


Review

Sustainable Digital Transformation in Healthcare: Advancing a Digital Vascular Health Innovation Solution

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Abstract: This systematic review focuses on digital transformation in vascular healthcare to identify key focus areas for innovation, benefits, challenges, best practices, sustainable approaches, and the impact on patient outcomes. This study includes mobile health technologies and artificial intelligence (AI), examining aspects such as data analytics and interoperability with patient-centered care. The finding reveals a growing utilization of telehealth, AI, and mobile health technologies in vascular (circulatory) healthcare. The use of telehealth services facilitates remote patient monitoring with an enhancement in patient access to care. AI supports predictive models and decision support, while mobile health technologies promote patient engagement and self-management. This review emphasizes that prioritizing digital transformation in vascular healthcare brings various advantages, including improved efficiency and enhanced patient outcomes with a reduction in cost. However, challenges such as limitations, interoperability issues, and data security concerns must be addressed. The best practice comprises stakeholders' engagement and comprehensive training. The impact of digital transformation on patient outcomes in circulatory healthcare is positive, mainly in the management of life-threatening conditions. This review offers valuable insights for prioritizing the digital transformation and enhancement of patient outcomes in vascular healthcare.

Keywords: healthcare; digital technology; vascular healthcare; digital transformation; circulatory health systems



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1. Introduction

Digital healthcare is changing the way doctors deliver care to their patients. This includes the use of technology to deliver a wide range of healthcare services such as telemedicine, electronic health records (EHRs), health management systems, and wearable devices. Digital healthcare management is efficient, accurate, and has changed healthcare. The use of electronic health records (EHRs) makes it easier for physicians to access patient information, monitor patient progress, and make informed decisions about patient care [1,2]. Health systems and wearable devices have enabled patient care in remote areas with easy-to-check technology. Through this medium, there is the potential to improve dental health and a group of conditions affecting blood vessels, including arteries and veins [3,4]. These conditions can range from mild to life-threatening and can have a significant impact on a patient's quality of life. Digital technologies such as telemedicine, wearable devices, and health monitoring systems have shown great promise for improving dental health. Telemedicine can enable healthcare providers to remotely diagnose and treat patients with dental disease, and for patients, results have improved. It can also enable healthcare providers to provide follow-up care to patients after treatment. Wearable devices and health monitoring systems play important roles in dental healthcare delivery, and patients can monitor their blood pressure, heart rate, and other vital signs, providing valuable information to healthcare providers [5].

According to Refs. [6–11], some of the key digital health innovations are data analytics, collaboration, and patient-centered care. However, data security concerns must be

addressed through challenges such as limited analytics and the automated handling of devices to ensure safe use. Best practices for successful implementation include stakeholder engagement, clear communication, and appropriate training for health professionals. While digital transformation has revolutionized the healthcare industry, dental healthcare has been slow to embrace digital health innovations. Addressing this issue requires identifying key areas of focus, and it is critical for digital health innovation in dental healthcare. This study seeks to address the methodological gaps in digital health research, and the findings of this study will be useful for policymakers, health professionals, and other stakeholders [1,12]. Figure 1 outlines questions for strategies in prioritizing digital transformations in networked health systems and is followed by a discussion of the points.

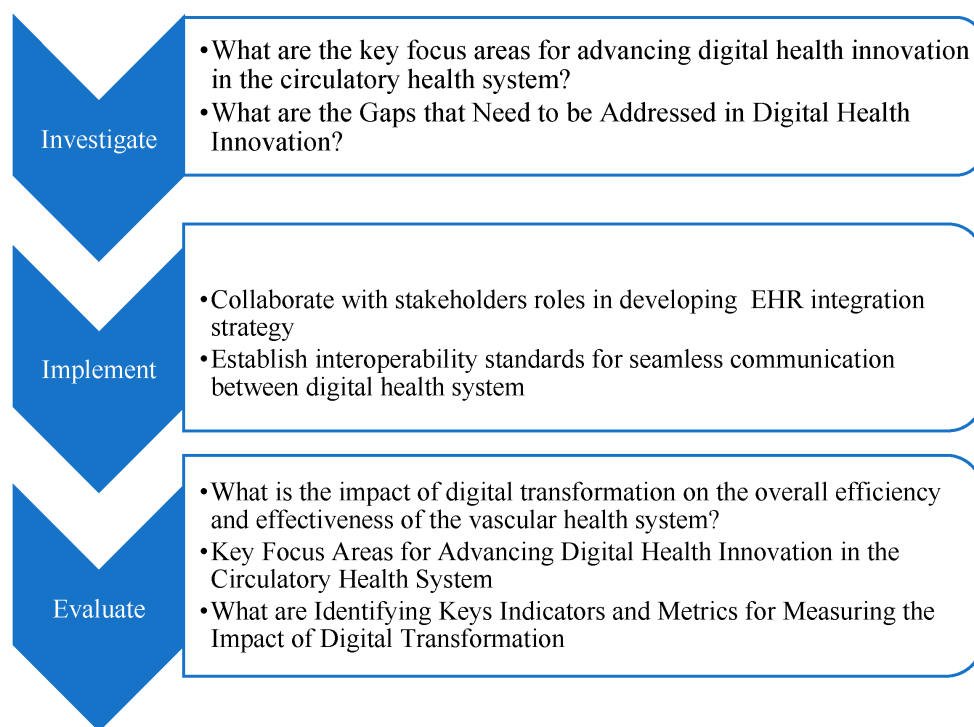


Figure 1. A flowchart illustrating the different steps involved in the research questions.

This study uses a systematic approach in an attempt to answer its research questions:

1. What are the key drivers of digital healthcare innovation in dental healthcare?
2. How can digital transformation improve dental health patient outcomes?
3. What are the barriers to digital transformation in dental healthcare and how can these be overcome?
4. What is the current state of digital health innovation in terms of dental healthcare, caps, and gaps to be addressed?
5. What are the key success factors in implementing a digital transformation in dental healthcare?
6. What is the impact of digital transformation on the overall efficiency and effectiveness of vascular healthcare services?

2. Overview

The vascular system is responsible for transporting blood throughout the body, delivering oxygen and nutrients to tissues and organs and removing waste products; this process is also called the circulatory system. When the vessels become damaged or diseased, they can cause a range of symptoms and complications, including pain, swelling, numbness, and even organ failure. Vascular healthcare providers use a range of diagnostic tools (components in Appendix A) and treatment options to identify and address these

issues [13]. One of the most common conditions treated by vascular healthcare providers is peripheral artery disease (PAD). This condition occurs when the blood vessels in the legs become narrowed or blocked, reducing blood flow to the extremities. Symptoms can include pain, cramping, and fatigue, particularly during physical activity. Treatment options for PAD may include lifestyle changes, such as quitting smoking and increasing physical activity, as well as medications and procedures to improve blood flow [14].

Another common condition treated by vascular healthcare providers are varicose veins. These are enlarged, twisted veins that can occur anywhere in the body but are most commonly seen in the legs. While they may be unsightly, they can also cause pain, swelling, and other symptoms. Treatment options for varicose veins may include lifestyle changes, such as losing weight and avoiding long periods of standing or sitting, as well as compression stockings, medications, and procedures to remove or seal the affected veins [15]. An aneurysm is another serious condition that may require vascular healthcare. An aneurysm occurs when a blood vessel wall weakens and bulges, potentially leading to rupture and life-threatening bleeding. Aneurysms can occur anywhere in the body but are mostly seen in the aorta, the body's largest artery. Treatment options for aneurysms may include close monitoring, medication to control blood pressure, or surgery to repair or remove the affected vessel [16]. Stroke is another serious condition that may require vascular healthcare. A stroke occurs when blood flow to the brain is disrupted, either by a blocked blood vessel or bleeding in the brain. Studies reveal that patients with a self-reported history of atherosclerotic cardiovascular disease are less likely to use health information technology to manage their health [17]. Some rehabilitation processes such as cardiac rehabilitation are used in some countries as a way to reduce the mortality rate; this is a very important component in cardiovascular health and secondary prevention [18]. Studies show that coronary artery graft, myocardial infarction, symptomatic peripheral arterial disease, and percutaneous coronary intervention are recommended as secondary prevention methods [19,20]. Although researchers and scientists are attempting to identify solutions that could lead to increased rates of good cardiovascular health, there are many barriers to accessing cardiac rehabilitation, such as language [21], transportation [22], and insurance coverage [23]. A study in which 879 patients with a high risk of coronary health disease underwent percutaneous coronary interventions with semi-personalized support, including regular checks, and were observed for months showed that the cardiometabolic risk showed no significant difference between outcomes [24]. A study was carried out using randomized churches and predominately African adults to test a mobile app that used digital means to support a reduction in death rates caused by cardiovascular disease. The digitalization effect of using an app was intended to promote health interventions. The FAITH app provided an educational model, including diet and physical activities such as self-monitoring and social networking [25], and some additional components, such as smoking, a healthy diet, and cholesterol level, blood level, sugar level, and glucose level checkers, were added. This digital app was to be observed for several months to determine whether there was any improvement. It was later shown that the intervention increased levels to 1.9 compared to 0.7, which had already been noticed. This digitalization shows improvement [26,27]. The intersection of digital transformation, digital healthcare, and vascular healthcare is particularly relevant in the management and prevention of cardiovascular diseases. Wearable devices can monitor vital signs, detect warning signs of cardiovascular disease, and track the progress of treatment plans. Remote monitoring systems enable healthcare providers to monitor patients' data in real time and provide timely interventions when necessary. Telemedicine and digital patient portals also provide patients with access to care from the comfort of their homes.

3. Material and Methods

We conducted a systematic literature review (SLR), using the approach cited by Rebelo et al., 2022 [25] to identify, select, and report entirely specific novel research domains with the help of VOSviewer version 1.6.19 released Jan 2023 (a tool that uses a layout algorithm

and constructs visualizations of bibliometric network publications to identify major themes from the selected literature)

The structure is presented in Figure 2. The SLR adopts the published guideline, with organized stages in conducting, planning, and presenting [26].

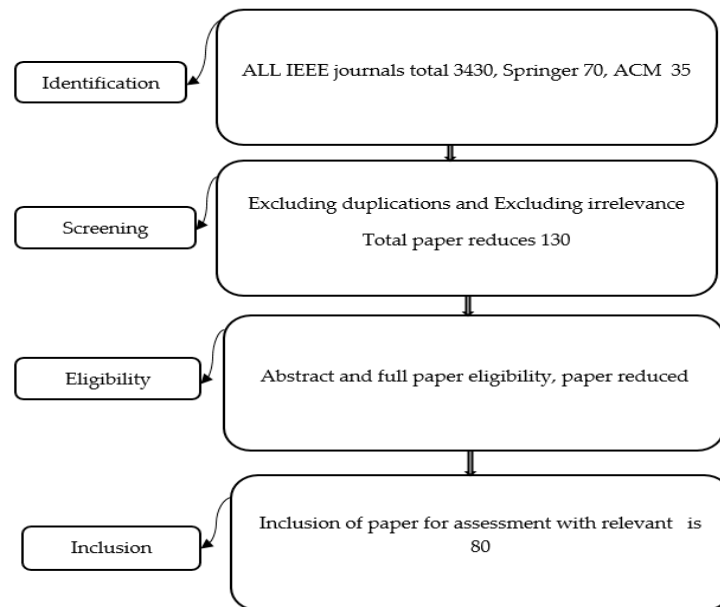


Figure 2. Methodology process: PRISMA flowchart.

3.1. Preparation Step

This is the first step that involves planning the research and comprises identifying the research question, defining the search terms, and selecting a scientific database for the systematic review.

3.2. Exploration Terms

There was sets of terms considered. The first target was to identify the type of wearable mechanism/vascular healthcare. The next objective was to discuss terms related to dynamic healthcare system management. This led to a selection of a wide range of terms that were interchangeable.

The second set of terms were explored (healthcare management, healthcare monitoring devices, the prevention of epidemics, and reductions in the death rates of chronic diseases).

3.3. Source Selection

In the conception stage, the targeted goal was the use of digital libraries (scientific databases) as the search sources. The ultimate goal is to use well-cited publishers and journals, including the Institute of Electrical Electronics Engineers Library, Springer, Elsevier, and ACM Library. Furthermore, in order to cover additional publishers, Scopus was searched using Engineering indexers to achieve a comprehensive search space.

3.4. Manual Search Sources

To achieve the targeted aim, a manual search source was employed using journals that regularly publish quality reviews, such as *IEEE Surveys*, *IEEE Access*, *IEEE Vascular Healthcare and Propagation*, *IEEE Biomedical*, and *Springer Medical Review*. This methodology is presented in Table 1.

Table 1. Methodology process.

Sources	Conducting State Statistic	Number of Papers	Search Fields
IEEE Surveys	Primary automatic search	2100	Titles
IEEE Access	After pruning duplicate	1200	Abstracts and keywords
IEEE Vascular Healthcare Propagation	After elimination criteria with skimming	100	Index term
IEEE Biomedical	Manual search	30	Article title and abstracts
Springer Medical Review	Initial snowballing	70	Keywords, title, and subject
ACM Digital library	After criteria searching	35	Abstracts, keywords, and index terms
Scopus	Skimming	28	All fields
Science Direct	Reporting	All	Article title and abstracts

3.5. Screening

This stage involved searching for and selecting relevant documents. Three search methods were adopted, including a manual search, snowballing, and an automatic search. The intent was to probe the study dynamic in achieving revolutionized digital health care.

4. Analysis and Results

In this paper, the comprehensive overview involved selecting important, useful elements with the aim of meeting the objectives of the study described above with respect to vascular healthcare.

The VOSviewer algorithm was executed, and the output in Figure 3 shows the emergence of themes that are grouped into five clusters indicated in different colors. The related research themes in the clusters are as follows:

Cluster 1: This cluster focuses on the use of wearable sensors and Internet of Things (IoT) technology to optimize healthcare for the elderly, using bio-electric and biosensor arrays and decision tree learning algorithms.

Cluster 2: This cluster centers around chronic health conditions and adaptive model tuning, with a particular focus on body-centric wireless communication systems and active aging.

Cluster 3: The themes in this cluster are data encryption, deep learning, medical images, and multi-sensor data fusion, with a focus on health applications and the Internet of Medical Things.

Cluster 4: This cluster revolves around the use of biosignal data, specifically electrocardiogram (ECG) signals, for mobile health applications, using fuzzy logic and denoising algorithms.

Cluster 5: The final cluster focuses on biomedical sensors and connected health devices, with topics such as diabetes, telerehabilitation, and cost modeling.

Figure 4 shows the progress of articles published from 2019 to 2023. The digital healthcare systems mini-survey in two source tiles, with 4044 publications over the years, shows what has been accomplished and recommends what should be undertaken in the future. In combination, 8080 sources were published, with one source published in the year in the book category. There are 14 source tiles with a total of 28,288 publications over the years; books have two source tiles, with a total of 4044 publications, and articles have 155 source tiles, with a total of 313,236 printed. This means that significant progress has been made by publishing many articles. The interplay between digital transformation, digital health, and vascular health is transforming the healthcare industry by leveraging the latest digital technologies to enhance patient outcomes and improve healthcare (see Figure 5). Digital transformation is transforming healthcare delivery by improving the efficiency, effectiveness, and quality of care through the use of digital tools and techniques.

The treatment and diagnostic data on digital vascular healthcare were extracted to show the progress in publications with citations over the years, shown in Figure 7, revealing that in the early stage of the digital transformation in the management of vascular healthcare, there were 10 citations for the work published by researchers, and there was significant progress in the citation of published work up to 2022. This progression improved with the various research studies carried out and published which contribute to knowledge.

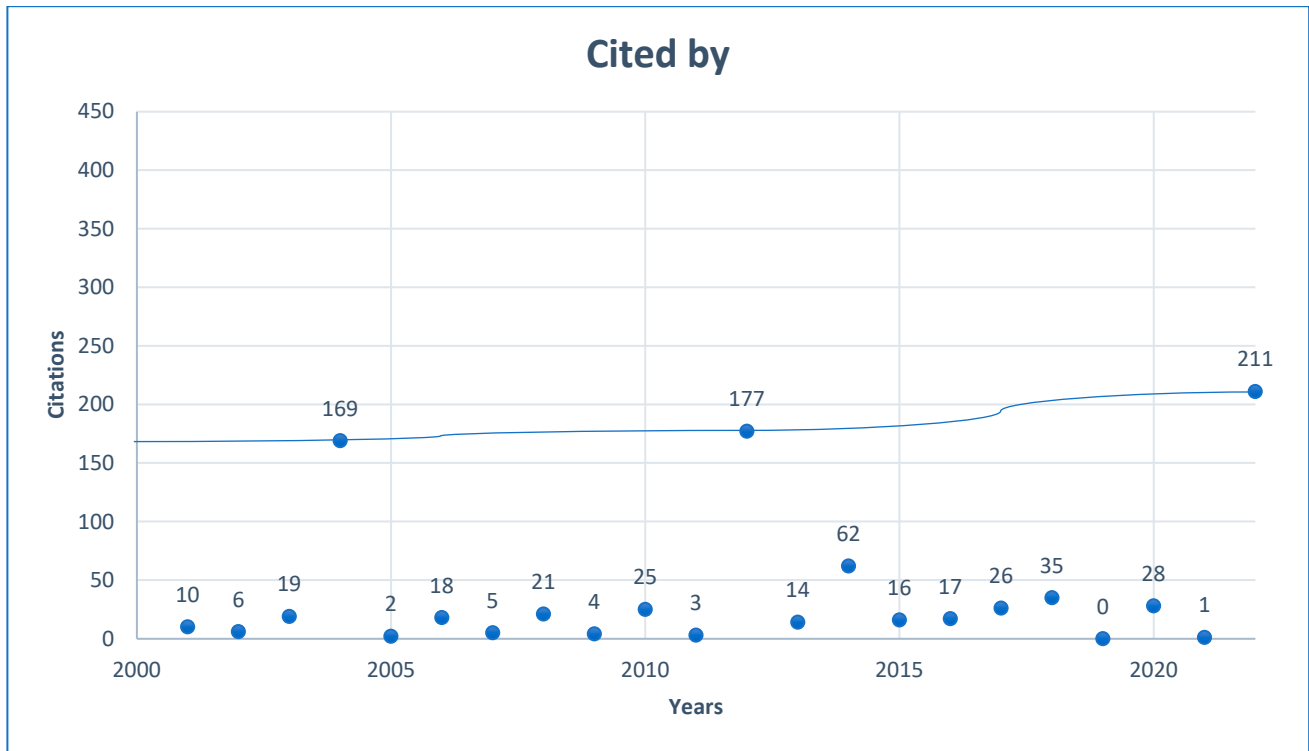


Figure 7. The progress of published articles for years and citations.

4.1. Content Analysis

This SLR identified the primary areas of focus for advancing digital health innovation in circulatory healthcare and the prioritization of digital transformation. The SLR focused on topics such as telemonitoring, digital healthcare, and mechanisms for improving patient care. The objective was to identify relevant content and theoretical concepts that define the areas that support the advancement of digital health innovation in vascular healthcare provision. The review conducted an in-depth analysis of the technological aspects of digitalizing healthcare, with a focus on prioritizing digital transformation.

4.1.1. The Potential of Digital Technology to Transform Vascular Care

Digital technology, such as telemedicine, artificial intelligence, and remote monitoring, has the potential to revolutionize the way vascular care is delivered and improve outcomes for patients and streamline medical procedures. With the advent of innovative tools like EMR, telemedicine, and mobile health applications, medical professionals can now access patient data and communicate with colleagues remotely, improving the speed and quality of care. The systematic literature review (SLR) revealed significant potential for integrating sustainability into digital transformation in healthcare, specifically in advancing digital health innovation for vascular health with a sustainable approach [29]. One area in which digital technology is making a significant impact is in the field of remote monitoring for patients with chronic vascular conditions. Remote monitoring tools such as wearable devices can provide physicians with real-time data on vital signs, enabling them to monitor a patient's health status remotely and intervene quickly if necessary. This can lead to im-

proved patient outcomes and reduced healthcare costs [30]. In addition, digital technology is helping to enhance the precision and accuracy of vascular interventions. For instance, medical professionals can now use 3D printing technologies to create customized stents and devices which can be tailored to a patient's specific anatomy. This can increase the efficacy of vascular procedures with minimal risks of complication. Furthermore, digital technology is helping improve patient education and engagement. Mobile health applications can provide patients with access to educational materials and personalized support, improving their understanding of their condition and increasing their adherence to treatment schedules (see Figure 8). The integration of digital tools into vascular care has the potential to transform how medical professionals deliver care, leading to improved outcomes and reduced healthcare costs. As digital technology continues to advance, we will likely see even greater benefits in the years to come [31–34]. The digital transformation development process for the provision of vascular healthcare involves several stages, including identifying the goals and objectives, selecting the appropriate technology and vendors, designing and implementing the system, training staff and patients, and continuously monitoring and evaluating the system's effectiveness [35,36]. This process requires collaboration between healthcare providers, IT professionals, and patients to ensure the system meets the needs of all stakeholders (see Figure 9).

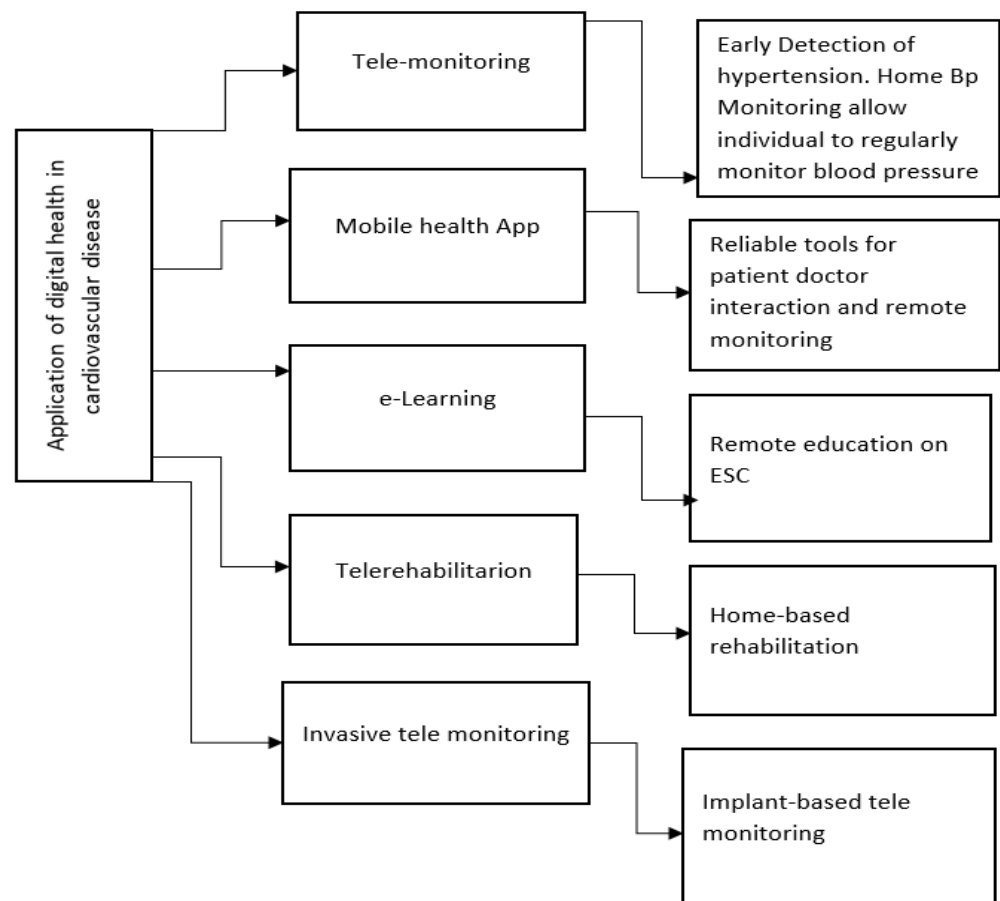


Figure 8. Application of digital healthcare in vascular healthcare [37–42].

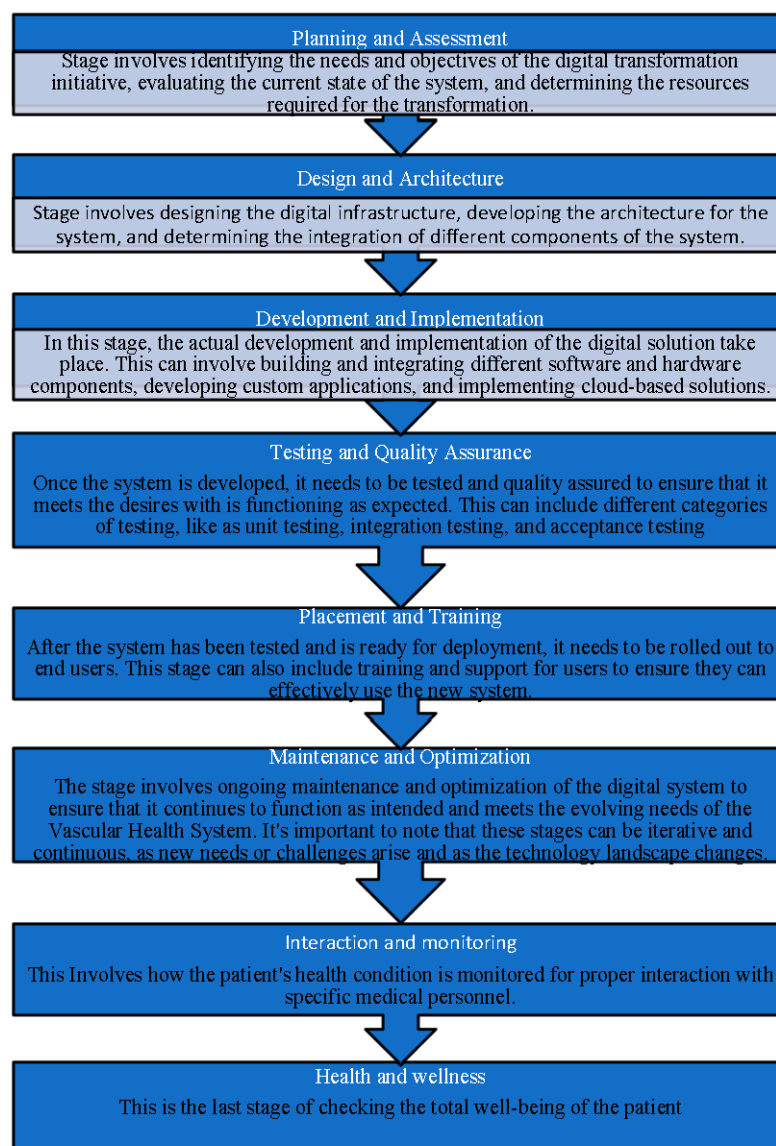


Figure 9. Digital transformation development for vascular healthcare.

4.1.2. The Challenges of Implementing Digital Technology in Vascular Care

Digital technology offers many benefits, but there are also challenges to implementing it effectively in vascular care, such as issues with data privacy and security, interoperability, and regulatory compliance. One of the primary challenges is the integration of new technology into existing healthcare systems. Many healthcare systems use legacy systems that may not be compatible with new technology, requiring costly upgrades or replacements [43]. Another challenge is ensuring data privacy and security. Electronic medical records and other digital tools contain sensitive patient information which must be protected from cybersecurity threats. Healthcare organizations must implement robust security measures, such as encryption and multi-factor authentication, to safeguard patient data [44]. Additionally, there are concerns about the potential for technology to worsen existing health disparities. Patients from disadvantaged backgrounds may lack access to technology or have limited digital literacy, making it difficult for them to benefit from digital tools. Healthcare organizations must work to address these inequities and ensure that all patients can access and use digital technology to improve their health outcomes. Another challenge is the need for healthcare professionals to adapt to new workflows and processes associated with digital technology. Staff training and education are essential to ensuring that healthcare professionals can use digital tools effectively and efficiently

without compromising patient safety or care quality. Finally, there is the issue of cost. Implementing digital technology can be expensive, and healthcare organizations must weigh the benefits of a new technology against its costs. They must also consider the long-term financial sustainability of digital tools, including ongoing maintenance and support costs. While the implementation of digital technology in vascular care holds great promise, healthcare organizations must address these challenges to ensure its successful integration and adoption [45]. Digital transformation in healthcare is closely tied to digital finance, which involves how transactions are carried out, influencing healthcare service [46].

4.1.3. The Role of Big Data in Vascular Care

With the advent of electronic health records and other digital tools, vast amounts of data are being generated with respect to vascular patients. The analysis of this data can help identify patterns and trends that can inform treatment decisions and improve outcomes. One of the main advantages of using Big Data in vascular care is the capacity to integrate and analyze large amounts of data from various sources. This includes electronic medical records, medical imaging, and other diagnostic tests. By analyzing this data, healthcare providers can identify patterns with tendencies that may be missed by traditional methods. For example, Big Data can be used to identify patients with undiagnosed hypertension, a major risk factor for cardiovascular disease [47]. Another benefit of the use of Big Data in vascular care is the ability to use predictive analytics to identify patients who are at risk of developing vascular disease. This can help healthcare providers develop targeted prevention and treatment strategies, resulting in better patient outcomes. For example, Big Data can be used to identify patients who are at risk for peripheral arterial sickness, permitting healthcare providers to implement early interventions to prevent complications. Big Data can also be used to improve the efficiency of healthcare delivery in vascular care. With analysis data on patient outcomes and resource utilization, healthcare providers can recognize areas for development with optimize treatment plans. This can result in cost savings and improved patient outcomes [48,49]. However, there are also challenges associated with the use of Big Data in vascular care. These include concerns around data privacy and security, the need for interoperability between different data sources, and the need for healthcare providers to be able to effectively analyze and interpret the data [50]. The usage of Big Data in vascular care has the potential to improve patient outcomes, reduce costs, and optimize healthcare delivery. However, healthcare providers must address the challenges associated with the use of Big Data to fully realize its potential authors.

4.1.4. The Importance of Patient Engagement in Digital Vascular Care

Digital tools can empower patients in taking an active role in the responsibility for their care by providing them with access to their own health data, educational resources, and self-management tools. One of the primary benefits of patient engagement in digital vascular care is improved communication between patients and healthcare providers. Digital technologies such as patient portals and telemedicine can enable patients to communicate with their healthcare providers more easily and efficiently. This can increase the quality of care by allowing healthcare suppliers to monitor patients' conditions to adjust treatment plans as necessary [51–53]. Moreover, patient engagement in digital vascular care can help patients better manage their conditions. By providing patients with access to educational resources and tools to monitor their symptoms, digital technologies can empower patients to take control of their care. For example, patients can use mobile apps to track their blood pressure, cholesterol, and other vital signs and share this data with their healthcare providers. Another benefit of patient engagement in digital vascular care is improved medication adherence. Digital technologies can remind patients to take their medications on time and provide them with information about their medications' side effects and interactions. This can lead to better medication adherence and fewer hospitalizations. Patient engagement in digital vascular care can also improve patient satisfaction. By providing patients with greater access to their healthcare providers and the tools they

need to manage their conditions, digital technologies can enhance patient experience. This can result in improved patient loyalty and greater patient retention. However, there are also challenges associated with patient engagement in digital vascular care. These include concerns around data privacy and security, the need for patient education and training, and the need for healthcare providers to effectively communicate with patients. Patient engagement is a critical aspect of digital vascular care that can significantly improve patient outcomes. Healthcare providers must address the challenges associated with patient engagement to fully realize the potential of digital technologies in vascular care [54].

4.1.5. New Developments in Digital Vascular Imaging

Advances in digital imaging technology, such as 3D modeling and virtual reality, are changing the way vascular imaging is performed and improving accuracy and precision in diagnosis. In recent years, there have been several new developments in digital vascular imaging that have further improved its diagnostic capabilities and patient outcomes. One of the most significant new developments in digital vascular imaging is three-dimensional (3D) printing technology. Three-dimensional printing technology can be used to produce physical models of a patient's blood vessels, allowing healthcare providers to better understand the anatomical structure and identify potential issues. This technology can also help healthcare providers to plan complex surgical procedures and optimize treatment outcomes [55,56]. Another significant development in digital vascular imaging is the use of artificial intelligence (AI) and machine learning algorithms. These technologies can help healthcare providers analyze large amounts of data and identify patterns that may not be apparent to the human eye. AI and machine learning algorithms can be used to increase the exactness of diagnosis and treatment planning and reduce the risk of complications. Furthermore, there have been developments in digital vascular imaging modalities such as ultrasound and magnetic resonance imaging (MRI). These technologies have become more advanced, allowing for more detailed and precise images of the blood vessels and organs. For example, contrast-enhanced ultrasound and dynamic MRI can provide detailed images of blood flow and vascular abnormalities that were previously difficult to visualize. Moreover, the use of virtual reality (VR) in digital vascular imaging has also shown promise in recent years. VR technology can create a 3D virtual environment that allows healthcare providers to visualize the blood vessels and organs in a more immersive way. This technology can be used for preoperative planning, surgical training, and patient education. AI and machine learning algorithms, advanced ultrasound and MRI technologies, and VR are improving the accuracy and precision of diagnosis and treatment planning for vascular diseases. These technologies have the potential to significantly improve patient outcomes and reduce the risk of complications. However, their adoption and integration into clinical practice require careful consideration of the challenges and opportunities presented by these technologies [57,58]. There is a need for a multidisciplinary approach to digital vascular care: effective digital vascular care requires collaboration between a range of healthcare professionals, including vascular surgeons, radiologists, nurses, and technicians.

5. Conclusions

In recent years, digital transformation has emerged as a critical strategy for improving healthcare delivery and patient outcomes. This systematic review aimed at ascertaining current trends in digital transformation in vascular healthcare, key focus areas for advancing digital health innovation in circulatory health systems, the benefits of digital transformation in vascular systems for peritonitis, the challenges and barriers to implementing digital health innovations in circulatory health systems, the best practices for the successful implementation of digital health technologies in vascular healthcare, and the impact of digital transformation on patient outcomes in circulatory health systems. The findings of this review indicate that digital transformation is gaining momentum in vascular healthcare, with the use of telehealth services, artificial intelligence, and mobile health technologies becoming increasingly common. Telehealth has emerged as a popular strategy for remote

patient monitoring, virtual consultations, and improving patient access to care. Artificial intelligence is being utilized for predictive modeling and decision support, while mobile health technologies are being used for patient engagement and self-management. This review identified several key focus areas for advancing digital health innovation in circulatory health systems, including data analytics, interoperability, and patient-centered care. Data analytics is a critical focus area for enabling effective population health management and improving patient outcomes. Interoperability is essential for integrating data from multiple sources and ensuring seamless communication between healthcare providers. Patient-centered care is another key focus area which involves incorporating patient preferences, needs, and values into the design and delivery of healthcare services. This review found that prioritizing digital transformation in vascular healthcare offers several benefits, including increased efficiency, improved patient outcomes, and reduced costs. For example, the use of a telehealth service can lead to reduced hospital readmissions and improved patient satisfaction. Digital transformation can also enable better management of chronic conditions, such as diabetes and hypertension, by providing patients with real-time monitoring and self-management tools. Despite the benefits of digital transformation, this review identified several challenges and barriers to its implementation, including limited resources, a lack of interoperability, and data security concerns. These challenges must be tackled for the good application of digital health technologies in circulatory health systems. This review identified best practices for the successful implementation of digital health technologies in vascular healthcare, which include stakeholder engagement, clear communication, and the proper training of healthcare providers. Stakeholder engagement is essential for obtaining buy-in from all parties involved in the implementation process. Clear communication is necessary for ensuring that all stakeholders understand the goals and objectives of the implementation, and the role of the stakeholder is the implementation of policy. The proper training of healthcare providers is crucial for ensuring that they are equipped with the skills and knowledge necessary to use digital health technologies effectively. Finally, this review found that the impact of digital transformation on patient outcomes in circulatory health systems is positive. The use of digital health technologies can lead to reduced hospital re-admissions, improved patient satisfaction, and better management of chronic conditions. These findings underscore the importance of prioritizing digital transformation in vascular healthcare and provide insights into the key focus areas for advancing digital health innovation in circulatory health systems. This systematic review highlights the importance of digital transformation in vascular healthcare and provides insights into the key focus areas for advancing digital health innovation in circulatory health systems. This review identifies the benefits of prioritizing digital transformation and the challenges and barriers to its implementation. The best practices for its successful implementation are also identified, as are as the positive impacts of digital transformation on patient outcomes in circulatory health systems. Ultimately, the findings of this review provide a roadmap for healthcare providers, policymakers, and other stakeholders to prioritize digital transformation and improve patient outcomes in circulatory health systems.

Future Research

Based on the conclusions drawn from the systematic review, several areas for future research can expand our understanding of digital transformation in vascular healthcare:

- Exploring the role of emerging technologies: While this review highlights the growing use of telehealth services, artificial intelligence, and mobile health technologies in vascular healthcare, there is potential for additional emerging technologies to be adopted. Future research could explore the roles of virtual and augmented reality, wearable devices, and blockchain in advancing digital health innovation in circulatory health systems.
- Evaluating the impact of digital transformation on health equity: This review indicates that digital transformation has the possibility of improving healthcare access and outcomes for patients with vascular conditions. However, it is essential to investigate

the influence of digital health technologies on health equity and to identify potential disparities that may arise from the implementation of these technologies.

- Examining the implementation of digital transformation in low-resource settings: While digital transformation has the potential to revolutionize healthcare delivery, it may be more challenging to implement in low-resource settings. Future research could focus on identifying best practices for implementing digital health technologies in resource-limited environments, as well as assessing the impact of these technologies on patient outcomes in these settings.

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Appendix A

Table A1. Components of vascular digital health care.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
1	Electronic Health Records (EHRs)	For tools for records of patient health information.	[59]	2	Picture Archiving and Communication Systems (PACS)	The system needed in the storage and retrieval of medical images.	[60]
3	Radiology Information Systems (RIS)	Systems for managing radiological images and data.	[61]	4	Computerized Physician Order Entry (CPOE)	System for electronically entering medical orders.	[62]
5	Clinical Decision Support Systems (CDSSs)	Systems for providing real-time guidance to clinicians in making diagnoses and treatment decisions.	[63]	6	Telehealth and Telemedicine	Systems for remote medical consultations and treatment.	[64]
7	Health Information Exchange (HIE)	System for sharing patient health information between healthcare providers.	[65]	8	Patient Portals and Mobile Apps	Systems for patients to access their health information and connect with their healthcare providers.	[66]
9	Wearable Devices and Sensors	Systems for monitoring patients' health statuses and activities.	[67]	10	Internet of Things (IoT)	System for connecting devices to the internet to enable data sharing and analysis.	[68]
11	Artificial Intelligence (AI) and Machine Learning (ML)	Systems for analyzing patient data and providing predictive analytics.	[69]	12	Natural Language Processing (NLP)	System for analyzing and extracting data from unstructured text.	[70]

Table A1. Cont.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
13	Clinical Analytics and Big Data	System for analyzing large amounts of patient data to identify patterns and trends.	[71]	14	Predictive Analytics, and Modeling	System for predicting future health outcomes based on patient data.	[72]
15	Population Health Management (PHM)	System for managing the health of a specific population or group of patients.	[73]	16	Clinical Trials Management Systems (CTMS)	Systems for managing clinical trials and study data.	[74]
17	Electronic Data Capture (EDC) Systems	System for collecting clinical trial data electronically.	[75]	18	Clinical Document Management Systems (CDMSs)	System for managing clinical documents and records.	[76]
19	Data Warehousing and Business Intelligence (BI) Systems	System for storing and analyzing large amounts of data.	[77]	20	Electronic Prescribing (eRx)	Enables healthcare providers to electronically send accurate and error-free prescriptions to pharmacies, enhancing patient safety and medication adherence.	[37]
21	Medication Reconciliation Systems	Aid in identifying and resolving discrepancies in medication lists across different care settings to ensure accurate medication information, reduce medication errors, and improve patient outcomes.	[38]	22	Patient Identification and Matching Systems	Help in accurately identifying and matching patients across multiple healthcare settings and systems, reducing the risk of medical errors and duplicate records.	[39]
23	Clinical Registry Systems	Collect and analyze data on specific patient populations to improve healthcare outcomes and support research activities.	[40]	24	Health Information Privacy, and Security Systems	Ensure privacy, and integrity, with the availability of sensitive patient health information, safeguarding patient privacy and protecting against security threats.	[41]
25	Authentication and Access Control Systems	Verify the identity of users and grants appropriate levels of access to health information based on user roles, protecting against unauthorized access and breaches.	[42]	26	Audit Trail and Monitoring Systems	Record and monitor user activities in electronic health records with other health information systems, enabling healthcare organizations to detect and respond to security incidents and breaches.	[78]

Table A1. Cont.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
27	Cloud Computing and Storage	Enables securing storage with sharing of electronic health records and other health information in a scalable and cost-effective manner, improving access to health information and supporting collaborative care.	[79]	28	Blockchain Technology	Provides a secure and tamper-proof platform for the storage and sharing of health information, enhancing privacy and security and supporting interoperability across different health information systems	[80]
28	Application programming interfaces (APIs)	Enable the integration and interoperability of different health information systems and applications, supporting the exchange of health information and enhancing patient care coordination.	[81]	30	Fast healthcare interoperability resources (FHIRs)	Provide a standardized format for exchanging health information between different health information systems and applications, supporting the interoperability of health information technology.	[82]
31	Health Level Seven International (HL7) Standards	Provide a set of values for the exchange, incorporation, and distribution, with the retrieval of electronic health information, enabling interoperability across different healthcare systems and applications.	[83]	32	International Statistical Classification of Diseases and Related Health Problems (ICD)	The ICD is a standardized system for coding diseases and other health conditions which helps to enhance the accuracy and the effectiveness of clinical documentation with billing. Its function is to provide a common language for healthcare professionals, researchers, and policymakers to communicate about health conditions and their impact.	[84]
33	Systematized Nomenclature of Medicine	Clinical Terms (SNOMED CT): SNOMED CT is a wide-ranging clinical terminology system that provides a standardized vocabulary for the description of clinical concepts, such as diagnoses, procedures, and observations. Its function is to enhance the exchange and division of clinical information among healthcare providers, organizations, and information systems.	[85]	34	Logical Observation Identifiers Names and Codes (LOINC)	LOINC is a standardized system for recognizing laboratory and clinical comments, such as blood tests, imaging studies, and important signs. Its function is to facilitate the interoperability and sharing of laboratory and clinical data across different healthcare organizations and systems.	[86]

Table A1. Cont.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
35	Unified Medical Language System (UMLS)	The UMLS is a comprehensive knowledge base that integrates several clinical terminologies and terminologies, such as SNOMED CT, and ICD, with LOINC. Its function is to enable the mapping and translation of different clinical terminologies and codes, which improves the interoperability and integration of clinical information across different healthcare systems and applications.	[87]	36	Clinical Quality Measures (CQMs):	CQMs are standardized measures of healthcare quality that are used to evaluate and improve the performance of healthcare providers and organizations. Their function is to provide a framework for measuring and reporting on the quality of care, based on clinical guidelines and evidence-based practices.	[88]
37	Electronic Clinical Quality Measures (eCQMs)	eCQMs are CQMs that are calculated and reported electronically using data from electronic health records (EHRs) with other clinical facts systems. Their function is to automate the measurement and reporting of healthcare quality, which reduces the burden on healthcare providers and improves the accuracy and timeliness of quality reporting	[89]	38	Quality Improvement (QI) Tools and Techniques	QI tools and techniques are methods and approaches for identifying, analyzing, and improving healthcare quality and safety. Their function is to provide a structured and systematic approach to quality improvement, based on data-driven and evidence-based practices. Examples of QI tools and techniques include root cause analysis, fishbone diagrams, Plan-Do-Study-Act (PDSA) cycles, and Lean Six Sigma methodologies.	[90]
39	Lean Six Sigma (LSS)	LSS is a methodology that combines principles of Lean manufacturing and Six Sigma quality management to improve process efficiency and effectiveness. Its function is to reduce waste, variability, and defects in healthcare processes, improving patient safety and satisfaction.	[91]	40	Rapid Cycle Improvement (RCI) Function	Rapid Cycle Improvement (RCI) is a quality improvement methodology used to identify and test changes in a process or system quickly and iteratively. It involves making small and frequent changes and analyzing the results to determine whether the change has improved the process or not. RCI is used to achieve measurable and sustained improvement in healthcare delivery.	[92]

Table A1. Cont.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
41	Plan-Do-Study-Act (PDSA) Function	Plan-Do-Study-Act (PDSA) is a value enhancement framework used to test and implement modifications in a process or system. It involves four stages: plan, do, study, and act. PDSA is an iterative process that enables healthcare professionals to make small and incremental changes, test the changes, and evaluate their effectiveness.	[93]	42	Human Factors Engineering (HFE) Function	Human Factors Engineering (HFE) is the application of scientific knowledge about human behavior and capabilities to the model of structures and mechanisms. HFE is used to improve the usability and safety of healthcare products, devices, and systems. It involves the consideration of the needs, abilities, and limitations of healthcare professionals and patients in the design process.	[94]
43	Usability Testing and User Experience (UX) Design Function	Usability testing and user experience (UX) design are used to evaluate and improve the usability of healthcare products, devices, and systems. Usability testing involves observing users as they relate to a product or system to identify complications and areas for improvement. UX design comprises designing products and systems with the user's requirements and favorites in mind.	[95]	44	Agile and Scrum Development Methodologies Function	Agile and Scrum development methodologies are used in software development to improve the speed, flexibility, and quality of the development process. These methodologies involve breaking the development process into small and manageable parts, with frequent testing and evaluation of each part. Agile and Scrum methodologies enable healthcare organizations to quickly adapt to changing needs and requirements.	[96]
45	Project Management and Change Management Systems Function	Project management and change management systems are used to plan, execute, and monitor healthcare projects and initiatives. These systems enable healthcare organizations to implement changes and improvements in a structured and organized manner, minimizing disruptions and ensuring the success of the project.	[97]	46	Electronic informed consent (eIC)	Enables patients to electronically sign informed consent documents, improving the efficiency of the consent process and reducing errors.	[98]

Table A1. Cont.

S/N	Components	Functions	Ref	S/N	Components	Functions	Ref.
47	Digital Imaging and Communication in Medicine (DICOM)	Provides a standardized format for storage and communicating medical images, enabling the exchange of medical images between different healthcare providers and systems.	[99]	48	E-learning	E-learning contributes to the development and implementation of effective vascular digital healthcare strategies.	[100]

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