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Understanding Similarities and Differences of Digital Health Platforms: Towards a Taxonomy

Research Paper

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Abstract. The increasing importance of Digital Health Platforms (DHPs) necessitates the development of a systematic approach to their categorisation and evaluation in order to optimise the integration of DHPs into the healthcare system. The paper develops a taxonomy for DHPs comprising 19 dimensions along the four meta-charecteristics Legal and Economic Aspects, Technology and Standards. By applying the taxonomy to the Apple Health platform, we demonstrate its practicability and potential to identify platform-specific characteristics, which can help with strategic positioning within the healthcare sector. The taxonomy also helps managers and developers to identify DHP's characteristics and act according to needs. Further research opportunities exist in adapting and extending the taxonomy to account for evolving trends and innovations in the field.

Keywords: Digital Platform, Digital Health, Digital Health Platform, Taxonomy.

1 Introduction

The digital transformation of the healthcare sector presents significant challenges and opportunities. Digital Health Platforms (DHPs) play a central role in this transition by enhancing the integration and efficiency of healthcare delivery (Bundesministerium für Gesundheit, 2023). DHPs are complex digital systems that extend beyond simple health apps to create integrated ecosystems by connecting multiple sides (e.g. patients, physicians and developers) through code. The market for digital health solutions, including telemedicine and mobile health (mHealth), is projected to exceed $650 billion by 2025 (Statista, 2024). The COVID-19 pandemic has further underscored the importance of DHPs, with the telemedicine market expected to grow to $280 billion by 2025 (Statista, 2024).

Current research highlights the need for detailed analysis and categorization of digital health platforms (DHPs) (Chrobok, 2023; Choueiri et al., 2020). Meister et al. (2017) underscore the importance of a comprehensive taxonomy to fully leverage digitalization in healthcare. The absence of such a taxonomy creates challenges in evaluating DHPs, hindering comparison and generalization of research findings (Asadullah

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et al., 2018; Blaschke et al., 2019; Staub et al., 2020; Gregor, 2006). Therefore, a systematic taxonomy is essential to consolidate existing knowledge about DHPs, guide their design, assure external and internal fit, and assess risks, patterns, and characteristics (Schermuly et al., 2019; Tiwana, 2014). A DHP taxonomy is essential for improving clarity, comparison, integration, compliance, market understanding, patient care, and research within the rapidly evolving field of digital health. In light of these considerations, our study aims to address the following research question:

How does a comprehensive taxonomy of DHPs look like that enhances DHP categorization, evaluation, and integration within the healthcare system?

This question will guide the development of a taxonomy that captures the diverse dimensions of DHPs. We develop the taxonomy following the taxonomy development method by Nickerson et al. (2013). The derived taxonomy encompasses 19 dimensions along four meta-characteristics. Our taxonomy provides a conceptual framework for better understanding DHPs and facilitating future research and theorizing regarding DHPs by establishing comparability among DHPs therby enhancing their effective utilization.

2 Research Background

Digital platforms (DPs) represent a complex phenomenon that cannot be fully captured by a single definition due to their diverse functions and manifestations (Hein et al., 2019; Sidorenko, 2022). According to Sidorenko (2022), they are best understood as software-based systems built upon a modular technological architecture. This architecture facilitates the coordination of external actors within an ecosystem, who may either drive innovation or compete with each other. As central hubs, DPs connect businesses or individuals to enhance the exchange of complementary services and products. From a service perspective, DPs act as bridges, facilitating interaction between different user groups such as providers and consumers. From a technological perspective, they are seen as tailored technical solutions designed to support and enhance digital interactions and exchange of digital information. Additionally, an ecosystems perspective views DPs as expansive digital ecosystems where numerous actors interact and cooperate to collectively create and share value.

The field of digital health encompasses the use of information and communication technologies within the healthcare sector, aiming to enhance both the treatment of diseases and the promotion of health. This is achieved through the targeted utilisation of digital data, images and other forms of information (WHO & ITU, 2020). The field of digital health is expansive, encompassing various sub-disciplines such as mobile health (mHealth), health informatics, wearable technologies, telemedicine and personalised medicine (Aanstadt et al., 2017). Digital health therby demonstrated the capability to enhance therapeutic results and overall well-being of the population while offering opportunities for more efficienct delivery of care (U.S. Food & Drug Administration, 2020; Hibbard and Greene, 2013; Shortell et al., 2017)

DHPs are digital multi-sided platforms in the healthcare sector that foster coordination, interaction, and exchange among otherwise independent parties (Fürstenau et al., 2019; Frishammar et al., 2023; Gawer & Cusumano, 2013). Broadly, DHPs do this via their extensible codebase “that provides core functionality shared by the modules that interoperate with it and the interfaces through which the agents interoperate” (Tiwana et al., 2010). The delivery of healthcare is especially complex as multiple highly specialized actors are involved, which different initiatives around the world found out in their efforts to enhance the sector's capacity and efficiency, increase service quality or reduce its costs (Aanestad et al., 2017; Malm-Nicolaisen et al., 2023). DHPs need to be differentiatied from individual health apps. While health apps often serve as access points to DHPs for end users, DHPs represent an integrative ecosystem that goes far beyond the functionalities of a single app. DHPs connect various actors, applications and services, and are central to digital health.

3 Methodology

Taxonomies are important tools used to "bring order to complex areas" by categorizing dimensions or characteristics and identifying similarities within the topics under study (Nickerson et al., 2013, p. 535). To develop a comprehensive taxonomy for DHPs, we employed a structured approach integrating a systematic literature review with the taxonomy development framework as proposed by Nickerson et al. (2013).

At the outset we defined three meta-characteristics for selecting and classifying DHPs within the taxonomy. Refelcting our interest in a socio-technological description of DHPs we formed the two charecteristics of “Economic Aspects” and “Technology”. We supplemented them with “Legal Aspects” as the healthcare sector is highly regulated. Like Nickerson et al (2013) observed, it was later in the development process that another meta-characteristic’s (“Standards”) high importance for the healthcare sector and heance for our taxnomy became appartent to us and was added.

As outlined by Nickerson et al. (2013), both subjective and objective criteria were established as ending conditions for the taxonomy development. These included a thorough examination of our sample and ensuring that no new dimensions or characteristics were added in the final iteration (saturation). The ending conditions of the taxonomy were designed to ensure conciseness, robustness, completeness, extendibility, and explanatory power. This was done to guarantee that the taxonomy was subjected to a rigorous review and adjustment process, thus maintaining its applicability and relevance for the systematic evaluation of DHPs (Nickerson et al., 2013).

We initiated the review of relevant literature with multiple searches of academic databases using the search strings as outlined in Table 1.

Table 1. Search String for Data collection

Search String	Applied Databases
“Digital Platform” OR “Digital Health*” AND (“Taxonomy” OR “legal" OR “compliance” OR “technology” OR “*Management” OR “economic” OR “Business Models” OR “Research Methodology” OR “Health Impact” OR “characteristics” OR “strengths” OR “weaknesses”	PubMed, Journal of Medical Research IEEE, AIS Electronic Library, ScienceDirect, Google Scholar

This process initially yielded 331 papers. We first examined the titles and abstracts to filter out what did not meet the inclusion criteria (articles focusing on either DPs, digital health or DHPs). We then reviewed the full texts and discarded those that did not meet our follow-up criteria (e.g. articles that lacked detailed information about DHPs, dealt with processes like implementation or development of DHPs or had a very narrow focus (as we thrive to gain a general understanding of DHPs)). To further enrich our literature sample, we conducted a forward and backward search. We also included gray literature, such as practice reports or white papers in our analysis, which supplemented our understandimg from a practical perspective. In the end, 61 articles formed the basis of our study.

Throughout the literature search and taxonomy development we adopted both conceptual-to-empirical (C2E) and empirical-to-conceptual (E2C) approaches (Nickerson et al., 2013). This allowed us to utilize deductive and inductive strategies, as described by Nickerson et al. (2013). Following an E2C analysis of existing DP taxonomies and the limited literature on DHPs, the taxonomy was designed and progressively refined through the C2E approach as outlined in Figure 1.

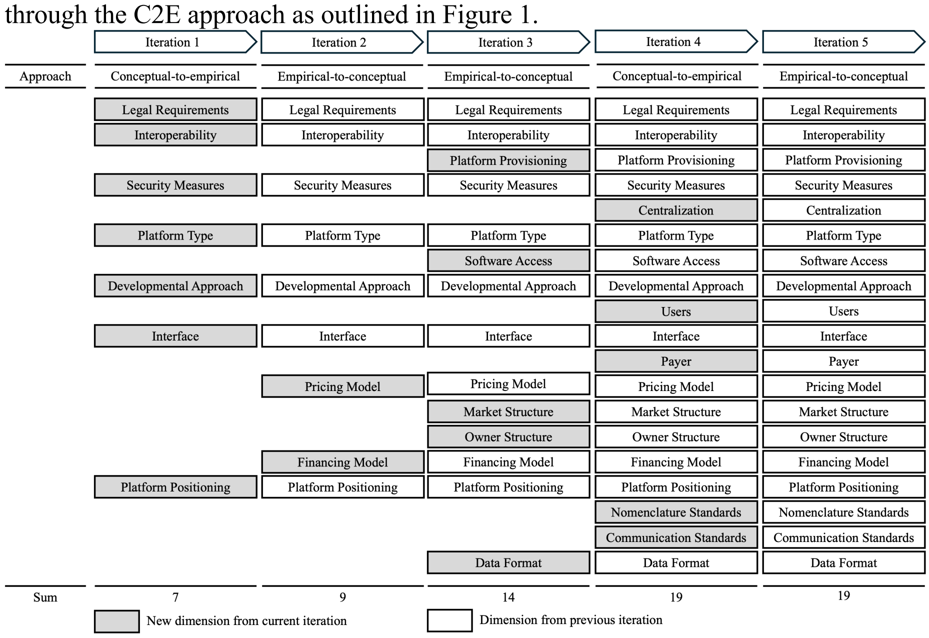

Figure 1. Development of Dimensions for the Digital Health Platform Taxonomy (presentation following Remane et al. (2016) adjusted for our research)

The subsequent stage involved the demonstration and evaluation of the taxonomy's relevance and efficacy in real-world contexts, with the objective of validating its practicality and usefulness for future applications (Nickerson et al., 2013). We selected Apple Health for this analysis due to its wide adoption, comprehensive integration of various health data sources, its significant impact on the digital health landscape and availablilty of data.

4 Digital Health Platform Taxonomy

Our DHP taxonomy showcased in Table 2 comprises four meta-characteristics: Legal, Technology, Economic, and Standards. Within these four meta-characteristics, a total of 19 dimensions are included. We classify dimensions as either exclusive (E) or non-exclusive (N), enabling precise analysis by indicating whether individual or multiple attributes can simultaneously apply to a DHP.

Table 2. Taxonomy for Digital Health Platforms

	Dimensions	Characteristics			E/N
Legal	**Legal Requirments**	Encryption	Anonymisation	Access control	N
	Interoperability	Open	Closed		E
Technology	**Platform Provisioning**	Private Cloud	Public Cloud	Hybrid Cloud	N
		On-Premises	On-Device		
	Security Measures	Encryption	Authentification	Physical Access	N
	Centralization	Central	Hybrid	Decentral	E
	Platform Types	Dataplatform	Metaplatform	Marketplace	N
		Horizontally-integrated	Vertically-integrated		
	Software Access	Open-Source-Software	Proprietary Software		E
	Developmental Approach	User-centric	Technology-centric		N
		Institution-centric	Information-centric		
	Users	Professionals	Patients	Insurances	N
		Developers	Researchers		
	Interfaces	Third-Party (API)	Web-based	PC-Client	N
		Mobile	Wearable		
Economic	**Payer**	Professionals	Patients	Partner / Developer	N
		Insusrances	Public		
	Pricing Model	per Use(r)	One-Off	Subscription	N
		Provisions	Advertisement	Data Brokerage	
	Market Structure	First healthcare market	Second healthcare market	Third healthcare market	N
	Owner Structure	Government	Private Company		E
		Non-Governmental Org.	Public-Private Partnership		
	Financing Model	Commercial	Public welfare oriented	Hybrid	E
	Platform Positioning	Specialized	Integrative		N
Standards	**Nomenclature Standards**	SNOMED	LOINC	ICD	N
		CPT	RxNorm		
	Communication Standards	HL7	FHIR	XDS	N
	Data Formats	DICOM	CCD	CDA	N

4.1 Meta-characteristic Legal

This meta-characteristic addresses the required security measures DHPs have to comply with for maintaining security, privacy, and operational integrity (Biasin et al., 2023). It emphasizes the importance of aligning DHP operations with legal standards to ensure compliance with privacy laws that protect sensitive health information. The dimension focuses on two critical areas: legal requirements and interoperability.

The integration of **Legal Requirements** is a legal necessity for the security and privacy of DHPs. Adhering to legal requirements for security practices such as encryption, anonymization, and access control is crucial to ensure the protection of sensitive health data and to comply with especially strict regulatory standards (Biasin et al., 2023; Rasche & Raab, 2023; Richter et al., 2023). Depending on the sensivity of the data, the legislator may impose varying degrees of stringent requirements for data handling. Advanced encryption techniques and strict access permissions protect against data misuse and promote user trust (Oh et al., 2021; Rodrigues et al., 2013; De Oliveira et al., 2022).

Interoperability is a key element in the operation of DHPs and is encouraged by regulatory frameworks. The ability of different systems and applications to efficiently exchange data and collaborate is critical to achieving comprehensive healthcare. Open platforms use APIs to facilitate the development of new services and encourage innovation, while closed systems provide a high level of security and continuity through their restrictive measures. The choice of platform architecture must meet both regulatory requirements and the technical and functional needs of DHPs (Asadullah et al., 2018; Malm-Nicolaisen et al., 2019; Nikayin et al., 2012).

4.2 Meta-Characteristic Technology

The Technology meta-characteristic employs a critical evaluation of the technological configuration that is essential to DHPs. It emphasizes key components and their functional characteristics, thereby illuminating the technological foundations that shape the efficiency and flexibility of digital solutions.

Platform Provisioning is a crucial aspect of DP structure, as highlighted in different contexts (e.g. Arnold et al. (2022), Richter et al. (2023)). It covers configurations such as private, public, and hybrid clouds, as well as on-premises setups. Private clouds provide enhanced control and security, which is vital for maintaining data privacy (Mahmoudi, 2017; Stephanie & Sharma, 2020). Although public clouds are cost-effective and scalable, they present inherent security risks (Knapcikova et al., 2022; Mahmoudi, 2017). Hybrid clouds combine the benefits of both, offering flexible data management ideal for digital health (Knapcikova et al., 2022; Mahmoudi, 2017). On-premises configurations ensure maximal data control (Fisher, 2018; Saa et al., 2017; Winkler & Brown, 2013), and on-device models reduce data breach risks by processing data locally on user devices.

The technical **Security Measures** dimension encompasses encryption, authentication, and physical access controls – key mechanisms to protect data integrity and confidentiality. As highlighted by Richter et al. (2023), encryption secures data confidentiality by restricting access to unauthorized users. Authentication verifies identities to secure access (Kwon & Johnson, 2018). Physical access control limits access to essential infrastructure to authorized personnel only (Richter et al., 2023). These measures collectively play a vital role in mitigating data breaches and boosting trust in digital infrastructures, which must continually adapt to evolving cyber threats.

The **Centralization** dimension categorizes DHPs into centralized, decentralized, and hybrid control structures, as detailed by Gelhaar et al. (2021) and the WHO & ITO (2020). Centralized DHPs centralize processes on the platform, utilizing external applications as front-end interfaces (Gelhaar et al., 2021; WHO & ITU, 2020). Decentralized DHP structures distribute processes and responsibilities while enhancing data management flexibility (Gelhaar et al., 2021; WHO & ITU, 2020). Hybrid models integrate both centralized and decentralized elements, thereby improving both flexibility and functionality (WHO & ITU, 2020).

The **Platform Types** dimension distinguishes data platforms, which analyze large datasets to enhance diagnosis and treatment; horizontally integrated platforms, which offer comprehensive care in specific medical domains; vertically integrated platforms, which connect various stages of healthcare for a holistic approach; meta-platforms, which combine horizontal and vertical elements to form extensive healthcare networks; and marketplace platforms, which facilitate the commerce of healthcare products and services, furthering healthcare digitization (Choueiri et al., 2020; Chrobok, 2023).

The **Software Access** dimension examines the rights and permissions granted to users and stakeholders to engage with, utilize, or modify DHPs. For instance, open-source software permits direct interaction with the software code, fostering innovation and customization (Aalami et al., 2023). Conversely, proprietary software restricts access to its source code to the owning company, thereby providing controlled environments and professional support strengthending operational security (Reynolds et al., 2011).

Recent advances in IS in healthcare are characterized by a multidimensional **Developmental Approach** that incorporates various academic perspectives. Richter et al. (2023) emphasize the integration of technological infrastructure and user information requirements for comprehensive DP designs. Aanstad et al. (2017) explore the integration of scalable and interoperable information infrastructures in healthcare, underscoring the need for systems that adapt to varying environmental demands. Maschewski & Lemmer (2023) advocate for a patient-centric framework that prioritizes patient enablement, empowerment, and engagement, reinforcing the user-centric dimension.

DHPs serve a diverse range of **Users**, unique to the healthcare sector and each with individual needs, preferences, and roles (Aanstad et al., 2017; Maschewski & Lemmer 2023). By addressing the needs, preferences and roles of each group, DHPs empower individuals and organizations to collaborate, communicate, and leverage technology to enhance health outcomes and promote well-being across the continuum of care (Maschewski & Lemmer 2023; Hibbard and Greene, 2013; Shortell et al., 2017).

DHPs utilize a variety of **Interfaces** to facilitate interaction, data exchange, and engagement between users, systems, and devices (Staub et al., 2021; WHO & ITU, 2020). These interfaces are designed to accommodate a wide range of needs, preferences, and technical requirements, ensuring seamless access to healthcare services and information. Interfaces play a pivotal role in extending the reach, accessibility, and functionality of DHPs, empowering its users (Staub et al., 2021; WHO & ITU, 2020).

4.3 Meta-Characteristic Economic

In the Economic meta-characteristic of DHPs, the economic setup is illuminated in order to shed light on the operational and strategic dynamics of DHPs.

The **Payer** dimension illuminates the various motivations that compel stakeholders to pay for DHPs. Due to the distinctive nature of the healthcare sector, a multitude of actors may be inclined or compelled to bear a portion of the cost for developing or running a DHP (Aanstad et al., 2017; Fürstenau et al., 2019). Depending on the general configuration of the DHP, patients are frequently subsidized in order to facilitate adoption (Aanstadt et al., 2017; Tiwana, 2014).

The **Pricing Model** dimension reveals how DHPs employ pricing models to meet the needs and preferences of the platform operator and the platform's strategic positioning, ensuring compliance with applicable laws (Fürstenau, 2019; Chrobok, 2023; Staub et al., 2021). The pricing models vary in terms of cost structure, payment flexibility, and value proposition (Tiwana, 2014). A platform may employ multiple pricing strategies concurrently, contingent on the targeted payer. Also factors such as user demographics, use cases, payer structure, and desired outcomes within the highly regulated healthcare sector are reflected (Tiwana, 2014; Fürstenau, 2019, Chrobok, 2023).

The dimension **Market Structure** allows for the classification of DHPs into three distinct healthcare markets: traditional medical treatment systems (often paid for by insurances), preventive care markets (often paid for by patients themselves), and shared economy models enhancing community health networks. This classification helps elucidate the roles DHPs play in healthcare delivery and wellfare, with each market presenting unique challenges and opportunities for system innovation and efficiency (Chrobok, 2023). DHPs may engage in one or multiple of these markets depending on the individual users condition. For instance, diet tracking DHPs functions might be part of health prevention (second healthcare market) or treatment (first healthcare market).

Owner Structure examines the influence of different ownership forms on DHPs' strategic direction, operational priorities, and regulatory compliance. Ownership can range from government entities ensuring transparency and strict regulation to private companies potentially prioritizing profits. In addition, non-governmental organizations (NGOs) and public-private partnerships (PPPs) offer models that blend public oversight with private sector efficiency, aligning closely with public health objectives (Anttiroiko et al., 2014; Mineraud et al., 2016; Santana et al., 2018).

The **Financing Model** dimension examines financial frameworks that enable DHPs to sustain and scale operations. Commercial models prioritize profitability, focusing on innovation and efficiency to remain competitive (Mettler et al., 2012; Rasche & Raab, 2023). Public welfare-oriented models, supported by nonprofit organizations or public funding and using open-source technologies, emphasize accessibility and quality of healthcare, prioritizing societal benefits over financial returns (Rasche & Raab, 2023). Hybrid models combine free basic services with premium features, promoting scalability and user engagement by allowing users to test services before committing financially (Bruhn & Hadwich, 2018; Rasche & Raab, 2023).

The **Platform Positioning** dimension determines the architectural design and functionality of DHPs within the healthcare ecosystem. Specialized DHPs are designed to focus on specific services or functions. As a result, they require strong integration with other systems to address interoperability and sustainability challenges (Richter et al., 2023). Integrative DHPs support a centralized system with interoperable interfaces and open standards. This enables effective communication and collaboration across various healthcare services, fostering a cohesive healthcare environment (Richter et al., 2023).

4.4 Meta-Characteristic Standards

In the evolving landscape of digital healthcare, standards play a crucial role in ensuring interoperability, data integrity, and patient safety. These standards are guidelines or frameworks that define unique ways how data in the healthcare sector is structured, communicated, and utilized across various actors (Roehrs et al., 2017).

Nomenclature Standards primarily focus on establishing uniformity in the terminology used within digital health systems. This includes the naming conventions for medical conditions, procedures, medications, and other health-related entities. By adhering to standardized nomenclature, DHPs can communicate effectively with stakeholders and accurately interpret and exchange information. Nomenclature standards provide comprehensive sets of codes and terms for various clinical concepts (WHO & ITU, 2020; ISO, 2024; Roehrs et al., 2017).

Communication Standards address the protocols and formats used for exchanging health information between different systems. These standards ensure seamless interoperability and data exchange, regardless of the underlying technology or platforms involved. Communication standards define messaging and interface specifications for health data exchange and facilitate the transfer of clinical and administrative information between healthcare applications, electronic health records (EHRs), and other health IT systems (WHO & ITU, 2020; ISO, 2024; Roehrs et al., 2017).

Data Formats delineate the specific categories and formats of health data that are standardized for collection, storage, and transmission. For instance, DICOM standardizes the formats for medical imaging data or CCD and CDA specify the structure and content of clinical summaries and documents. These standards ensure consistency and accuracy in capturing different types of clinical and administrative information. They standardize the formats enabling interoperability and compatibility among various imaging devices and systems. Additionally they specify the structure and content of clinical summaries and documents, facilitating the exchange of patient information across different care settings (WHO & ITU, 2020; ISO, 2024; Roehrs et al., 2017).

4.5 Taxonomy Application

To demonstrate the taxonomy’s applicability, we evaluated Apple Health as a representative DHP. The results in Table 3 show how the taxonomy systematically categorizes DHPs. This structured analysis aids researchers in comparative studies and best practices. For management, it highlights the platform’s uniqueness, guiding strategic decisions and fostering innovation.

Legal. Apple Health's cybersecurity is reinforced by end-to-end encryption and controls like Passcode, Touch ID, and Face ID, ensuring that data is accessible only on trusted devices and parties (Apple Inc., 2023). Apple is unable to access encrypted data without user consent, and Differential Privacy further anonymizes user data (Hargitai et al., 2018). Interoperability is maintained through a closed platform model, where data sharing with third-party apps requires explicit user consent and reasoning for access requests (Apple Inc., 2023; Asadullah et al., 2018).

Technology. Apple Health emphasizes on-device processing to handle health data locally and protect user privacy (Apple Inc., 2023). The platform's security measures demonstrate its commitment to encryption, authentication, and physical access controls. HealthKit data is encrypted on-device and end-to-end for users with iOS 12 or later, and access to the Health app requires two-factor authentication and a passcode, ensuring that only authorized users can access the data. Health and fitness data is encrypted and only accessible with a passcode, ensuring user control and security (Apple Inc., 2023). Apple Health's hybrid nature allows for centralized data collection and processing on Apple devices and integration with external data sources, while maintaining full user control over their data (Apple Inc., 2023; Apple Inc., 2024c). As a data platform, Apple Health collects and processes health data from Apple devices and authorized third-party applications. As a horizontal integration platform, it consolidates disparate sources of health data. As a meta-platform, it shares data with healthcare providers to create a comprehensive network of health information and services (Apple Inc., 2024b). The software access for Apple Health is proprietary (Apple Inc., 2023). Apple Health is both user-centric and technology-centric, prioritizing patient empowerment and engagement while leveraging advanced technologies such as end-to-end encryption and on-device processing. This dual focus enhances the user experience and ensures data security (Apple Inc., 2023; Apple Inc., 2024c). It offers the Health SDK as an API and a mobile interface in the Health App (Apple Inc., 2023; Apple Inc., 2024c).

Economic. Apple Health is funded by patients who pay for the devices and by developers who pay to publish apps linked to Apple Health (Apple Inc., 2023; Apple Inc., 2024c). It is part of the second healthcare market, focused on individual wellness and prevention, and illustrates how DHPs are disrupting traditional market structures. The integration of external data sources, such as Adidas Running, underscores this dynamic (Apple Inc., 2023; Apple Inc., 2024c). Apple Health is a private company (Apple Inc., 2023) and uses a provision-based pricing model. It supports the development of third-party apps through the Apple Developer Program, charges fees to deploy apps in the App Store, and benefits from an extensive ecosystem (Apple Inc., 2020; Apple Inc., 2024a). Apple Health's business strategy promotes a dynamic and diverse offering of apps while supporting the distribution of Apple devices optimized for the use of these apps (Apple Inc., 2020; Apple Inc., 2024a). Apple Health represents a specialized platform with significant integrative capabilities, combining advanced health monitoring tools with comprehensive data aggregation capabilities (Apple Inc., 2023).

Standards. Apple Health utilizes standardized nomenclature systems to ensure that data recorded and shared across different devices and health systems is consistent and interpretable. One of the key nomenclature systems used is the LOINC (Apple Inc., 2024d). Additionally, for medication, Apple HealthKit supports coding systems like RxNorm, which provides normalized names for clinical drugs and is commonly used in pharmacy management and drug interaction software (Apple Inc., 2024d). Apple

Health primarily uses HealthKit, its proprietary framework, to manage the health data on iOS devices. HealthKit provides a secure container for storing health-related information and offers an API for developers to access and interact with that data. For interoperability with external health systems and EHRs, Apple supports the FHIR standard (Apple Inc., 2024e).

Table 3. Taxonomy Application Apple Health

Dimensions		Characteristics			E/N
Legal	**Legal Requirments**	Encryption	Anonymisation	Access control	N
	Interoperability	Open	Closed		E
Technology	**Platform Provisioning**	Private Cloud	Public Cloud	Hybrid Cloud	N
		On-Premises	On-Device		
	Security Measures	Encryption	Authentification	Physical Access	N
	Centralization	Central	Hybrid	Decentral	E
	Platform Types	Dataplatform	Metaplatform	Marketplace	N
		Horizontally-integrated	Vertically-integrated		
	Software Access	Open-Source-Software	Proprietary Software		E
	Developmental Approach	User-centric	Technology-centric		N
		Institution-centric	Information-centric		
	Users	Professionals	Patients	Insurances	N
		Developers	Researchers		
	Interfaces	Third-Party (API)	Web-based	PC-Client	N
		Mobile	Wearable		
Economic	**Payer**	Professionals	Patients	Partner / Developer	N
		Insusrances	Public		
	Pricing Model	per Use(r)	One-Off	Subscription	N
		Provisions	Advertisement	Data Brokerage	
	Market Structure	First healthcare market	Second healthcare market	Third healthcare market	N
	Owner Structure	Government	Private Company		E
		Non-Governmental Org.	Public-Private Partnership		
	Financing Model	Commercial	Public welfare oriented	Hybrid	E
	Platform Positioning	Specialized	Integrative		N
Standards	**Nomenclature Standards**	SNOMED	LOINC	ICD	N
		CPT	RxNorm		
	Communication Standards	HL7	FHIR	XDS	N
	Data Formats	DICOM	CCD	CDA	N

5 Discussion, Limitations, and Future Research

Our study aimed to address the lack of a systematic taxonomy for understanding DHPs, which have gained significant attention but lack a comprehensive classification framework. Existing research focuses on specific requirements or architectural elements without a holistic view. This limitation hinders the comparability of DHPs and the ability to draw broader conceptual insights. To address this we developed a taxonomy following Nickerson et al.'s (2013) method. By validating the taxonomy with the example of Apple Health we prove to that our work helps to enhance DHP categorization and evaluation, which in turn can support integrative efforts with the healthcare system.

Our taxonomy comprises four meta-characteristics and 19 related dimensions, providing a structured approach to categorizing DHPs. Our work contributes to both academic and practical fields by providing a detailed classification scheme that enhances understanding of the multifaceted nature of DHPs. The taxonomy allows researchers to better capture the unique characteristics of DHPs, supporting further theoretical developments and the design of more effective platforms. For practitioners, this taxonomy serves as a valuable tool for analyzing and distinguishing between different DHPs, facilitating platform development and optimization, promoting sustainable health improvements, and enhancing both patient satisfaction and therapeutic outcome.

Despite its contributions, this study has its limitations. First, the static nature of a taxonomy and the rapidly evolving field of digital health mean that we only provide a snapshot of the current state of DHPs. This limitation means that we cannot guarantee the completeness of the dimensions and characteristics identified. Second, we did not explore in detail the potential interrelationships between individual characteristics and dimensions. Third, some dimensions, such as cybersecurity, may have limited utility in distinguishing different types of DHPs, as robust cybersecurity measures are a universal requirement for all platforms. Nevertheless, we included this dimension to highlight its critical importance and the need for detailed future research on cybersecurity implementations to improve differentiation. Although we followed established guidelines and used both E2C and C2E approaches, additional empirical validation is encouraged to verify the robustness of the taxonomy.

Future research should focus on identifying specific archetypes of DHPs to allow for a more nuanced classification. By examining these archetypes, researchers could explore whether certain types of DHPs are more effective than others in certain setting, leading to the derivation of specific design principles for DHPs. In addition, further exploration of the relationships between dimensions and their characteristics may provide deeper insights into the design and performance of DHPs, contributing to the continuous improvement of DHPs. In conclusion, while our taxonomy provides a structured and comprehensive framework for understanding DHPs, ongoing research and empirical validation are essential to adapt and refine our taxonomy in response to the evolving digital health landscape.

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