predictive medicine through big data analysis. In underserved areas, telemedicine and remote monitoring contribute to the reduction of healthcare inequities. Active engagement of hospitals, universities, start-ups, and the private sector in pilot projects demonstrates the progressive integration of AI into practical healthcare applications across the country (54) (5).

By enabling continuous patient monitoring, advanced data analysis, and greater diagnostic capabilities, the IoMT is revolutionizing healthcare and eventually improving clinical results. (55). IoT devices like smart glucose meters, wearable heart rate monitors, and connected blood pressure sensors enable continuous monitoring of chronic conditions, allowing healthcare providers to intervene before complications arise.

In Morocco, IoMT is emerging as a transformative tool in healthcare, linking connected medical devices, sensors, and telemedicine platforms to improve patient care. National programs also aim to expand e-health services, connecting rural health centers to urban hospitals (50).

4.4. Health Education and Public Awareness Campaigns

Public health campaigns are essential for raising awareness about the importance of preventing and managing chronic diseases.

The Ministry of health carries out multiple national and digital communication campaigns each year to raise awareness on priority health issues, using diverse media such as brochures, videos, live

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sessions, and social platforms. These initiatives include campaigns heart attacks, cancer screening, chronic diseases and celebrations of major World Health Days (33).

Educating the public about healthy lifestyles, the risks of smoking, unhealthy eating, and the importance of regular physical activity can help reduce the incidence of chronic diseases (56).

Programs that teach patients to manage their conditions, adhere to prescribed treatments, and adopt healthy lifestyle habits can greatly improve long-term health outcomes, especially by helping prevent and control chronic diseases such as hypertension (57).

4.5. National Health Programs and Policy Development

The Moroccan government, guided by royal directives, has launched a comprehensive reform of its national health system through Framework Law 06.22. This reform is essential to support the generalization of social protection and to address long-standing challenges in the health sector (22) (58).

The law is built upon four strategic pillars:

- Enhancing governance and oversight across all levels of the health system
- Investing in and incentivizing human resources through sector-specific reforms and improved working conditions
- Upgrading healthcare services to ensure quality and equitable access nationwide
- Digitizing the health system by developing an integrated information platform for efficient data management.

These efforts aim to promote social equity, improve public health outcomes, and support sustainable development.

4.6. Improved Access to Medications and Treatment

Ensuring that patients have access to affordable and essential medications is vital for effective chronic disease management. Morocco has made efforts to subsidize the cost of medications for chronic conditions, making them more affordable for patients, especially in low-income communities (59) (60).

Morocco is strengthening its pharmaceutical sovereignty through an ambitious national policy, the modernization of regulatory governance, and the assurance of quality, accessibility, and safety of medicines and healthcare products. In order to ensure the nation's healthcare needs, these steps are accompanied by initiatives to combat illicit trade, improve quality control, and digitize procedures. (61) (62).

4.7. Significance of Digital Health Initiatives in Morocco

These early initiatives underline the growing interest and commitment of Moroccan authorities to explore innovative models of care. Telemedicine, supported by artificial intelligence and the Internet of Medical Things, has the potential to significantly transform chronic disease management and contribute to a more resilient and equitable healthcare system (63).

Timely and efficient therapeutic interventions are made possible via telemedicine, which enables the remote transfer of health data via connected equipment. It facilitates individualized patient monitoring, reduces healthcare access inequities, cuts down on waiting times, improves the general standard of care, and increases efficiency by saving patients' time and money (64).

In Morocco, the development of AI and IoT is seen as a major factor in eliminating health disparities, digitizing healthcare services, and increasing access to healthcare, especially in remote and rural regions (65) (42). However, several challenges remain, including infrastructure limitations (connectivity, 5G deployment), the need for trained professionals (developers and clinicians skilled in digital tools), regulatory frameworks, and data protection. Multiple studies and reports highlight these factors as critical conditions for the successful implementation of such initiatives (66).

Despite existing challenges, these pilot experiences demonstrate both the feasibility and the growing interest in leveraging digital health technologies to improve healthcare delivery in Morocco.

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Continued investment in healthcare infrastructure and public health education will be crucial to addressing these issues and reducing the long-term impact of chronic diseases on the Moroccan population.

4.8. The New Reform of Morocco's Healthcare System

On 15 June 2023, the World Bank approved a $450 million loan to support Morocco's comprehensive health sector reform, with the objective of strengthening the quality, efficiency, and equity of public healthcare services, while reinforcing the longstanding collaboration between Morocco and the Bank and aligning with ongoing initiatives to expand social protection (67).

The reform of Morocco's healthcare system introduces structural changes that directly strengthen the monitoring and long-term management of chronic diseases. Central to this reform is the creation of Territorial Health Groups (THGs) under Law 08.22, which unify Primary HealthCare Centers (PHCCs / Établissements de soins de santé primaire), Regional Hospital (RH / Hôpital Régional), and University Hospital (UH/ CHU – Centre Hospitalier Universitaire) within each region (68). By guaranteeing that patients with chronic diseases (such as those with diabetes, hypertension, or cardiovascular disorders) benefit from standardized protocols, expedited referrals, and shared follow-up pathways across all levels of the health system, this coordinated framework facilitates continuity of care.

In addition, the reform places a high priority on equitable access to chronic care, encouraging public-private cooperation and a balanced territorial distribution of services. By taking these steps, inequalities in access to imaging, laboratory monitoring, routine check-ups, specialized consultations, and treatment education are minimized (69).

In order to enhance access, patient management, and diagnostic efficiency, Morocco is putting into practice concrete digital health initiatives, such as telemedicine for remote areas, chronic disease monitoring platforms, and AI-assisted diagnostic tools. (70). These initiatives also serve as a strategic lever to enhance care quality and system governance, though their impact is limited by infrastructure gaps, insufficient professional training, and an incomplete regulatory framework (71).

According to Chapter VIII of Framework Law 06.22, digitizing Morocco's healthcare system means establishing a shared medical record (Article 29) to identify, track, and assess each patient's care pathway in complete compliance with data protection laws, as well as implementing an integrated national health information system to collect, analyze, and monitor data from all public and private healthcare facilities (Article 28) (69).

Table 1 demonstrates that, despite Morocco's growing number of digital health initiatives, most of them are still pilot-based and insufficiently evaluated. Feasibility and access improvements are frequently reported, but standardized clinical, economic, and system-level findings are mainly inadequate, limiting scalability and evidence-based implementation into standard care.

Table 1. Overview of Digital Health Pilot Projects and Initiatives in Morocco.

Initiative	Year	Scope	Target Population	Technologies	Main Outcomes	Key Limitations
National Telemedicine Pilot Program	2018	Rural / underserved areas	Rural populations	Teleconsultation platforms	Improved access; feasibility demonstrated	No published clinical or economic outcomes
Telemonitoring of Peritoneal Dialysis Patients (CHU Fez)	~2019–2020	Regional	50 CKD patients	Automated dialysis devices; telemonitoring system	Reduced hospital visits; real-time monitoring	Small sample; no long-term or cost-effectiveness data
Unified Shared Medical Record & Electronic Care Sheet	2024	National	Patients and healthcare providers	Interoperable digital health records	Improved data access and governance	Adoption rate and interoperability performance not reported

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AI Applications in Healthcare	Ongoing	National	Patients and clinicians	AI for imaging, data analysis, prediction	Enhanced diagnostic and decision support	Fragmented pilots; lack of standardized evaluation
IoMT-Based Remote Monitoring Initiatives	Ongoing	National (incl. rural areas)	Chronic disease patients	Connected medical devices; sensors	Continuous monitoring; early intervention potential	Connectivity, data security, and regulatory challenges
Primary Healthcare Facility Rehabilitation Program	Ongoing	National	General and chronic disease populations	Upgraded primary care infrastructure	Improved accessibility to basic care	Impact on chronic disease outcomes not assessed
National Health Awareness & Digital Education Campaigns	Ongoing	National	General population	Digital media; educational platforms	Increased public awareness	Behavioral and long-term health impact not measured
National Health System Reform (Framework Law 06.22)	2022	National	Entire population	Governance reform, system digitization	Structural foundation for digital health	Implementation maturity indicators not yet available

As illustrated in Figure 4, digital health initiatives in Morocco have evolved over the past decade through successive phases, from early telemedicine pilots and regulatory frameworks to more recent efforts toward system-wide digitization and integration of AI and IoMT technologies.

The majority of programs are still in the pilot or early implementation stages, despite significant governmental commitment and increasing experimentation. The stated results are mostly restricted to feasibility and enhanced access, especially for telemedicine in underserved areas. The absence of standardized KPIs and publicly available outcome data hinders objective evaluation of clinical effectiveness, cost-efficiency, and long-term sustainability, while AI- and IoMT-based applications remain fragmented and poorly integrated into national health information systems. Overall, the timeline and thematic overview underscore the need to shift from pilot-driven efforts toward coordinated, interoperable, and systematically evaluated digital health programs for chronic disease management.

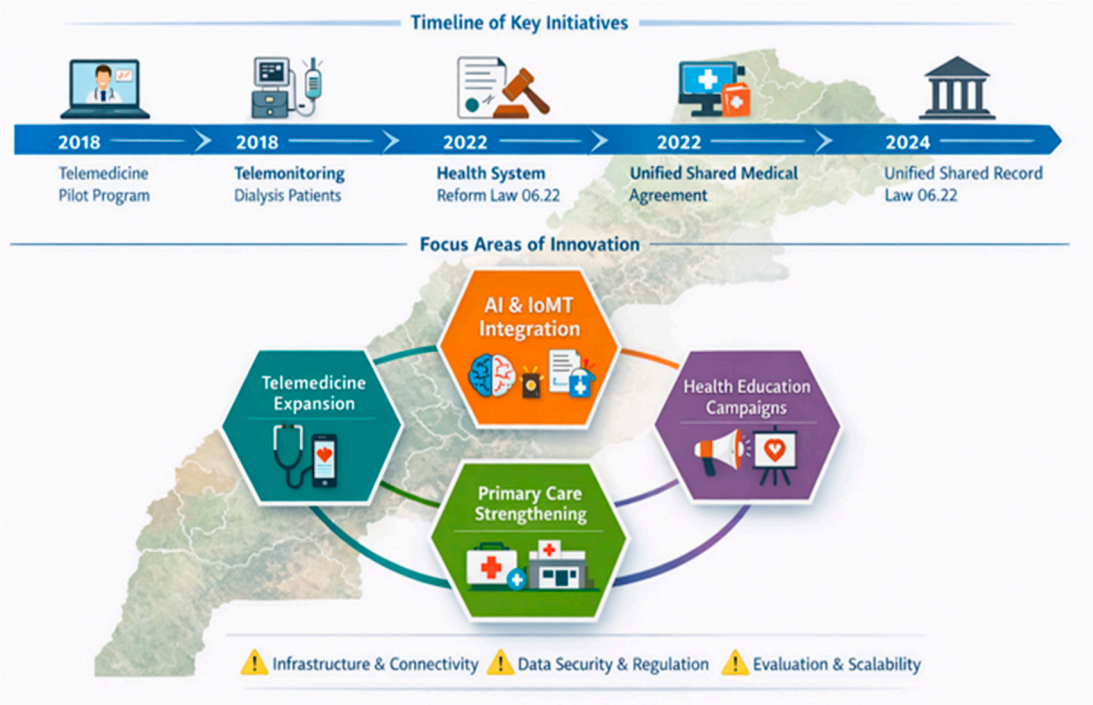

Figure 4. Key Digital Health and Telemedicine Initiatives in Morocco.

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5. Discussion: Toward an Integrated Digital Health Model for Enhanced Chronic Disease Management

The shift to digital health in Morocco has enormous potential to improve patient self-care and the management of chronic diseases. However, as shown in figure 5, this shift is constrained by heterogeneous, weakly interoperable legacy health information systems across the public sector (primary, regional, and university care levels). The effective implementation of telemedicine, IoMT platforms, and AI-driven clinical decision support is constrained by the structural interoperability gap caused by the absence of an integrated national architecture and standardized data sharing (55).

In addition to the public facilities, private clinics and hospitals contribute substantially to chronic care delivery in Morocco. However, their largely proprietary systems are rarely integrated with public HIS, highlighting the need for a nationwide interoperability framework encompassing both sectors.

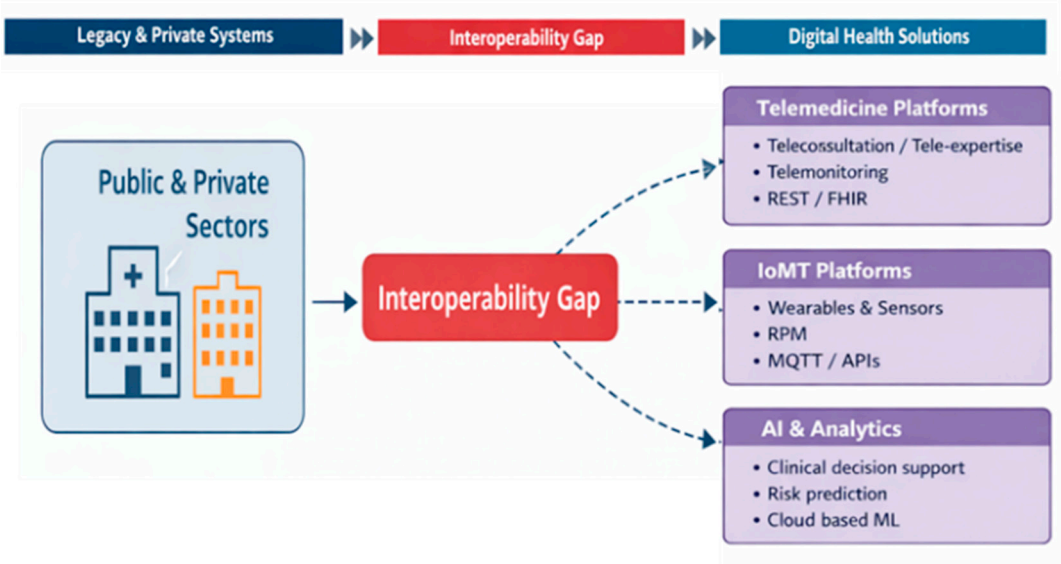

Figure 5. Interoperability Gaps in Morocco's Public and Private Health Systems.

5.1. Innovating Healthcare in Morocco: A Multidomain Digital Transformation Model

This study proposes an integrated digital health transformation framework aligned with Morocco's health system priorities, supported by national and international evidence (50) (72) (73). Telemedicine, mHealth applications, and the Internet of Medical Things (IoMT) have demonstrated strong potential to expand access to care in rural and underserved regions and to improve chronic disease management while reducing geographic and logistical barriers (48) (52). As shown in Figure 6, interoperable digital infrastructures, shared electronic medical records, and national e-health platforms form the system-level foundation for improving efficiency, continuity of care, and chronic disease surveillance (50). In line with WHO's people-centered digital health vision, patient-centered digital interventions, such as mobile health applications, improve engagement, self-management, and adherence to treatment (73). Artificial intelligence (AI) contributes to this ecosystem by enabling advanced clinical decision support and predictive analytics that support early detection and personalized treatment plans. Finally, sustained capacity building through health professional training and digital health literacy initiatives is consistently identified as a prerequisite for scalable and sustainable digital health adoption (54).

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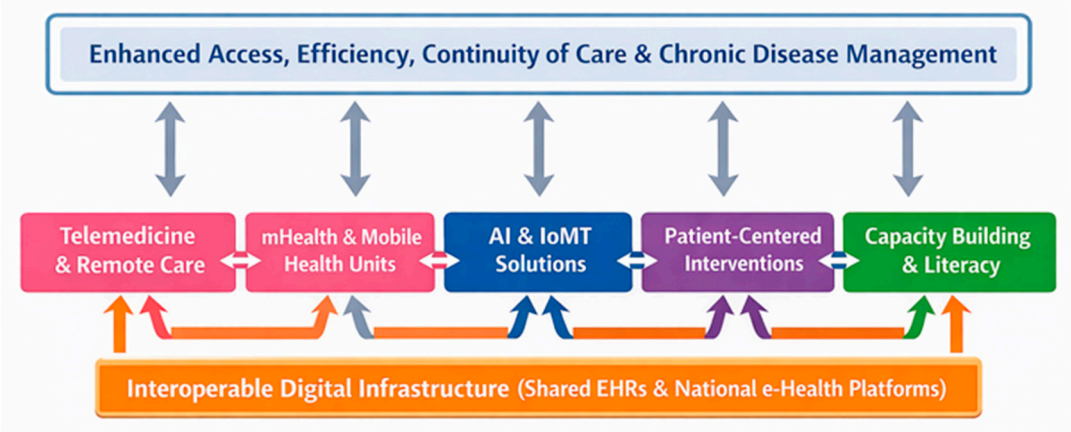

Figure 6. Multidomain Digital Transformation Model for Healthcare in Morocco.

5.2. Proposed Model for National Connected Care Architecture Integrating Public and Private Healthcare Entities in Morocco

The idea is to create an integrated, intelligent, and resilient healthcare network in which primary healthcare centers (PHCCs), regional hospitals (RH), and university hospitals (UH) collaborate in real time through IoMT, telemedicine, and AI services to improve access, quality, and equity of care across the entire country (74) (75).

1- Primary healthcare centers (PHCCs), serving as local hubs for both curative and preventive services, constitute the initial point of contact between individuals and the healthcare system, serving as the gateway to the broader healthcare network and playing a pivotal role in prevention, early detection, and the longitudinal management of chronic diseases (76). They refer patients requiring specialized or advanced care to RH or UH (77).

2- Regional Hospitals (RH) are public healthcare institutions positioned between primary healthcare centers and university hospitals within the national health system. It delivers both general and specialized medical services to the population of a given region, encompassing diagnostics, therapeutic interventions, surgical procedures, and routine clinical care (78).

3- University Hospitals (UH-CHU) : In the Moroccan health system, it fulfills the functions of a regional hospital while also carrying out five core missions: patient care, education and training, research, expertise and innovation, and public health. It serves as a reference center providing advanced diagnostic, therapeutic, and surgical services, while integrating healthcare delivery with the training of health professionals and the conduct of medical and biomedical research in collaboration with university faculties (79) (80).

The proposed National Connected Care Architecture in Morocco is a multi-layered digital health ecosystem designed to integrate public and private healthcare sectors, enhance patient-centered care, and leverage advanced digital technologies. The model connects patients, healthcare providers, and administrative bodies through interoperable digital infrastructure, including national Electronic Health Records (EHRs) and e-health platforms (34) (81).

As illustrated in Figure 7, telemedicine Within the proposed model plays a central role in enabling remote consultations, remote monitoring, and care coordination across both public and private healthcare entities (52) (82). The model supports continuity of care, reduces geographical barriers, and facilitates equitable access to specialist services, particularly for chronic disease management and underserved populations (50) (83).

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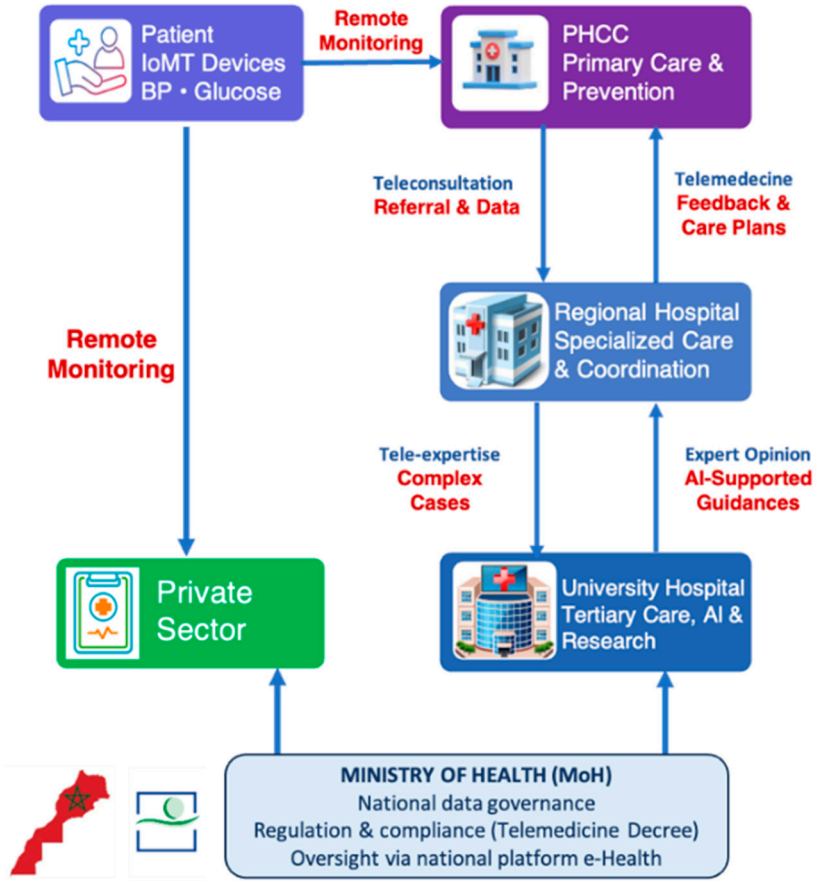

Figure 7. Proposed Model for National Connected Care Architecture in Morocco.

Table 2 summarizes the technical components across the digital health architecture layers. At the patient level, mobile apps and IoT devices communicate via BLE/Wi-Fi using JSON over REST APIs for secure and standardized data exchange, with digital consent and local alert mechanisms. (27) (84) PHCCs and private centers employ IoMT devices with MQTT and edge gateways, local encryption, and FHIR-lite APIs, enabling basic AI alerts. (85) Regional and private hospitals leverage Health Information Exchange (HIE), PACS, REST APIs, and ESB middleware for interoperable data exchange and workflow integration, supported by secure network protocols such as VPN, TLS 1.3, AES-256, SSO, and audit trails to protect sensitive health information. Industry integration frameworks demonstrate that standards-based APIs (e.g., REST with FHIR) and middleware enable scalable interoperability across disparate healthcare systems, while PACS ensures consistent medical imaging exchange. (86) University and private hospitals use hybrid cloud, GPUs, data lakes, and MLOps, with TLS 1.3, AES-256, SSO, and audit trails; HL7, FHIR and DICOM interoperability; and clinically validated AI for research and decision support. (84) (87) (88)

Table 2. Technical Requirements and Standards Across Digital Health Architecture Layers.

Level	Technologies / Protocols	Security & Identity	Interoperability	AI & Analytics
UH / Private Hospital	Hybrid Cloud, GPU, Data Lake, MLOps	TLS 1.3, AES-256, SSO, audit trail	HL7, FHIR, DICOM	Clinical AI validation, research
RH / Private Hospital	HIE, PACS, REST API, ESB	IPsec VPN, patient ID management	FHIR / DICOMweb	AI triage, workflow optimization
PHCC / Private Center	IoMT devices, MQTT, Edge gateway	Local encryption, offline buffer	FHIR-lite API	Basic AI (vital alerts)
Patient	Mobile apps, IoT BLE/ Wi-Fi	Digital consent	JSON / REST	Local alerts, prevention

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Table 3 details the core standards and protocols supporting the digital health architecture layers described in Table 1. For each functional domain, it specifies the standards enabling secure and interoperable medical data exchange, medical imaging, IoMT communication using MQTT and CoAP, digital identity management, and data governance across patient, primary care, hospital, and cloud-based layers of the national connected care system. Privacy and data protection are ensured through ISO/IEC 27001 and 27701 for information security and privacy management, General Data Protection Regulation (GDPR) EU 2016/679 for patient data protection, and Moroccan Law 09-08 regulating personal health information. (29) (71)

Table 3. Recommended Norms and Standards.

Domain	Standard	Description
Medical Data Exchange	HL7 FHIR R4	Standard format for exchanging clinical information
Medical Imaging	DICOM / DICOMweb	Universal format for medical images
IoMT Communication	MQTT / CoAP	Lightweight protocols for connected sensors
Security & Encryption	TLS 1.3 / AES-256	Secures data transmission and storage
Digital Identity	OpenID Connect / OAuth2	Unified authentication and authorization
Privacy	ISO/IEC 27001 / 27701	International standards for security and privacy management
Data Governance	GDPR / Moroccan Data Law 09-08	Protection of personal health data

5.3. Future Directions: Toward an Adapted Digital Transformation Approach for Chronic Disease Management

The Morocco-Adapted Digital Transformation Model for Chronic Disease Management (89) leverages a fully interconnected digital health ecosystem to improve monitoring, continuity of care, and clinical decision-making across public and private sectors. Figure 8 illustrates a streamlined digital transformation model for chronic disease management in Morocco, integrating patient technologies, health data systems, AI analytics, and public–private care within a continuous feedback loop. (71) (82)

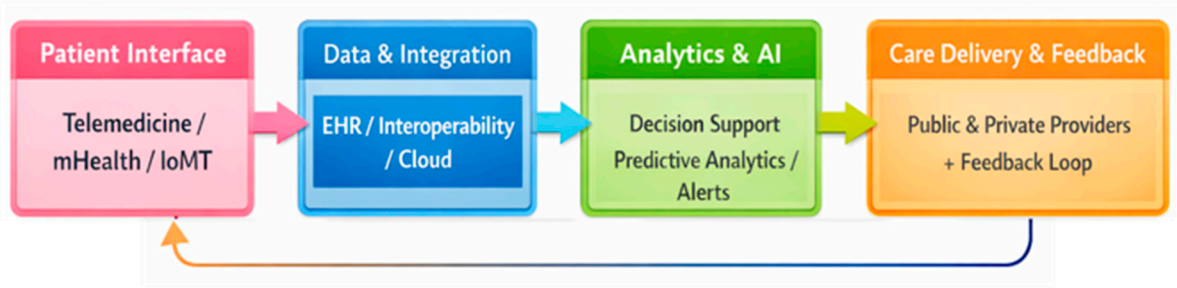

Figure 8. Adapted Digital Transformation Approach for Chronic Disease Management.

As illustrated in Figure 8, IoMT devices (e.g., BP cuffs, glucose monitors, and ECG sensors) capture real-time patient data and send it to a secure Edge Gateway, which performs on-site preprocessing, filtering, and basic analytics to minimize latency and bandwidth usage. Processed data is transmitted through an Ingestion & Messaging layer using MQTT, enabling reliable, lightweight, real-time communication between remote patients, facilities, and national platforms. The data is then standardized and integrated into an FHIR server, ensuring semantic interoperability and enabling seamless data exchange with digital services and AI modules. Hospital information systems and legacy applications communicate through HL7v2 messages, supporting orders, lab results, and

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admissions workflows. Finally, all validated data is consolidated into the national EHR, giving clinicians a longitudinal view of chronic disease patients, improving referrals, enhancing early detection, and supporting evidence-based care throughout Morocco's healthcare network. (85) (86)

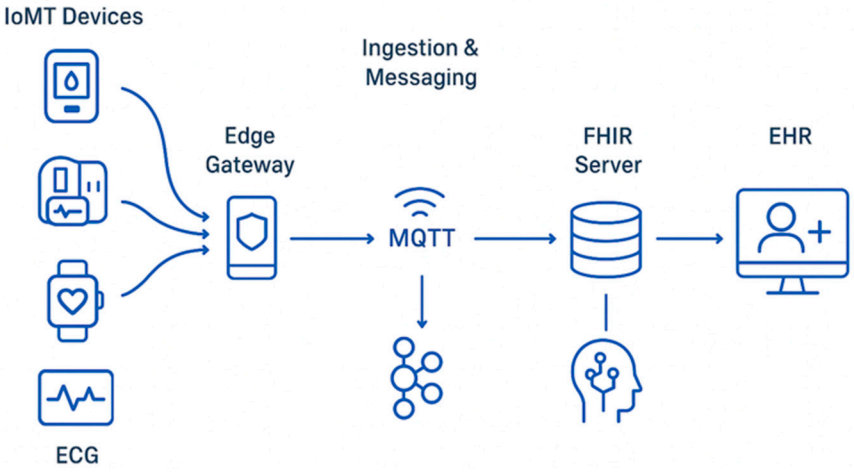

Figure 9. System Architecture for Digital Chronic Disease Management.

This system architecture for digital chronic disease management will serve as the foundation for our forthcoming work on IoMT-based health data analysis to support monitoring diagnosis and the deployment of augmented and personalized medicine for chronic care in Morocco. (90)

Building on this architecture, predictive models for chronic diseases can be developed by leveraging multimodal IoMT data, including physiological signals, clinical records, and longitudinal patient monitoring data. Securely integrated through interoperable standards and processed within cloud and edge analytics pipelines, machine learning and AI models enable early risk stratification, disease progression prediction, and personalized clinical decision support. In Morocco's public and private healthcare systems, this predictive capacity promotes proactive, enhanced, and customized chronic care, enabling prompt interventions and better results (91) (92)

6. Conclusions

In summary, Morocco could benefit from the integration of advanced technologies such as telemedicine, IoMT, AI, and interoperability to improve the management of chronic diseases. This would help create a more efficient, accessible, and integrated healthcare system while reducing costs associated with hospital care. The challenge lies in establishing the necessary infrastructure and training healthcare professionals to optimally use these technologies.

As demonstrated by the proposed model for national connected care architecture in Morocco, scalable digital architectures that integrate edge computing, standardized data exchange, and national EHR systems can effectively enable real-time monitoring, early disease detection, and personalized chronic disease management. Together, these advances highlight a promising future for digital health in Morocco, with the potential to enhance care coordination, strengthen clinical decision-making, and improve long-term health outcomes at the national level.

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Abbreviations

The following abbreviations are used in this manuscript:

IoMT	Internet of Medical Things
AI	Artificial Intelligence
WHO	World Health Organization
NCDs	Non-Communicable Diseases
CD	Chronic Diseases
IDF	International Diabetes Federation
CVD	Cardiovascular Diseases
MRI	Magnetic Resonance Imaging
IoT	Internet of Things
HIS	Hospital Information System
EHR	Electronic Health Records
RIS	Radiology Information System
CT scans	Computed Tomography scans
PACS	Picture Archiving and Communication Systems
LIMS	Laboratory Information Management System
QMS	Quality Management Systems
PhIS	Pharmacy Information Systems
mHealth	Mobile Health
THGs	Territorial Health Groups
PHCCs	Primary HealthCare Centers
RH	Regional Hospital
UH/ CHU	University Hospital/ Centre Hospitalier Universitaire
CKD	Chronic Kidney Disease
KPI	Key Performance Indicator
REST	Representational State Transfer
FHIR	Fast Healthcare Interoperability Resources
RPM	Remote patient monitoring
MQTT	Message Queuing Telemetry Transport
API	Application Programming Interface
ML	Machine Learning
BP	Blood Pressure
BLE	Bluetooth Low Energy
JSON	JavaScript Object Notation
HIE	Health Information Exchange
ESB	Enterprise Service Bus
VPN	Virtual Private Network
TLS	Transport Layer Security
AES	Advanced Encryption Standard
SSO	Single Sign-On
GPUs	Graphics Processing Unit
MLOps	Machine Learning Operations
HL7	Health Level Seven International
DICOM	Digital Imaging and Communications in Medicine
CoAP	Constrained Application Protocol
ISO	International Organization for Standardization

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IEC	International Electrotechnical Commission
GDPR	General Data Protection Regulation
ECG	Electrocardiogram

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