MAPPING THE LANDSCAPE OF DIGITAL HEALTH USAGE IN INFORMATION SYSTEMS RESEARCH

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This study investigates the use of digital healthcare in information systems (IS) research, emphasizing the need for a nuanced understanding of the conflation of related terms. The lack of an agreement on the definition of "digital healthcare usage" in research within this domain complicates assessing its impact. A conceptual framework is essential to clarify these terms and facilitate further investigation of digital health in IS. Through a combined quantitative and qualitative analysis of 5510 carefully identified articles from the IS literature, we outlined the landscape of digital healthcare usage. This groundwork is a crucial stepping stone for understanding technology integration and users' engagement, pivotal for sustainable digital health development. The analysis revealed evolving trends in digital health research, shifting from utility, usability, and user-centric design to sustainability, privacy, and security considerations. The proposed framework not only provides clarity in terminology but also serves as a foundation for future research. This study is instrumental in guiding future IS research.

Keywords: digital healthcare, information systems, usability, sustainability

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1 Introduction

A significant segment of individuals now has access to internet via smartphones and tablets, leading to an increased interaction with digital platforms to meet various needs, such as health-related information seeking (Hollis et al. 2015). This increase in digital interaction is part of a larger trend referred to as the digital transformation.

Digital health is broadly defined as the understanding and application of digital technologies to enhance health outcomes (Yao et al. 2022; Saukkonen et al., 2022; Adjekum, Blasimme, and Vayena, 2018). Digital health includes electronic health (E-health) and mobile health (m-health) (Adjekum, Blasimme, and Vayena, 2018). These terms refer to healthcare provided online using technology such as mobile phones and remote monitoring equipment (Hollis et al. 2015).

Achieving synergy between clinical information and communication technology (ICT) solutions and advanced computer science is vital to realising digital health's potential and improving healthcare management and care delivery (Kostkova 2015). The digital health sector, focusing on innovations in public health and ICT, promotes multidisciplinary research, and advocates collaboration among stakeholders to enact meaningful change (Kostkova 2015). However, several challenges remain. Improving patient outcomes while lowering costs is a global challenge for healthcare providers. Furthermore, the effective use of digital health is hindered by factors such as outdated systems, the absence of standardized data sources, technology-related debt, security concerns, and privacy issues (Kruse et al. 2017; Gopal et al., 2019).

The use of digital healthcare solutions has been the topic of a significant amount of literature. However, a shared understanding of the term "usage" is missing, resulting in sometimes conflicting interpretations in the academic discourse. Based on Jakob Nielsen's definitions (1993), if a system can be used to accomplish a desired goal, it is useful, and usefulness is defined by a pair of usability and utility. While utility measures whether the system's functioning can meet the required needs, usability refers to how well that function can be utilized by users. When health information systems are considered, usability is primarily defined by the factors impacting the likelihood of their usage, such as response time or the user's ability to figure out the necessary actions to achieve their desired activity (Overhage 2003). The development of this discipline has been shaped by its initial foundations in statistics and psychology towards a focus on user-centric design (Lewis 2014). Despite existing definitions of the usage of systems, an understanding of what defines "usage" in this field is required. This research aims to differentiate between the descriptor terms utilized for characterizing the use of digital health solutions, such as utility and usability. This misconception can lead to challenges when assessing the impact of digital healthcare solutions, resulting in overlooking broader implications in addressing users' needs and sustainable development elements. This research aims to provide an in-depth understanding of the terminology and principles through the following research objectives:

- RO1: Identifying and categorizing the dominant key-terms related to the "use of digital healthcare" in the field of IS to understand how researchers in this field have conceptualized and approached the use of digital healthcare.
- RO2: Understanding the evolution of key concepts of digital health utilization over the years in IS, to reveal the most prominent research areas and gaps
- RO3: Mapping the evolution of the "use of digital healthcare" in Information Systems research and the interconnections with related concepts.

This article presents a conceptual framework to define the landscape of research terms associated with the "use of digital healthcare" in the field of information systems. This groundwork can play an important role as the background of future studies to discern effective factors influencing the sustainable use of digital healthcare solutions.

2 Methodology

In this study we present the analysis of 5510 articles focused on the use of digital healthcare within IS. By categorizing terms, analysing trends, and visualizing interconnections, this research aims to effectively map out this fast-evolving field.

2.1 Data Collection

In identifying relevant articles, we used the Scopus database. The research term query included a combination of terms from two groups: (i) related to digital healthcare, and (ii) related to its usage. The term digital health can be used interchangeably with digital medicine, electronic health, mobile health (mHealth), telecare, and telehealth (Adjekum, Blasimme, and Vayena 2018). To ensure coverage of all related terms, their synonyms and alternative spellings were verified in EBSCOhost (Academic Search Complete), Cambridge dictionary thesaurus, and Mesh terms.

The database search was completed on 1.3.2024 using the research term presented in Table1. The screening of articles was done in several stages, as shown in Table 1. The initial search based on Article title, Abstract, and Keywords in Scopus resulted in 67,795 articles. In the subsequent screening phases, the records were filtered based on language, document type, the Scopus subject area (Information Systems). The final number of records included in our research was 5510.

Table 1: Data collection table

Research-terms	Databases	Findings
ALL=(("digital health*" OR "e-health" OR "ehealth" OR "telemedic*" OR "health information system*" OR "telehealth*" OR "tele-health*" OR "mobile health*" OR "mhealth*" OR "m-health*" OR "online health*" OR "virtual*medicine" OR "virtual health*" OR "tele*care" OR "remote health*" OR "telemonitoring*" OR "teleconsult*") AND ("usage*" OR "utili?ation*" OR "usabilit*" OR "utilit*" OR "use"))	**Scopus** Title, Abstract, Keywords	67795
	Refined By: Languages: English Document Types: Article	41599
	Refined By Scopus subject area: Computer Science	5510

2.2 Bibliometric analysis

Bibliometric analysis refers to a quantitative method to study scientific publications (Lazarides 2023). Bibliometric analysis is recognised for its capacity to handle vast amounts of scientific data (Donthu et al. 2021). The advancement and availability of bibliometric software like VOSviewer, scientific databases such as Scopus and Web of Science, and the cross-disciplinary use of bibliometric methodology have contributed to the growing popularity of bibliometric analysis in research (Donthu et al. 2021). Bibliometric analysis tools can assist researchers in uncovering domain trends, gaining perspective and identifying knowledge gaps (Li and Zhou 2021).

In this study, the collected data was analysed to identify the spectrum of terminologies employed to describe the use of digital health technologies, employing the keyword co-occurrence analysis method. Following this initial data analysis, the data was further investigated using in two steps: (i) trend analysis and (ii) network analysis. These steps aimed to find and visualise concepts' trends over time, and to seek a way to place the key-terms in the correct sections of the conceptual framework. This was achieved through the application of Pandas for data manipulation, Openpyxl to read the data files, Matplotlib and Seaborn for visualization, and NetworkX for network analysis and visualisation.

2.3 Co-occurrence analysis

At first step of data analysis, the data file extracted from Scopus database was utilised for author keywords co-occurrence data mapping applying VOSviewer. The minimum number of occurrences was set at 10. The thesaurus file, including the 1823 most frequently co-occurring words, was created after data cleansing. The data was cured manually and by using Excel to merge spelling differences, ignore irrelevant terms, remove repetitions in order to have the most occurrent terms focused on use of digital healthcare in the field of Information Systems. This process is depicted in Figure 1.

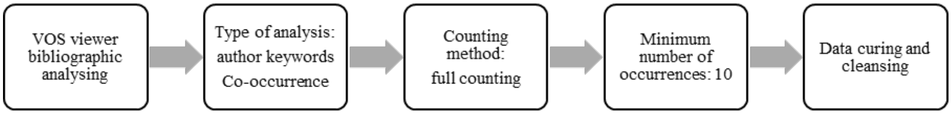

Figure 1: Process of data analysis by VOSviewer
Source: Own

2.4 Data Curing

Numerous procedures were taken into account during the curation and cleansing of the data to guarantee accuracy and clarity. The issue of spelling differences is addressed by merging different spellings of the same terms, such as "user center design" and "user centered design" and "user-center design", or "access to healthcare" and "access to health care". Singular and plural forms were merged, for example, "health outcome" and "health outcomes". Abbreviations were expanded and merged into their complete forms, for instance, "tam" and "technology acceptance model". This process seeks to reduce duplication and prevent the scattering of data with similar values, thereby enabling more efficient data analysis. Finally, certain terms that were considered too general or irrelevant to the focus of the study were excluded, like "people", "health", "diseases", "nurse", "hospital", "alcohol", "Wi-Fi", and "student". The steps of this process are summarized in Figure 2. After the data cleaning process, VOSviewer was utilized to calculate and visualize the co-occurrence of keywords in order to understand how "usage" is conceptualized. In this study, the words that had most occurrence with the author keywords, called "key-terms". The list of key-terms presented in Appendix 1.

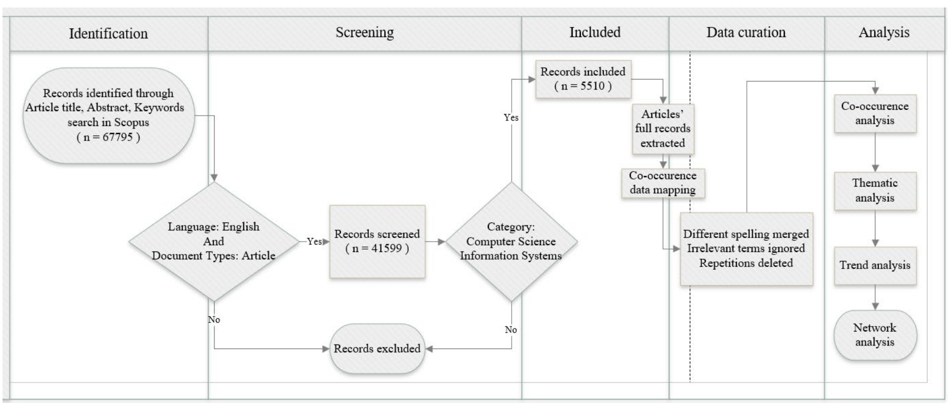

Figure 2: Workflow diagram
Source: Own

2.5 Thematic analysis

In qualitative research, thematic analysis is an approach for extracting significant themes and patterns from unstructured data (Thompson 2022). Rather than just summing or categorising codes, themes are deliberate patterns or concepts derived from data gathering that address a study issue (Kiger and Varpio 2020). The study's conceptual framework was formed utilising a thematic approach to identify dominant themes and patterns in the dataset. During this process, patterns and themes are derived from textual data of articles' title, abstract, and keywords. The elements of this framework are defined by using Jakob Nielsen's definitions on usability and utility as the starting point, and shifting focus to user-centric design as mentioned by Lewis in 2014. The framework was expanded by incorporating two other most frequent concepts, resulting in a framework with five core concepts: "user-centred design", "usability", "utility", "sustainability", and "considerations". These categories will serve as elements of the conceptual framework.

In the following analysis phases, the most co-occurring terms used in included documents on "use of digital healthcare" in IS area, categorised into these five sections, based on their connections in the co-occurrence network.

2.6 Trend analysis

To further explore the co-existing conceptualizations regarding the notion of "use" of digital healthcare, content analysis was performed on the included articles. This step involved doing trend analysis on included articles to track the citations of the main concepts ("usability", "utility", and "user-centred") over time to understand the impact and evolution of these concepts.

The extracted data file was cleaned by eliminating rows with missing values and by standardizing terms with thesaurus. The main analysis involved identifying articles that address the concepts of "usability", "utility", and "user-centred design" through string matching in the "Title", "Abstract", and "Author Keywords" columns, the "Concepts" column appended to the data frame in order to categorize each article effectively. The final data frame was carefully curated to retain only pertinent data, included "Title", "Year", "Cited by", "Author Keywords", "Abstract", and "Concepts". This structured approach enabled a comprehensive and detailed analysis of the thematic trends within the dataset. The citation trends of "utility", "usability", "user-centred design", "Sustainability", and "Considerations" visualized over time to provide insights into understanding changes in the key concepts of digital health utilization over the years along with their citation. Figure 3 presents this plot.

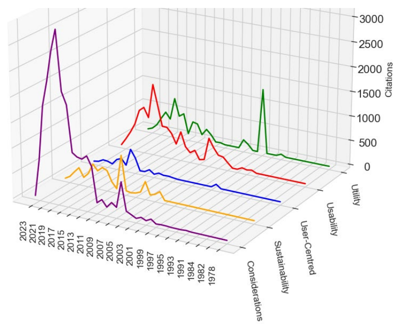

Figure 3: 3D view of concepts' changes over time
Source: Own

2.7 Network analysis

The data created in the previous phase was used for network analysis. A new thesaurus was defined to address alternative representations of identified key-terms, to accurately identify and normalize terms in the dataset. A network was constructed using NetworkX package in Python. It involved checking co-occurrence, extracting and normalising thesaurus terms and their variants within the "Title", "Abstract", and "Author Keywords" of the articles. Nodes and weighted edges were generated in the graph based on the co-occurrences these terms with the concepts in each article. This network was visualised, using Matplotlib and shown in Figure 4. In this figure, size of nodes represents their degrees and edges are weighted to represent the strength of connections.

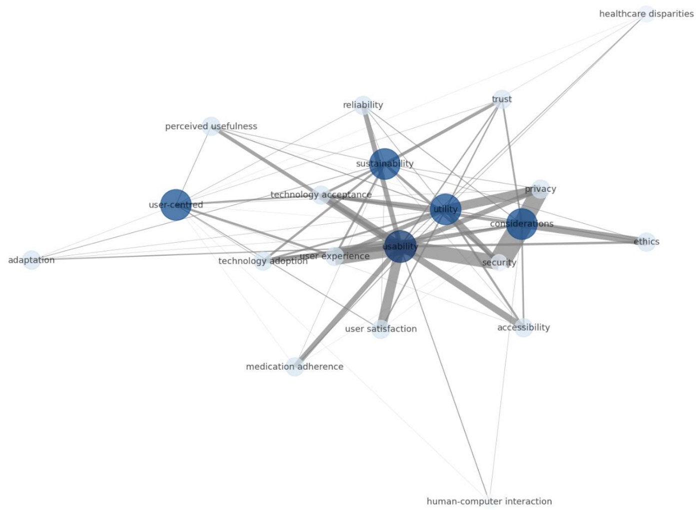

Figure 4: Network visualization of use of digital health

Source: Own

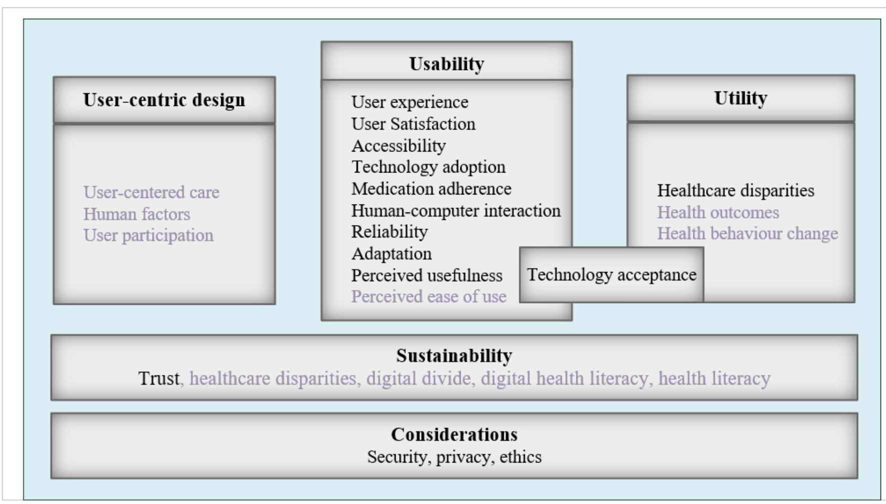

Figure 5: Conceptual Framework

Source: Own

The edge data of the network, was saved in a table, including source, target, and weight. This data frame, which can be found in Appendix 2, provides detailed insights into the connections between different nodes in the network, and was applied to categorise the "use of digital healthcare" most co-occurrent key-terms, to the appropriate sections of the conceptual framework according to their connection to each concept. The conceptual framework is shown in Figure 5.

3 Findings

The findings of this study provide insights into the prevalent research areas and terms associated with the use of digital healthcare in IS. The key-terms in the context of "use of digital healthcare" in the IS field, have been presented as a density visualisation of co-occurring key terms in Figure 6 and components of the framework in Figure 5. These results, linked with the first study objective, indicate that the dominant studied concepts include utility, usability, and user-centric design. The most studied key-terms, related to the use of digital healthcare, which are applied by researchers in IS, are usability, technology acceptance, technology adoption, human-computer interaction, and user experience, as well as privacy and security. These key-terms can be seen in Figure 6.

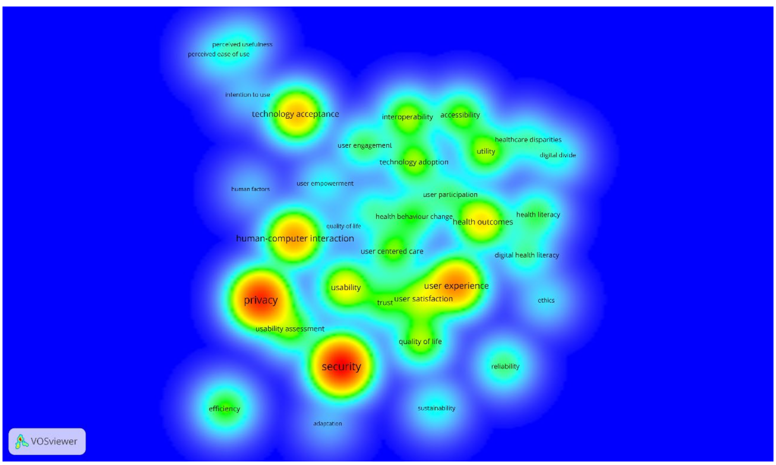

Figure 6: Density visualisation of author keywords co-occurrence
Source: Own

In order to investigate the use of digital healthcare, most of the IS studies have initially dealt with "usability", and then "utility", as demonstrated in Figure 4. Articles in the IS field that have addressed these concepts, focused primarily on assessing various aspects of health technology, including user experience, accessibility, technology adoption, reliability, or technology acceptance (perceived ease of use, perceived usefulness). Additionally, further frequently used key terms include security, privacy, and ethics. While they are more recent in their evolution (as shown in Figure 3), these terms have surpassed usability and utility in terms of frequency in recent years as well as in cumulative numbers. This demonstrates the increased significance and focus placed on these ethical considerations in the past few years as further supported by Figure 7. The concept of "user-centered" care, which emerged as a newer and less prominent concept, was expected to encompass key terms like user participation, user-centered care, and human factors. However, these terms were found to have lower frequency and co-occurrence in the included articles, as well as not being sufficiently associated with other nodes in the network. As a result, they did not appear in the network graph shown in figure 4.

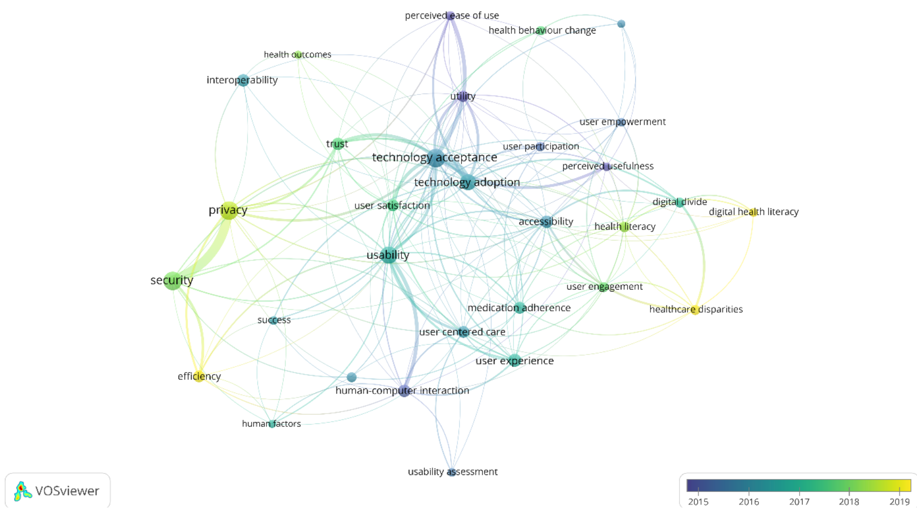

Figure 7: Overlay visualisation of keyword co-occurrence
Source: Own

The visualisation results for keyword co-occurrence, displayed in Figures 3 and 6, reveal that past studies mostly concentrated on three main concepts: utility, usability, and user-centric design. More recent research has emphasised the significance of privacy and security, sustainability, healthcare disparities, digital divide, digital literacy, and health literacy. Regarding the second research objective, analysing the evolution and impact of research contributions on these concepts over time, as depicted in Figure 3, it is evident that prior to 2000, the concept of "utility" was a dominant topic and received significant focus from IS researchers. Subsequently, it experienced a period of neglect before regaining attention and recognition (measured by citations), particularly leading up to 2020. Study on the concept of "usability" has accelerated after 2000 and has gradually become the trendiest research concept related to use of digital healthcare in the field of IS. The notion of "user-centred design" in this field is a newer concept and has not yet gained as much prominence. The concept of "sustainability" is a new trend in this field of study and is gradually gaining increased attention from academics. Although the notion of consideration, has gained more attention and recognition in recent years, it has emerged as the most current trending concept in the field.

Figure 4 and the Appendix 2, effectively addressed the requirement to map out the evolution of key-terms based on their interconnections, as outlined in the third study's objective. The results show that ethical "considerations" have strong connections with dominant concepts of "usability" and "utility". It indicates the importance of these considerations in academic research through the use of main concepts of digital healthcare. The two main concepts of "usability" and "utility", have almost similar edges weight, when it comes to the "sustainability" concept in use of digital healthcare studies. Because the concept of "user-centered design" is newer and less prevalent in this domain, there may be a reason to weaker interconnection of this concept with ethical "considerations" and "sustainability". These two concepts seem to have a contextual impact in the field, and can be positioned as contextual section in framework, because of having significant connections with two of three core concepts.

4 Discussion and Conclusions

The basic objective of digital health, as highlighted by Yao et al. (2022), Saukkonen et al. (2022), Adjekum et al. (2018), and Gopal et al. (2019), is to enhance health outcomes and elevate quality of life. The simultaneous occurrence of these words in key-terms and in definition of digital healthcare, could demonstrate their importance in the research terminology of this field. Although these key-terms, "health outcomes" and "quality of life", appeared at the first stage of this data analysis as some of the most co-occurring terms in this field, but they were less prevalent in IS research and require further investigation. Kruse et al. (2017) expressed concerns over the security of health information systems that store sensitive patient information and diagnostic data, pointing out that technological advancements are raising the dangers of threatening the privacy and security of these systems. The ethical concerns, raised by Kruse et al. (2017), Gardiyawasam Pussewalage and Oleshchuk (2016), and Gopal et al. (2019) regarding the use of digital healthcare have been recognised by IS researchers as well. Recent trends on this topic, as revealed by the findings, support this. In order to establish confidence and guarantee the protection of sensitive patient data, it is essential that digital health solutions prioritise security and privacy. Yao et al. (2022) highlighted the significance of user-centered care in digital healthcare research. However, the patterns revealed a lack of attention and recognition of this concept in IS research. This trend may be attributed to the novelty of this concept or the transition of focus to a more recent concept. Disparities in digital health technologies reveal unequal access to the use of healthcare, resulting in different health outcomes. Age, eHealth literacy, and geographic location can also impact health disparities across different groups (Yao et al. 2022). These terms have lower frequency and co-occurrence in the findings, and do not have sufficient interconnection with other nodes to appear in the network graph. Terms that meet these criteria, along with similar terms, were manually reviewed and categorised in sections of the framework, indicated by a fader colour. This fading indicates that they received less attention in IS studies and can be considered more in future studies.

The most important output of this study is its conceptual framework, that serves as a foundation for further exploration in the use of digital healthcare, allowing for a more shared understanding and agreed-upon terminology, as well as identification of research, highlighting research gaps such as unequal access, ethical challenges, and evolving trends in technology adoption. Moving forward, it will be vital to analyse the concepts of the included articles to deepen understanding and create frameworks that align with practical and theoretical development in digital health usage. Providing defined terminology and key-points, researchers may better design studies that contribute to the sustained development of digital healthcare in society.

It is important to mention some of the limitations of the study. Thematic analysis, a qualitative analysis method, is accurate yet susceptible to the researcher's interpretation bias, which may impact the classification and comprehension of key-terms and concepts. Filtering the documents by English language, article type, and computer science area (Information Systems), might result in to missing significant data.

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Appendix 1: List of key-terms

No.	Key-term
1	Human factors
2	Human-computer interaction
3	User centered care
4	User participation
5	Perceived ease of use
6	Perceived usefulness
7	Reliability
8	Success
9	Usability
10	Usability assessment
11	User experience
12	User satisfaction
13	Interoperability
14	Intention to use
15	Efficiency
16	Health behaviour change
17	Health outcomes
18	Medication adherence
19	Quality of life
20	Technology acceptance
21	Technology adoption
22	User empowerment
23	User engagement
24	Utility
25	Adaptation
26	Ethics
27	Privacy
28	Security
29	Trust
30	Accessibility
31	Digital divide
32	Digital health literacy
33	Health literacy
34	Healthcare disparities
35	Sustainability

Appendix 2: Network edge data table

Source	Target	Weight
user experience	user-centred	22
technology acceptance	user-centred	17
user satisfaction	user-centred	8
perceived usefulness	user-centred	6
technology adoption	user-centred	4
reliability	user-centred	4
trust	user-centred	3
privacy	user-centred	3
user-centred	accessibility	2
user-centred	adaptation	2
medication adherence	user-centred	1
human-computer interaction	user-centred	1
ethics	user-centred	1
user-centred	healthcare disparities	1
usability	user experience	172
usability	security	143
usability	user satisfaction	96
technology acceptance	usability	88
usability	accessibility	64
usability	technology adoption	52
usability	medication adherence	52
usability	privacy	50
usability	reliability	48
perceived usefulness	usability	35
usability	ethics	23
usability	trust	13
usability	adaptation	11
usability	human-computer interaction	9
usability	healthcare disparities	7
utility	privacy	90
utility	security	49
utility	user experience	42
utility	technology acceptance	37
utility	accessibility	21
utility	technology adoption	19
utility	user satisfaction	14
utility	trust	13
utility	ethics	10
utility	perceived usefulness	9
utility	medication adherence	8
utility	reliability	6
utility	healthcare disparities	5

Source	Target	Weight
utility	adaptation	3
sustainability	trust	30
security	sustainability	27
technology acceptance	sustainability	23
technology adoption	sustainability	22
user experience	sustainability	20
sustainability	adaptation	6
perceived usefulness	sustainability	5
sustainability	privacy	5
sustainability	ethics	5
reliability	sustainability	4
user satisfaction	sustainability	3
sustainability	medication adherence	3
sustainability	accessibility	3
sustainability	healthcare disparities	2
security	considerations	216
considerations	privacy	172
considerations	ethics	75
technology acceptance	considerations	31
user experience	considerations	28
technology adoption	considerations	17
considerations	trust	17
considerations	accessibility	16
reliability	considerations	8
considerations	human-computer interaction	3
considerations	adaptation	2
perceived usefulness	considerations	1
user satisfaction	considerations	1
considerations	medication adherence	1