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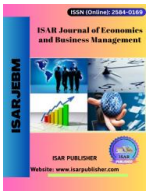


ISAR Journal of Economics and Business Management

Volume 3, Issue 5, 2025, Page: 8-16

Abbriviate Title- ISAR J Econ Bus Manag

ISSN *(Online)*- 2584-0169

https://isarpublisher.com/journal/isarjebm

Adoption of Digital Health Technologies in the Gulf: A Case Study of Saudi Arabia and the UAE

Puja Sunil Pawar[1*], Amal Alshehri[2], Deemah Alqubily[2], Sara Alruwayjih[2]

[1]Assistant Professor, Department of Economics, College of Business Administration, Princess Nourah Bint Abdulrahman University, P.O. box 84428, Riyadh 11671, Saudi Arabia.

[2]Lecturer, Department of Economics, College of Business Administration, Princess Nourah Bint Abdulrahman University, P.O. box 84428, Riyadh 11671, Saudi Arabia.

***Corresponding Author**

Puja Sunil Pawar

Assistant Professor, Department of Economics, College of Business Administration, Princess Nourah Bint Abdulrahman University, P.O. box 84428, Riyadh 11671, Saudi Arabia.

Article History

Received: 25.03.2025
Accepted: 20.04.2025
Published: 12.05.2025

Abstract: This study addresses the need to understand how digital healthcare transformation impacts economic growth and sustainability in Saudi Arabia and the UAE. It explores the factors driving this transformation and examines the outcomes, while identifying areas where further improvement and investment are required to ensure long-term benefits. Highlighting the link between digital healthcare transformation and sustainability by emphasizing how advancements in technology can lead to more efficient resource utilization, reduced carbon footprints, and improved healthcare delivery. By providing insights into the sustainable development of healthcare systems, the study contributes to building a framework for long-term economic and social growth in both nations.

Keywords: Digital Healthcare, Economic Growth, Sustainability, Saudi Arabia, United Arab Emirates, Healthcare Transformation.

Introduction

Businesses and governments worldwide are adopting digital technologies to improve efficiency and enhance product and service delivery, driving economies toward sustainable growth. Among all businesses, healthcare plays a critical role not only in supporting economic development but also in directly impacting the well-being of the population. As a result, many developed nations have been motivated to transform their healthcare systems through the adoption of advanced technologies that enhance patient experience, reduce costs, and improve accessibility. In the context of Saudi Arabia, the government has established its Vision 2030, a set of programs that consist of transformational roadmap to drive the economy and the society toward diversity and innovation. One of its core initiatives is the Health Sector Transformation Program which aims to improve access to healthcare, provide the sector with the latest technologies and expand growth opportunities. As part of this initiative, the government has made significant investments in Telemedicine, AI-powered medical tools, and innovation. Moreover, the government is forming Public-Private Participations (PPPs) to further develop ecosystem. Since the launch of the Ministry of Health's eHealth strategy in 2010 and through the establishment of Vision 2030, Saudi Arabia were able to provide its population with comprehensive and universal healthcare services. Saudi Arabia by it is Vision 2030 is not only working to reshape and sustain the healthcare systems but also is striving to achieve broader economic, social, and environmental goals that go along with the health sector transformation.

On the other hand, the UAE through Vision 2021 has pursued to become one of the countries with the highest living standards in the world. Where it sets the objective of providing healthy long lives for its population, focusing on healthcare accessibility as the main factor. The UAE's commitment to Artificial Intelligence and machine learning is the key element for efficient healthcare delivery. The government has been working on the accessibility of healthcare through providing free or low-cost service for citizens and residents. The UAE government is not only focusing on transforming the healthcare sector by the adoption of cutting-edge technologies, but it also commits to sustaining the improvements by forming a government-backed regulatory framework. Ultimately, both Saudi Arabia and UAE are working to boost sustainable economic growth, by setting objectives to enhance the efficiency and patient outcomes by adopting advanced digital technologies.

Various studies provide valuable insights into the digital healthcare advancements in Saudi Arabia and the UAE, but our focus is to offer a comparative analysis of both countries' healthcare

Cite this article:

Pawar, P. S., Alshehri, A., Alqubily, D., Alruwayjih, S., (2025). Adoption of Digital Health Technologies in the Gulf: A Case Study of Saudi Arabia and the UAE. *ISAR Journal of Economics and Business Management, 3*(5), 8-16.

infrastructures. Unlike the individual focuses on specific technologies or partnerships, our study aims to provide a holistic view of digital health solutions and their impact on sustainability. By evaluating the role of digital healthcare in optimizing resource use, and enhancing patient outcomes, our research contributes uniquely to the understanding of environmental and resource sustainability in the healthcare sector.

Saudi Arabia has undertaken a comprehensive transformation of its healthcare sector as part of its Vision 2030 initiative, a strategic framework aimed at reducing the country's dependence on oil, diversifying the economy, and enhancing public services. At the heart of this vision is the digitalization of the healthcare system, which seeks to improve accessibility, efficiency, and quality of services for a rapidly growing population. Central to this effort are the implementation of advanced technologies such as electronic health records (EHR), telemedicine, and artificial intelligence (AI) in diagnostics and patient management. Over the past two decades, the number of digital hospitals has surged, telemedicine consultations have grown exponentially, and the adoption of EHR systems has expanded across the nation. These advancements have significantly contributed to economic development by creating opportunities for innovation, streamlining healthcare processes, and fostering sustainable practices. Saudi Arabia's commitment to digital healthcare is not only reshaping the sector but is also positioning the nation as a global leader in health innovation, with a strong emphasis on integrating sustainability into its strategies.

The UAE, in parallel, has emerged as a leader in healthcare innovation, driven by its ambitious national agendas, such as UAE Vision 2021 and the National Artificial Intelligence Strategy. These frameworks highlight the integration of advanced technologies to create a resilient and efficient healthcare ecosystem. The UAE has strategically invested in telemedicine, AI-driven health applications, and state-of-the-art EHR systems to enhance patient care and accessibility. These efforts have resulted in the rapid establishment of digital hospitals, the widespread adoption of AI solutions, and a substantial increase in the use of telehealth platforms. The UAE's focus on innovation has not only improved healthcare delivery but has also strengthened its economic foundations by fostering a technology-driven approach to growth. By combining cutting-edge solutions with a strong commitment to sustainability, the UAE aims to build a healthcare system that not only meets the needs of its population but also addresses broader challenges such as resource efficiency and environmental impact. The UAE's progress reflects its dedication to remaining at the forefront of digital healthcare, setting a benchmark for other nations in the region.

Digital healthcare in both Saudi Arabia and the UAE has become a critical area of focus as these nations seek to balance economic growth with sustainability. The transition from traditional healthcare systems to digital solutions reflects a shift towards more efficient, accessible, and environmentally conscious healthcare delivery models. While Saudi Arabia focuses on expanding healthcare services to underserved rural areas and aligning its efforts with Vision 2030's sustainability objectives, the UAE emphasizes leveraging AI and advanced technologies to achieve regional leadership in healthcare innovation. Despite their differing approaches, both nations recognize the transformative potential of digital healthcare in addressing existing healthcare challenges and creating opportunities for sustainable economic growth.

AlOtaibi and AlSaab's study (2023) focuses on the digital transformation of Saudi Arabia's healthcare sector, driven by initiatives such as Vision 2030. They highlight the significant advancements made in telemedicine, electronic health records (EHR), and the establishment of digital platforms that connect multiple hospitals across the nation. The study emphasizes how these technologies have enhanced healthcare delivery and accessibility in Saudi Arabia (AlOtaibi & AlSaab, 2023). McKinsey & Company's report (2024) provides a comprehensive analysis of the growth opportunities in digital health within Saudi Arabia and the UAE. The report identifies key areas where digital health technologies can drive economic and healthcare improvements, including telehealth, AI diagnostics, and remote patient monitoring. The emphasis is on identifying and leveraging these opportunities for sustained growth in the healthcare sector (McKinsey & Company, 2024). The World Economic Forum's publication (2024) explores the broader landscape of digital innovation in Middle Eastern healthcare, with a specific focus on Saudi Arabia and the UAE. The study discusses the implementation of advanced technologies such as AI, machine learning, and telemedicine, and their impact on improving healthcare services and patient outcomes. It also addresses the challenges and future potential of digital healthcare in the region (World Economic Forum, 2024). Frost & Sullivan's analysis (2021) examines how strategic public-private partnerships are accelerating the adoption of telehealth in Saudi Arabia and the UAE. The study highlights the role of collaboration between government entities and private companies in expanding telehealth services, enhancing accessibility, and improving healthcare quality. It also addresses the regulatory and infrastructural challenges that need to be overcome (Frost & Sullivan, 2021).

Omnia Health Insights' article (2023) provides an in-depth look at the digital healthcare initiatives in Saudi Arabia, emphasizing the country's commitment to embracing advanced technologies for improved healthcare delivery. The study discusses the implementation of EHR systems, telemedicine platforms, and other digital health innovations that contribute to the nation's healthcare transformation (Omnia Health Insights, 2023). Khan et al., (2021) proved that the use of technological applications is a successful method in combating the COVID-19 pandemic in the Kingdom of Saudi Arabia. In the case of Al Madinah Al Munawwarah, after implementing the use of technologies, the most important of which is the Tawakkalna application, the number of active daily cases decreased by 61%. This indicates that the use of technology played a crucial and effective role in containing the pandemic in the Kingdom of Saudi Arabia. Wu and Raghupathi (2012) examined the correlation between Information and Communication Technology (ICTs) and public health delivery at the country level by using panel data analysis at the period from 2000 to 2008. In particular, the study examined the association of five ICT factors with five public health indicators: adolescent fertility rate, child immunization coverage, tuberculosis case detected, life expectancy, and adult mortality rate. The findings indicate that ICT accessibility has a strong association with effective delivery of public health. Wang. et al. (2023) explored the impact of digital transformation and green growth on health outcomes in Asian economies. Using the ARDL-PMG methodology, the findings indicate the significant and positive impact of digital transformation and green growth on health in both the long and short run. The study findings highlight the need for digital

transformation and green growth, especially in healthcare, to improve quality of life and life expectancy. Ubalaeze, et al. (2024) examined the challenges of digital transformation in Nigerian healthcare. The findings show that digital health initiatives have improved access to care, enhanced health education, and streamlined healthcare delivery. The study also makes several recommendations to overcome the challenges in digital health transformation in Nigeria. Lee, et al. (2024) contributed to the theoretical understanding of the impact of digital transformation on mental healthcare, identifies opportunities and challenges, and examines the role of AI chatbots in mental health symptom management in three countries using Structural equation modeling. The results support the relationship between digital transformation and the role of AI chatbots in mental health symptom management. Muafa, et al. (2024) evaluated current applications of artificial intelligence in the healthcare sector in Riyadh and their impact on digital transformation, and identifying opportunities and challenges for adopting artificial intelligence to improve healthcare services. The findings demonstrate how AI technologies can significantly transform the healthcare sector in Riyadh by contributing to early detection of diseases, providing personalized healthcare, improving the management of healthcare facilities, and enhancing scientific research in the field of health.

Shao, et al. (2022). clarified that Information and Communication Technologies factors can influence national health outcomes by using the fixed effect model of a set of 141 countries' panel data from 2012 to 2016 from World Bank and World Economic Forum, and ICT social impact can play an important partial mediating role between them. This research can help global policymakers drive the implementation of the Sustainable Development Goals (SDGs) and continue to improve the overall health at the national level. Onaran and Yurtkoru (2024) revealed how digital transformation and organizational resilience affect the healthcare industry in Turkey and the role of intellectual capital in this relationship. The study is based on a quantitative research method using a structured questionnaire for 204 healthcare employees from different types of hospitals. Regression analyses were performed, and Sobel test was performed for further analysis. The results indicated that digital transformation has a positive impact on the resilience of organizations in the healthcare sector, and that intellectual capital has a partial mediating effect in this relationship. Khafaji et al. (2022) assessed the knowledge and perception of artificial intelligence (AI) among radiology residents across Saudi Arabia and assess their interest in learning about AI by using an observational cross- sectional study carried out among radiology residents. The findings stated that 53% that AI will increase accuracy and reduce reporting workload, while 28% expected an increase in workload and 42% anticipated that job positions would decrease. The systematic review by Alqurashi et al. (2025) sought to analyze the effect of AI applications' diagnostic accuracy in Saudi Arabia's healthcare and identify the challenges and opportunities of using artificial intelligence to improve diagnostic accuracy. The results showed that the use of AI has been increasing in healthcare, and its use is enhancing the overall healthcare outcomes and is helpful in a wide variety of diseases and conditions, including chronic diseases.

Data and Methodology

This paper analyzes the influence of the intersection of digitalization in the healthcare industry and the economy of both Saudi Arabia and the United Arab Emirates. It emphasizes the number of digital hospitals (X1), the number of hospitals with Electronic Health Records (EHR) (X2), and the number of telemedicine consultations (X3) as independent variables. These variables are treated as the crucial building blocks of the digital transformation process in healthcare, from which it is hypothesized that growth in each country's Gross Domestic Product (GDP) (Y) is derived. Statistical analysis of the data was conducted using Excel spreadsheets, focusing on calculating averages for the variables considered in the study, including mean, median, mode, and correlation coefficients. The correlation analysis, performed using Excel's CORREL function, helps measure the strength and direction of the relationships between independent variables and GDP. This approach provides insights into how digital health initiatives correlate with economic growth.

Y = -458.35 + 5.29 X1 + 59.75 X2 - 1121.63 X3

Where:

Y = Gross Domestic Product (GDP) as an indicator of digital transformation in the economy

(dependent variable).

$X1$= Number of digital hospitals.

$X2$ = Number of hospitals using Electronic Health Records.

$X3$ = Number of uses of telemedicine services

This model is appropriate for analyzing the effects of digital transformation in healthcare on GDP, as it allows for measuring how each independent variable affects economic growth. The selected variables were based on their significance in assessing digital transformation in the healthcare sector and their potential correlation with enhanced efficiency and improved quality of healthcare services, which could lead to faster and more sustainable economic growth.

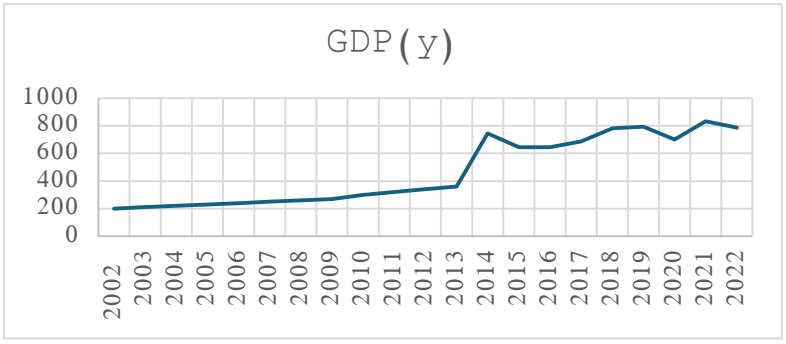
Results and Discussion

Table 1: For Saudi Arabia

	(y)	(x1)	(x2)	(x3)
AVERAGE	467.5238095	214.7619048	118.8095238	13523.80952
MEDIAN	340	200	90	2000
MODE	646	200	90	2000
CORREL	-	0.876954856	0.92766401	0.610328345

Source: Authors calculation

Graph 1: For Saudi Arabia



Source: Authors calculation

Saudi Arabia has witnessed significant changes in the digital healthcare sector over the past two decades. GDP increased from $200 billion in 2002 to $833 billion in 2021, with significant growth after 2014 as a result of Vision 2030. The number of digital hospitals increased from 100 in 2002 to 400 in 2022, with the pace of digitization accelerating after 2010. Additionally, the number of hospitals using electronic health records increased from 20 in 2002 to 300 in 2022, especially after 2015. Telemedicine consultations have seen significant growth from 100 consultations in 2002 to 100,000 in 2022, driven primarily by the repercussions of the COVID-19 pandemic.

The table 1 represents the mean, median, mode, and correlation coefficient between y which is GDP, and the variables which are (x1) number of Digital hospitals, (x2) number of hospitals using electronic health records, and (x3) number of telemedicine construction.

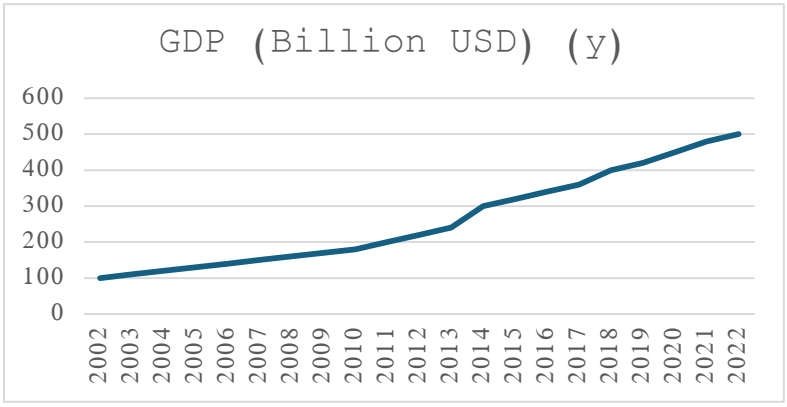
Mean: Displays the middle values for each column, the y value is 467.52381, the x1 value is 214.761905, the x2 value is 118.809524 and the x3 value is 13523.8095. Median: The midpoint in each row, splitting the info into two equal parts. The y point is 340, the x1 point is 200, the x2 is 90, and the x3 is 2000. Mode: The number that shows up most in each row. In the y row, it's 646. In x1 it's 200, in x2 it's 90, and in x3 it's 2000. CORREL (link grade): It maps the link of inputs (x1, x2, x3) with the y. Link grade y to (x1): 0.8769 (high, shows a firm bond). Link grade y to(x2): 0.9277 (very high, points to a very firm bond). Link grade y to (x3): 0.6103 (mid, points to a mid-bond). Correlation shows the relationship between variables y, and x2 appears to have the highest relationship with, followed by x1 and then x3. The data points to a rise in values over time. Links between the parts (x1, x2, x3) and the big part (y) show a good tie, most with x1 and x2. This info might point to a look at a thing, money-like or social, over time. The table data shows how digital change and money put into health and money base affect long-term goals in Saudi Arabia. The big rise in GDP and more digital health places like online hospitals and digital health files show growth that helps keep money and social growth going. This fits with the Saudi Vision 2030 plan to make life better and cut down on old resource use. The development of digital health services and Saudi Arabia's economic growth were found to be strongly positively correlated by the study. The number of digital hospitals, the use of electronic health records, and the frequency of telemedicine services all rose in tandem with the GDP. This suggests that making investments in the healthcare industry's digital infrastructure greatly enhances service quality and broadens its reach. However, sustained investment in cybersecurity and training and development is essential to ensuring sustainability.

Table 2: For UAE

	Y	X1	X2	X3
AVERAGE	261,428571	158,095238	71,1904762	3243,80952
MEDIAN	220	120	60	1000
MODE	220	120	60	1000
CORREL	-	0,98397273	0,9956796	0,82187508

Source: Authors calculation

Graph 2: UAE's



Source: Authors calculation

The United Arab Emirates (UAE) has witnessed significant growth in its digital healthcare sector over the past two decades. GDP increased from $100 billion in 2002 to $500 billion in 2022, with substantial growth following 2010 due to investments in the digital transformation of the healthcare industry.

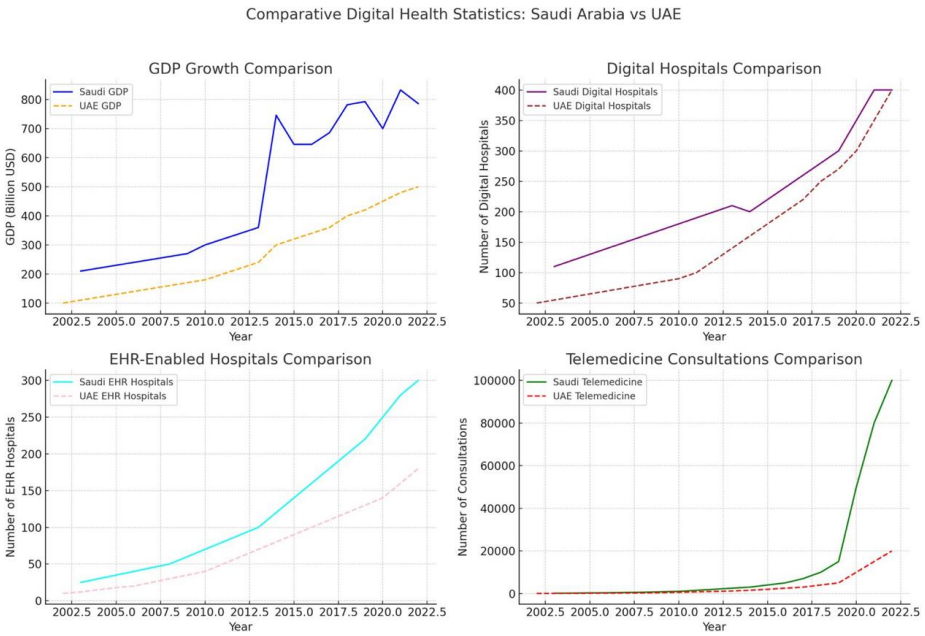
The number of digital hospitals rose from 50 in 2002 to 400 in 2022, while hospitals using Electronic Health Records (EHR) increased from 10 to 180 over the same period. Additionally, telemedicine consultations saw significant growth, increasing from 50 consultations in 2002 to 20,000 in 2022, largely driven by the adoption of advanced technologies and the response to the COVID-19 pandemic.

The table 2 outlines the mean, median, and mode for GDP (Y), the number of digital hospitals (X1), the number of hospitals using EHR (X2), and telemedicine consultations (X3). Mean: Shows the average value for each variable. Y (GDP) equals 261.428571, X1 is 158.0952381, X2 is 71.19047619, and X3 is 3243.80952 Median: The midpoint of the dataset, splitting it into two equal parts. The median for Y is 220, for X1 it is 120, for X2 it is 60, and for X3 it is 10,000.

Mode: Indicates the most frequently occurring value. For Y, the mode is 220, for X1 it is 120, for X2 it is 60, and for X3 it is 10,000. CORREL (correlation coefficient): Demonstrates the relationship between Y (GDP) and the other variables: Correlation between Y and X1 = 0.98397273 (very strong bond). Correlation between Y and X2 = 0.9956796 (very strong bond). Correlation between Y and X3 = 0.82187508 (strong bond).

The data highlights how digital transformation and investments in healthcare have positively influenced the UAE's long-term economic growth. The strong correlations between GDP and the key variables—digital hospitals, EHR adoption, and telemedicine—demonstrate the pivotal role of digital health infrastructure in enhancing both economic and social outcomes. This aligns with the UAE's Vision 2030, emphasizing the role of innovation in improving quality of life and expanding access to healthcare services. However, sustained investment in cybersecurity, training, and operational efficiency remains critical to ensuring long-term success and sustainability.

Comparative Analysis for KSA and UAE



The correlation coefficient between GDP and services for digital health the quantity of digital hospitals Saudi Arabia: The correlation coefficient revealed a robust positive association, suggesting that the construction of digital hospitals is growing quickly in tandem with the country's improving GDP. UAE: With obvious strategic investments in digital hospitals as part of national development ambitions, the connection was likewise very positive. Result: When it comes to the connection between economic expansion and the advancement of digital hospitals, the United Arab Emirates and Saudi Arabia are comparable.

The number of Saudi Arabian hospitals that use electronic health records is moderately to highly positively correlated, suggesting that the country is still in the early stages of adopting electronic health records. UAE: The UAE has made modest strides toward implementing electronic records, and the relationship is generally beneficial. As a result, Saudi Arabia is catching up quickly, but the UAE may be steadier in implementing electronic record-keeping. Numerous consultations via telemedicine: Saudi Arabia: There has been a notable increase in the usage of telemedicine consultations, particularly in rural locations, and the relationship is very strongly positive. UAE: With an emphasis on contemporary technologies to improve remote health services, the partnership is also quite good. Result: Both countries have shown remarkable progress in this area, with a significant convergence in growth rates. Priorities for Investments In accordance with "Saudi Vision 2030," Saudi Arabia is concentrating on enhancing digital health infrastructure, with an emphasis on raising the standard of healthcare and extending services to remote locations. observes a notable rise in funding for digital hospitals and the expansion of telemedicine and other technology applications. UAE: A comprehensive digital health strategy based on "UAE Vision 2021" and the artificial intelligence strategy aims to establish regional leadership. emphasizes the use of cutting-edge technologies and sophisticated services like telemedicine. Typical difficulties: Training medical staff and acquiring the technological know-how needed to properly implement electronic health records are problems Saudi Arabia faces. UAE: The expenses of digital infrastructure and preserving data security while growing digital health services present difficulties. Advantages and Unique Features Saudi Arabia a notable increase in telemedicine consultations, which is indicative of how well rural health programs are working. The use of digital technology is expanding quickly in an effort to increase productivity and quality. With its quick development in smart health services, the UAE is a leader in the application of artificial intelligence and cutting-edge digital health. a well-defined plan for the future growth of the health sector in collaboration with the commercial sector.

We can say that both nations are advancing rapidly in the area of digital health, as evidenced by their similar rates of innovation and growth. The UAE stands out for being a leader in the application of artificial intelligence and cutting-edge technology, while Saudi Arabia is rapidly expanding its digital footprint and raising the standard of healthcare across the board. Despite the similarities, both nations can improve innovation and grow in a sustainable way by learning from one another. Both Saudi Arabia and the United Arab Emirates must keep funding workforce development, cybersecurity, and digital infrastructure in order to achieve sustainability in digital health. The data supports future visions for a sustainable health system by highlighting the role that digital transformation plays in improving healthcare quality and efficiency.

Conclusion

The analysis revealed that the digital healthcare transformation in Saudi Arabia and the UAE played a significant role in promoting economic growth and better healthcare services. Over the past two decades, both nations invested heavily in technologies such as electronic health records, telemedicine, and digital hospitals, which enhanced healthcare accessibility and efficiency. Saudi Arabia prioritized expanding healthcare services to rural areas and integrating sustainability into its Vision 2030 goals, while the UAE leveraged advanced technologies and AI to establish itself as a leader in digital innovation. The strong positive correlations between digital healthcare advancements and GDP growth in both countries highlighted the substantial economic benefits of these initiatives. Despite facing challenges in training, cybersecurity, and affordability, both nations made remarkable progress in creating sustainable and innovative healthcare systems.

Both countries should continue investing in digital healthcare infrastructure to maintain growth and meet increasing demands. Workforce Development: Training programs must be prioritized to equip healthcare professionals with the skills to effectively use digital tools. Cybersecurity Enhancements: Strengthening data security measures is critical to protect sensitive patient information and foster trust in digital systems. Collaboration and Knowledge Sharing: Cross-border partnerships between Saudi Arabia and the UAE can accelerate progress by leveraging shared expertise and best practices. Focus on Accessibility: Further expanding telemedicine services, especially in underserved areas, can ensure equitable access to high-quality healthcare for all populations.

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Appendix

Table 1: KSA's Data set

Digital Health Statistics in Saudi Arabia (2002 - 2022)				
Year	GDP (Billion USD) (y)	Number of Digital Hospitals (x1)	Number of Hospitals Using Electronic Health Records (EHR) (x2)	Number of Telemedicine Consultations(x3)
2002	200	100	20	100
2003	210	110	25	150
2004	220	120	30	200
2005	230	130	35	300
2006	240	140	40	350
2007	250	150	45	500
2008	260	160	50	600
2009	270	170	60	800
2010	300	180	70	1000
2011	320	190	80	1500
2012	340	200	90	2000
2013	360	210	100	2500
2014	746	200	120	3000
2015	646	220	140	4000
2016	646	240	160	5000
2017	686	260	180	7000
2018	782	280	200	10,000
2019	793	300	220	15,000
2020	700	350	250	50,000
2021	833	400	280	80,000
2022	786	400	300	100,000
AVERAGE	467.5238095	214.7619048	118.8095238	13523.80952
MEDIAN	340	200	90	2000
MODE	646	200	90	2000
CORREL		0.876954856	0.92766401	0.610328345

Table 2: UAE's Data set

Digital Health Statistics in the UAE (2002 - 2022)				
Year	GDP (Billion USD) (y)	Number of Digital Hospitals (x1)	Number of Hospitals Using Electronic Health Records (EHR) (x2)	Number of Telemedicine Consultations (x3)
2002	100	50	10	50
2003	110	55	12	70
2004	120	60	15	100
2005	130	65	18	150
2006	140	70	20	200
2007	150	75	25	250
2008	160	80	30	300
2009	170	85	35	400
2010	180	90	40	600
2011	200	100	50	800
2012	220	120	60	1000
2013	240	140	70	1200
2014	300	160	80	1500
2015	320	180	90	2000
2016	340	200	100	2500
2017	360	220	110	3000
2018	400	250	120	4000
2019	420	270	130	5000
2020	450	300	140	10,000
2021	480	350	160	15,000
2022	500	400	180	20,000
AVERAGE	261.4285714	158.0952381	71.19047619	3243.809524
MEDIAN	220	120	60	1000
MODE	220	120	60	1000
CORREL		0.983972729	0.9956796	0.821875075