Original research

DIGITAL HEALTH

Digital Health
Volume 8: 1–9

DOI: 10.1177/20552076221117742
journals.sagepub.com/home/dhj
SAGE

Digital health transformation in Saudi Arabia: A cross-sectional analysis using Healthcare Information and Management Systems Society' digital health indicators

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Abstract

Background: The digital revolution has had a huge impact on healthcare around the world. Digital technology could dramatically improve the accuracy of diagnosis, treatment, health outcomes, efficiency of care, and workflow of healthcare operations. Using health information technology will bring major improvements in patient outcomes.

Purpose: This study aims to measure the readiness for digital health transformation at different hospitals in the Eastern Province, Saudi Arabia in relation to Saudi Vision 2030 based on the four dimensions adopted by the Healthcare Information and Management Systems Society: person-enabled health, predictive analytics, governance and workforce, and interoperability.

Methods: The study was conducted with a cross-sectional design using data collected through an online questionnaire from 10 healthcare settings, the questionnaire consists of the four digital health indicators. The survey was developed by Healthcare Information and Management Systems Society for the purpose of assessing the level of digital maturity in healthcare settings.

Results: Ten healthcare facilities in the Eastern Province, both private and governmental, were included in the study. The highest total scores for digital health transformation were reported in private healthcare facilities (median score for private facilities = 77, public facilities = 71). The 'governance and workforce' was the most implemented dimension among the healthcare facilities in the study (median = 80), while the dimension that was least frequently implemented was predictive analytics (median score = 70). In addition, tertiary hospitals scored the least in digital transformation readiness (median = 74) compared to primary and secondary healthcare facilities in the study.

Conclusion: The results of the study show that private healthcare facilities scored higher in digital health transformation indicators. These results will be useful for promoting policymakers' understanding of the level of digital health transformation in the Eastern Province and for the creation of a strategic action plan.

Keywords

Health information systems, Data Science, Health Information Interoperability, Health Status Indicators

Submission date: 23 June 2022; Acceptance date: 18 July 2022

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Introduction and background

Health Information Technology has been contributing to dramatic changes in healthcare by reshaping the health service delivery system and introducing new modalities of patient care. In fact, health care as a specialized field of an industry cannot survive in such a dynamic and rapidly changing environment without accelerated adoption of new and innovative technology and investing in further development of digital health infrastructure. Digital health as an emerging specialization focuses on the use of information technology and electronic communication services, tools, and processes to deliver health care services and facilitate better health.[1] The technological revolution has had a huge impact on healthcare in the world. Moreover, advances in information and communication technologies in all sectors have raised the ambitions of the healthcare sector around the world for providing high-quality services.[2]

In 2013, the World Health Organization (WHO) issued a global strategy on digital health to improve healthcare by developing and adopting digital health for appropriate, accessible, and affordable healthcare for all. The strategy calls for developing infrastructure that enables countries to support healthcare delivery through digital health technologies.[3] It is evident from the literature that there is the heterogeneity of the results across countries in terms of digital transformation.[4] For instance, Catalonia in Spain has been considered a forerunner of eHealth adoption in Europe. Since 2009, Catalonia achieved robust information exchange deployment, which allowed health care workers in the public health system to share clinical information.[5] This indeed supported Catalonia's health system to sustain healthcare delivery during the coronavirus crisis and helped to a high extent decreasing the unnecessary visits to the hospitals during the pandemic.[5]

In the case of Saudi Arabia, the country has experienced rapid socioeconomic changes, contributing to major shifts in public health priorities and leading to extensive health reform.[6,7] As part of Saudi Vision 2030, the kingdom launched the National Transformation Program (NTP) in 2015 which is an executive program designed to transform the healthcare delivery system through technology and innovation. Having a solid foundation of digital health infrastructure will surely contribute to achieving the country's vision in the health of facilitating access to equitable, affordable, and universal high-quality healthcare for all.[3] However, one of the major challenges identified by the NTP is developing an effective strategy for digital health transformation of the Saudi Ministry of Health (MoH) due to the lack of an integrated IT system for healthcare services.[8] Therefore, the MoH has generated several programs and systems to overcome this challenge. Three main solutions are being implemented: automating patient care, electronic health records, and billing; standardizing regulations and procedures for the quality and exchange of information, and establishing the National Health Observatory.[9]

Since 2015, Saudi Arabia has made remarkable progress in the implementation of digital health. However, only a few studies have assessed the current status of Saudi Arabian digital health efforts. One study analysed the readiness of Saudi Arabian healthcare facilities to change in accordance with the Saudi National Healthcare Plan of Saudi Vision 2030.[10] Based on a review of different resources on organizational readiness for change, the study concluded that many factors would facilitate the efficient implementation of the Saudi healthcare transformation plan. These factors mainly depend on the determination of the organization, the effort of the members of the organization, and the availability of resources.[10]

Another study assessed the state of digital health maturity in Saudi Arabia compared to other countries.[11] The study used the Global Digital Health Index Platform (GDHI), which has seven main dimensions: strategy and investment, workforce, legislation and policy, leadership and governance, standards and interoperability, infrastructure, and services and applications. The study concluded that there are many digital health initiatives in the country; multiple key implementation solutions have been launched, and digital health in Saudi Arabia is evolving steadily.[11] Moreover, a recent study published in 2021 measured the status of HIS implementation in 18 hospitals in the Eastern Province in Saudi Arabia – which is the same geographical setting as this study – the results showed a variety in implementation stages, however, most of the hospitals indicated using the basic functionalities such as clinical documentation.[12]

The Saudi MoH strongly supports continuous progress in digital health transformation by focusing on building digital infrastructure and improving healthcare quality. However, it is unclear whether the current level of digital health implementation fulfils the expectations of Saudi Vision 2030. This study aims to measure the readiness for digital health transformation at different hospitals in the Eastern Province, Saudi Arabia in relation to Saudi Vision 2030 based on the four dimensions adopted by the Healthcare Information and Management Systems Society (HIMSS): person-enabled health, predictive analytics, governance and workforce, and interoperability. Further discussion of this instrument will be provided under the Methods section. The results of this study could help health care policymakers at MoH and the National Transformation Unit to identify and address the gap between the aims of Saudi Vision 2030 and the current situation. The study could also inform the general literature on digital transformation by providing information on the actual level of digitalization in a setting with rapid changes in health system reforms.

Materials and methods

This is a quantitative cross-sectional study. The study included government and private healthcare facilities in

three major cities in the Eastern Province of Saudi Arabia (Al-Khobar, Dammam, and Dhahran).

Using the purposive sampling technique, the current study questionnaire was sent via email to the head of the Information Technology at the selected study sites. A total of 10 facilities participated in this study by completing the questionnaire.

The independent variables are the Healthcare Facility Type (Private or Governmental), and Healthcare Facility Level (Primary, Secondary or Tertiary). The dependent variables are the four dimensions of digital health as presented in the survey: *Interoperability*, *Governance & Workforce, Predictive Analytics*, and *Person-Enabled Health*. The outcome variable in the research is the overall digital health transformation score of each facility. The data was collected using an online survey that was sent to hospitals in the Eastern Region of Saudi Arabia.

The questionnaire used an existing open-source questionnaire developed and validated by the Healthcare Information and Management Systems Society Healthcare Information and Management Systems Society (HIMSS).[13] The study took place from January 2021 to June 2021, while data was collected between March 2021 and May 2021.

The questionnaire includes two main sections, general questions about the facility, and the digital transformation four indicators. General questions are related to the facility characteristics, such as the healthcare facility type (private or governmental), and the healthcare facility level (secondary or tertiary).

The digital transformation indicators section comprises four dimensions. Each dimension has three indicators, and the answers were measured on a scale of 0 to 10 rate of implementation. The first dimension is the *Interoperability* of the foundational, structural, semantic, and organizational features of the healthcare facility. The second dimension is the *Governance & Workforce*, which measures the stewardship, policy and decision-making, transparency, and workforce capacity and competency of the facility. The third dimension is *Person-Enabled Health*, which has three indicators, personalized care delivery, proactive risk management, and predictive population health. The fourth dimension is *Predictive Analytics*, which measures personalized analytic tools, predictive analytics tools, and operational analytics. Face validity of the four dimensions of digital health was tested using qualitative content analysis.[13]

All participants were asked for their voluntary participation and consent before filling out the questionnaire and were free to withdraw from the study at any time.

The study complies with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) at Imam Abdulrahman Bin Faisal University, Saudi Arabia in December 2020, ethical approval number is IRB-UGS-2020-03-424.

All of the numerical data collected by the questionnaire were analysed using the statistical package for social sciences (SPSS).[14] healthcare facilities' characteristics and the four digital health dimensions (interoperability, governance & workforce, person-enabled health, and predictive analytics) were analysed using descriptive analysis. Furthermore, to detect statistical significance a normality test was conducted on these dimensions. Mann-Whitney test was used to assess the statistical differences between the digital health dimensions and type of healthcare facility, whereas the Kruskal-Wallis test was used to assess the statistical differences between the digital health indicators and level of a healthcare facility.

Results

Ten healthcare facilities in the study were assessed regarding their perceived digital transformation readiness. Half of the facilities in the study were governmental and the other were private. The healthcare facilities in the study varied in their level of care, 60% were tertiary hospitals ($n = 6$), 30% were secondary ($n = 3$), and 10% were primary healthcare centres ($n = 1$) (Figure 1).

The digital transformation dimensions measured in the study are *interoperability, Governance & Workforce, Person-Enabled Health*, and *Predictive Analytics.* Scores of the indicators were calculated using the tool provided by HIMSS DHI rapid assessment,[13] where a higher score indicates better readiness.

Descriptive analysis of the hospital's responses regarding these dimensions is shown in Tables 1 and 2. *Governance & workforce* has the highest median score among the rest of the dimensions (median = 80.00), followed by *interoperability* (median = 78.5), then *person-enabled health* (median = 71.50). When the normality of the dimensions was assessed using the skewness and kurtosis criteria of normality,[15] all dimensions appeared normal except the *interoperability*. In addition, specific item rating is available in Table 2, which it shows that the average score for all items ranges from 6.20 to 8.20.

When the digital transformation readiness was compared across different healthcare facility levels, no statistically significant associations were found. However, as shown in Table 3, secondary hospitals in the study have the lowest mean score in the *interoperability* dimension. On the other hand, secondary hospitals appear to have the highest mean score in the *governance & workforce* and *predictive analytics* dimensions. In addition, tertiary hospitals in the study had the lowest mean score in the *person-enabled health* dimension. Finally, the mean score of the total digital health readiness across different healthcare facility levels is almost the same.

The digital transformation readiness was measured across two healthcare facility types (governmental and private) (Table 4). None of the digital transformation

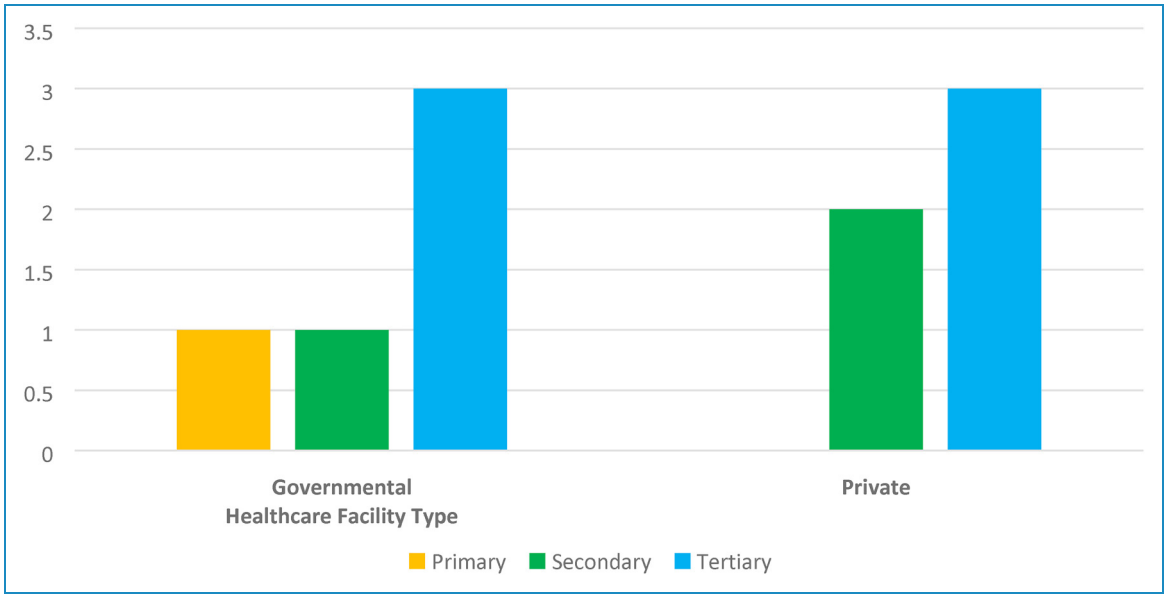

Figure 1. Characteristics of the healthcare facilities in the study.

Table 1. Descriptive statistics about the digital transformation dimensions in the study ($n = 10$).

	Interoperability	Governance and workforce	Person enabled health	Predictive analytics
Median	78.50	80.00	71.50	70.00
Skewness	−1.852	.205	.284	.660
Kurtosis	4.229	.076	.093	.460
Minimum	7.00	60.00	57.00	60.00
Inter-quartile range (IQR)	26	16	13	11
25th percentile	59.25	72.25	67.00	67.00
50th percentile	78.50	80.00	71.50	70.00
75th percentile	85.50	88.50	79.50	77.75
Maximum	100.00	100.00	90.00	87.00

dimensions appeared to be significantly related to the facility type. However, the mean score of the dimensions is higher in private healthcare facilities in the study compared to governmental ones.

Discussion

The main aim of this study is to investigate and assess the digital health transformation capacity at healthcare facilities in the eastern province of Saudi Arabia. This was accomplished by measuring and analysing the total score for digital health indicators. The authors used the HIMSS DHI rapid assessment which focuses on four digital health dimensions: *Interoperability*, *Governance & Workforce, Person-Enabled Health*, and *Predictive Analytics*.

The study findings reveal that *Governance & workforce* has the highest mean score among the rest of the dimensions. In addition, secondary hospitals in the study have

Table 2. Indicators summary.

Indicator	Mean (SD)	Median (IQR)
1. **Interoperability** – $\bar{x}$ (SD) = 71.70 (26.192)		
1.1. Individuals have access to their personal health records, health system services, educational tools and health navigation tools to support health decisions, navigate access to care and services from their own homes. Includes fully integrated virtual care and remote patient monitoring with intervention.	7.40 (2.72)	8.0 (4)
1.2. Clinicians use secure devices in daily practice routines, to enable collaboration with other clinicians, including secure messaging, consultations, and real-time access to patient data, securely managed to protect privacy.	7.60 (3.10)	8.5 (4)
1.3. Security breaches and alerts are tracked using machine learning technologies to identify accuracy and risk of alerts, cost to manage breaches, and track compliance with security legislation.	6.50 (2.68)	7.0 (4)
2. **Governance and workforce** – $\bar{x}$ (SD) = 79.60 (11.616)		
2.1. Staff are accountable for supporting care that is personalized to the unique needs, circumstances, and choices of the individual informed by evidence of value and person-reported outcomes.	7.90 (1.29)	8.0 (2)
2.2. Organizational strategy and performance outcomes are shared publicly to inform the community of impact and value achieved by the organization or health system.	7.80 (1.75)	7.5 (3)
2.3. Organizational policies are responsive to value for patients, informed by patient participation at all levels of governance, to inform and support digital healthcare systems.	8.20 (1.55)	8.0 (3)
3. **Person enabled health** – $\bar{x}$ (SD) = 73.50 (9.778)		
3.1. Data is mobilized to track population health outcomes to inform personalized care strategies that support and sustain population health and wellness.	7.90 (1.29)	8.0 (2)
3.2. Care delivery focuses on keeping people well by proactively intervening to reduce risk using predictive analytic tools.	7.90 (0.99)	8.0 (1)
3.3. Individuals are the primary decision-makers and use digital tools to self-manage their health and wellness.	6.20 (1.93)	6.5 (3)
4. **Predictive analytics** – $\bar{x}$ (SD) = 71.80 (7.757)		
4.1. Analytic tools at the point of care track individual outcomes to inform care decisions that mitigate health risks and optimize health outcomes.	7.20 (1.14)	8.0 (2)
4.2. Predictive analytic tools segment the population based on risks and outcomes for population segments to identify the conditions under which best outcomes are achieved, to inform proactive interventions that strengthen population health.	6.80 (0.92)	7.0 (1)
4.3. Analytic tools track operational performance in real-time to inform leadership decisions to strengthen quality, safety, and cost outcomes across the organization/system.	7.50 (1.51)	7.0 (3)

the lowest mean score in the *interoperability* dimension and highest mean score in two dimensions, *governance & workforce*, and the *predictive analytics* dimensions, whereas tertiary hospitals in the study had the lowest mean score in the *person-enabled health* dimension. Interestingly, there was no significant relationship between the digital transformation dimensions and facility type. However, the mean score of the dimensions is higher in private healthcare facilities in the study compared to government healthcare facilities.

The '*Governance & Workforce*' dimension got the highest mean score compared to the other dimensions. Marcelo et al.,[16] believe that digital governance is one of the pillars for implementing digital health solutions, which

Table 3. Digital transformation readiness in relation to the healthcare facility level.

	Healthcare facility level Median (IQR)			
Item	Primary	Secondary	Tertiary	Kruskal-Wallis test (*P*-value)
Interoperability	83.0[a]	83.0[a]	77.0 (26)	.644 (.725)
Governance & Workforce	73.0[a]	80.0[a]	80.0 (21)	.806 (.668)
Person Enabled Health	77.0[a]	77.0[a]	70.0 (10)	.889 (.641)
Predictive Analytics	70.0[a]	73.0[a]	68.5 (13)	.689 (.709)
Total digital transformation readiness	76.0[a]	77.0[a]	74.0 (12.5)	.069 (.966)

[a]Inter-quartile range cannot be calculated since there isn't enough data in the group.

Table 4. Digital transformation readiness in relation to the healthcare facility type.

	Healthcare facility type Median (IQR)		
Item	Governmental	Private	Mann-Whitney *U*-test (*P*-value)
Interoperability	77.00 (76)	83.00 (27)	4.500 (.093)
Governance & Workforce	80.00 (14)	87.00 (25)	7.500 (.289)
Person Enabled Health	70.00 (20)	73.00 (15)	9.500 (.527)
Predictive Analytics	70.00 (12)	73.00 (15)	9.000 (.458)
Total digital transformation readiness	71.00 (20)	77.00 (13.5)	5.500 (.141)

will in turn manage different health systems processes, such as electronic health records, health insurance payment processes, and systems evaluation. The lack of governance or low implantation of governance in digital health systems will lead to the inefficient implementation of strategic and smart investment decisions.[16] In addition, Tanniru et al.[17] relate the reason behind the movement toward digital governance to the fact that global digital transformation is touching all work fields, and therefore health organization faces pressure to adapt to this rapid change as well as it has to raise to the customer expectations.

In Saudi Arabia, a governance program has been implemented among healthcare facilities to fulfil the 2030 vision.[8] This program enforced policies focusing on enabling patients to be more active in managing their care. It also publicly advertises the different applications designed by the MoH and ensures the confidentiality and security of their data. These could be some of the reasons this dimension achieved such a score. Further, the attention given by MoH to make sure that all these changes are value-based could also be contributing to the high score.

On the other hand, the study findings have shown that implementation of *interoperability* as a distinctive aspect of digital health transformation is relatively low compared to the other dimensions of the digital health indicators. The *Interoperability* dimension received a low mean score in implementation rate, especially at the secondary governmental healthcare facilities. This could possibly be a result of having the data go through multiple systems, which increases the possibility of errors and incomplete data. In fact, privately owned hospitals have a higher rate of implementation and adoption compared to their public counterparts. In concordance, Alghamdi[18] believed that the difference in interoperability between public and private healthcare facilities can be attributed to the higher adoption of Electronic Health Records in general and Personal Health Records in particular which increases their interoperability score based on the rapid assessment. Furthermore, Luna et al.[19] concluded that data are usually

managed by one entity, using one healthcare system at the private facilities making it easier to be interoperable organizations.

Also, the limited interoperability implementation can be traced back to other different reasons including the cost of initiation and maintenance of the technical infrastructure, privacy and security of the data being exchanged, and regulatory agencies' involvement.[20] Persons et al.[20] have discussed three attempts for interoperability implementation in three different countries including Canada, Austria, and the USA. The study found there is a greater chance for interoperability in national health systems supported by a national governing body in terms of financially sponsoring the initiatives and regulating the health information exchange between different organizations. What we have seen in this study, however, is the opposite with public hospitals scoring relatively lower in interoperability and this simply can be attributed to having more pressing public health priorities compared to the private sector that could limit funding of Health IT initiatives.

In fact, Alghamdi[18] concluded that cost is a major barrier to the implementation of EHRs and Health IT in the Saudi public healthcare system. Other factors also include high maintenance costs, lack of technical skills and capabilities, perceived security and privacy threats, and resistance to new technology. Furthermore, having to assume the responsibility of population health also is the same factor that makes the private sector less invested in interoperable technical infrastructure for public health purposes as suggested by Persons et al.[20] Also, Persons et al.[20] concluded that interoperability is less common in private silo healthcare institutions compared to private multi-hospital systems and this could further describe the lower interoperability score as all participating private facilities are individual institutions.

In addition, the *Person-Enabled Health* dimension shows some similarity to the *Interoperability* dimension, where private facilities got a higher implementation rate compared to governmental facilities. Similarly, a study conducted by Lu et al.[21] in public hospitals in China revealed that information technology infrastructure, system reliability, and government policy are considered as barriers to rapid adoption of a person-enabled health, that is, mhealth, in Chinese public hospitals. This could be because private facilities are keen on finding different ways to enhance patients' satisfaction regarding the care provided to them. Which ensures the facility's continuous patronage with the patients, expecting more involvement in the decision-making process, considering that the patients are paying for the services. Private hospitals are making efforts to use patients' data to provide more personalized and customized care.[22] Similar efforts are needed in private and public hospitals in order to attain digital transformation in healthcare facilities.

Tertiary hospitals have the lowest score in person-enabled health. This could be because these hospitals treat patients with the most severe cases, thus they do not feel the need to focus on the personalization of patient care, and the overall wellness and how it could be achieved. Supporting that, a study conducted in two tertiary hospitals located in Nigeria and South Africa revealed that healthcare workers perceived that the use of person-enabled health, such as mhealth might be negatively disruptive while engaging with patients.[23] Thus, it is important to take into account the type of work activity and the contextual factors, such as the type of healthcare facility, that might negatively affect digital transformation.[23] In future studies, it is recommended to identify the barriers that hinder the implementation of digital transformation in tertiary hospitals.

As for the *Predictive Analytics* dimension, it shows a low implementation rate compared with the other three dimensions with private hospitals scoring slightly higher. This is expected due to the complexity of healthcare and the need for some pre-existing system requirements to be in place.[24] In fact, predictive analytics requires higher implementation status of the EHR functional and technical capabilities. This could be a significant barrier to implementation, especially in the Saudi public healthcare system that is still building its health IT infrastructure.[18] Furthermore, the same complex dynamics involved in interoperability implementation could play a role in the adoption of predictive analytics as well including the cost of initiation and maintenance, lack of skills, and resistance to technology.[18]

However, efforts are currently made to improve such a critical area of the healthcare system by stressing the importance of collecting and using the data to ensure a better outcome for the population.[8] Furthermore, the same complex dynamics involved in interoperability implementation could play a role in the adoption of predictive analytics as well.

The highest total scores reported for digital health capacity in this study, as assessed by the DHI Rapid Assessment tool, were reported by the private healthcare facilities. Private facilities are commonly more technologically advanced compared to governmental (public) healthcare facilities. This could be a result of the resources private hospitals have, especially large ones, which allow them to allocate a considerable amount of funding to advance their digital health status. In a contrast, governmental facilities in the study have lower total digital, which could be due to more financial, organizational, and regulatory challenges compared to private facilities.[25] However, this is changing now with Vision 2030, which aims to improve the needed indicators to ensure a digital health transformation. Also, the baseline needed for such transformation, which is Governance and Workforce, is one of the highest scored dimensions in the current study. This shows a real possibility of achieving digital health

transformation across Saudi healthcare facilities in the near future.

The first limitation of this study is the use of HIMSS' rapid assessment tool rather than the original instrument due to lack of funding. However, the rapid assessment instrument is still considered a reliable and valid instrument to summarize the digital health indicators and can be generally used as a precursor for the original instrument as suggested by HIMSS.

The second limitation of this study is that it is restricted to the healthcare facilities in the Eastern Region of Saudi Arabia which can affect the generalizability of the findings. Another perceived limitation of this research is the low sample size of the participating facilities. The researchers believe this could not be a flaw of this study because all major acute care facilities in the Eastern Region were included and therefore, results can be valid to be utilized within this geographical area.

The main strength of this study is that it is the first of its kind in the country and the results will be very informative in identifying the current status of digital health adoption and future opportunities for improvement in the region.

Conclusion

This study aimed to measure the digital health transformation in multiple healthcare facilities across Eastern Saudi Arabia using digital health indicators.

It was found that there are high implementation rates in general, and the total digital transformation score in the private healthcare facilities was higher compared to governmental hospitals. The study showed that from all the dimensions, the 'Governance & Workforce' was the highest implemented dimension, while 'Predictive analytics' was the lowest implemented dimension.

This study's findings could help policymakers to understand the level of transformation of digital health in Eastern Saudi Arabia. It could also help in knowing which indicators are the most applied in the Eastern Province's healthcare facilities, and which need more attention. Moreover, the result of this study could help health strategic planners to focus on understanding why the governmental facilities got a lower rate in Governance & Workforce dimension, so they can improve it.

Author contributions: All authors contributed equally to the conceptualization, data acquisition, project administration, data analysis, writing the first draft, and reviewing of the final draft.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: The study complies with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) at Imam Abdulrahman Bin Faisal University, Saudi Arabia in December 2020, ethical approval number is IRB -UGS-2020-03-424.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

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