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Understanding patient perception of digital value co-creation in electronic health record through clustering approach

Ilma Nurul Rachmania[1]✉, Gatot Yudoko[1], Mursyid Hasan Basri[2] & Santi Setyaningsih[3]

Patients are central to healthcare services, and comprehending their perceptions is crucial for fostering effective value co-creation. This study aimed to investigate the user characteristics and perceptions of value co-creation within the context of Mobile Electronic Health Records (EHR). Using a questionnaire collected from 422 patients, the study employed the K-modes clustering algorithm in R-Studio to group users based on shared characteristics and perceptions of value co-creation. The analysis revealed three distinct user clusters, which are high familiarity-positive perception, low familiarity-positive perception and high familiarity-neutral to negative perception. These clusters characterized by unique attributes such as socio-economic, history of medical visit, intention to use, technological familiarity, and different perception of value co-creation in Mobile EHR systems. Descriptive statistics were used to further interpret the clusters, revealing differences in user characteristics and perception across cluster. The findings emphasize the importance of alignment between user expectations and system interactions. Effective alignment fosters value co-creation through resource access, sharing, integration, and recombination, while misalignment may result in value destruction. This study highlights the need to design and implement Mobile EHR systems that align with the diverse characteristics and of their users to enhance engagement and promote value co-creation.

Keywords Co-creation, Co-destruction, Patient perception, Healthcare service, Electronic health record

The development of service-dominant (S-D) logic and the concept of value co-creation have profoundly influenced service research literature[1]. Value co-creation has become service research priority, focusing on integrating roles and resources[2,3]. The expanding body of service research on value co-creation highlights its role as a crucial driver of innovation[4,5] and well-being[6–8]. Although the initial concept of co-creation acknowledged the active role of customers within the value chain[9], its progression and implementation have remained inextricably linked to technological advancements and developments[10]. Digital technology is characterized not only as an operand resource, acting as a facilitator or enabler, but also as an operant resource, serving as an initiator or actor in the value co-creation process[11]. Digital advancements significantly shape healthcare by fostering the active involvement of patients, clinicians, and practitioners and enhancing efficiency in time and resource utilization[12]. This concept is rooted in the idea that value is not produced in isolation by a single entity but is generated through interactions and collaboration of all actors facilitated by digital tools and platforms[13].

Digital technology transformation presents new opportunities for healthcare service. Digital transformation in healthcare services refers to integrating and adopting digital technologies to improve and revolutionize healthcare services and operations[14,15]. Digital technology enables a shift from fragmented services to more integrated services, which can facilitate multiple stakeholders through a collaboration mechanism[16]. The pandemic has accelerated the use of digital technology and led to the emergence of digital value co-creation[17,18]. Electronic Health Record (EHR) exemplify a collaborative technological resource integrated within a complex network of multiple partners, where various stakeholders, such as patients, doctors, nurses, pharmacists, and other healthcare professionals, collaboratively co-create value[19]. One of the primary challenges in the widespread adoption of eHealth practices is the complexity of interactions across and between various levels of the healthcare service ecosystem[20].

[1]School of Business and Management, Bandung Institute of Technology, Bandung 40116, Indonesia. [2]Faculty of Economy and Business, Bangka Belitung University, Bangka Belitung 33172, Indonesia. [3]School of Regional Sciences and Business Administration, Széchenyi István University, Győr 9026, Hungary. ✉email: ilma.nurul@sbm-itb.ac.id

The Indonesian Ministry of Health developed the 2024 Health Digital Transformation Strategy Blueprint to reform health governance through the integration of information systems. This strategy, aimed at collaboratively creating a Healthy Indonesia with the entire health industry ecosystem, prioritizes three key Health Technology Transformation activities[21]. One of these activities focuses on integrating and developing an individual-based health data system via a unified EHR. SATU SEHAT evolved from Peduli Lindungi, an Electronic Health Alert Card (e-HAC) application used during COVID-19, representing Indonesia's national digital health ecosystem. The SATU SEHAT Mobile platform facilitates greater access to health data and empowers individuals to manage their health independently. One of its features is the One National Health Data (Single Identity Health Record), which is integrated with electronic medical records in healthcare facilities via the SATUSEHAT Platform. SATU SEHAT Mobile assists in providing information and monitoring health based on the user's physical condition, which is accessible anytime and anywhere.

Previous studies highlight the significant role of customers in value co-creation[22–24]. However, more studies are needed to explore users' perspectives on digital value co-creation. To foster the value co-creation process, it is essential to increase the involvement of the users/beneficiaries[24]. Within the context of EHR, the role of patients as customers or user involvement as resource integrators is emphasized[25]. This implies that patients are active participants in maintaining their health information rather than merely passive beneficiaries of care. They use the EHR system to track their medical history, test results, and treatment plans. Patients actively manage their health information, ensuring that EHR systems are user-friendly and cater to their need for accessibility, accuracy, and privacy[26]. Most studies on customer value co-creation focus on the factors that facilitate customer participation, whereas only a few have investigates the factors that hinder it[27]. Service providers must understand and incorporate customer perceptions into their designs[28]. The alignment of user goals with clearly expressed value propositions establishes the competitiveness of a service offering[29]. Service providers need to have a deep understanding of how users view value in their local context to design the best tools to manage that value and foster co-creation[30].

This study aimed to investigate the user characteristics and perceptions of value co-creation within the context of Mobile EHR systems. To support this aim, the study focuses on the following research questions: (1) What distinct user groups can be identified based on their characteristics and perceptions of value co-creation in the context of Mobile EHR systems? (2) How do user characteristics and perceptions differ across these groups in relation to value co-creation?

The paper is structured as follows. The first section covers the study's background and objectives; the second describes the literature review. The third section details the methodology, including data collection, instrument building and data analysis. The fourth section summarizes the clustering analysis findings, highlighting patient/user characteristics. Followed by discussion in the fifth section. The concluding section addresses research implications, limitations, and suggestions for future research.

Literature review

The concept of value co-creation has gained growing importance in academic discussion, challenging the traditional view of value created solely by the firm[31]. Traditionally, based on goods-dominant logic, the concept of value originates from economics and industrial contexts with value being created by the firm, embedded in tangible products and assessed to straightforward evaluations of costs and benefits[31,32]. This perspective was contested by the service-dominant logic introduced by Vargo and Lusch in the early 2000s, which posits that value is created by using and consuming services rather than being inherent in products[33]. Interaction is the central point where value is co-created, and the firm extracts economic value, with these co-creation experiences forming the foundation of value[34].

Service-dominant logic emphasizes the importance of the services exchanged between actors, highlighting the role of interaction and collaboration in creating value[35]. As outlined by Grönroos and Voima[36], value co-creation takes place within joint sphere through direct interaction of customers and firms. This approach calls a deeper understanding of the collaborative processes through which firms and customers create value. Furthermore, it is crucial to consider how different contexts influence the ways in which customers and firms interact and co-create value[37]. To implement effective value co-creation strategies, firms need to prioritize developing strong value propositions, fostering customer engagement and enhancing the overall service experience[38].

Value co-creation is not always successful in all circumstances. Missing resources, mishandled resources, or misaligned processes lead to value co-destruction[39]. Value co-creation may be less common than value co-destruction in complex scenarios. Participants in the value creation process can disintegrate or not integrate resources—intentionally or accidentally, in addition to integrating resources effectively[40]. Value can be produced, only when resources are exploited properly[41]. With the emergence of the digital age, consumers now have more access to resources and information, information asymmetry between businesses and consumers has been eliminated, and their position in the value creation process has evolved[42].

Methods

This study employed a descriptive quantitative research approach to address its aim of investigating user characteristics and perceptions of value co-creation within the context of Mobile EHR systems. It provides a detailed analysis of user characteristics and identifies patterns related to their familiarity and perceived value co-creation within Mobile EHR systems.

Data collection

The data for this study was collected through a structured survey administered to a sample of 422 respondents from four cities/districts in West Java, Indonesia. A stratified random sampling method was employed to ensure

Variables	References
Socio-demographics	47–49
Age	
Gender	
Level of education	
Occupation	
Level of income	
History of medical visit	50,51
Intention to use	52,53
Technology familiarity	54–56
Value co-creation	57,58
Resource access	
Resource sharing	
Resource integration & recombination	

Table 1. Variables in this study.

Familiarity stage	Definition
Awareness	Users first become aware the existence of EHR application
Interest	Users begin to show interest in EHR application and seek more information about the new technology
Evaluation	Users have installed the application and consider whether trying the EHR application
Trial	Users have installed the application and try to use the application on small scale to improve their estimate of its value
Adoption	Users decided to make full and regular use of the EHR application.

Table 2. EHR familiarity stage.

that the sample accurately reflected the diverse socioeconomic strata of the population[43]. This approach allowed the study to capture a representative cross-section of the population, enhancing the generalizability of the findings[44]. Stratification based on key socioeconomic indicators ensured representation of all major population groups. The population was divided into distinct strata, with random sampling applied within each to reduce selection bias. Proportional allocation was applied to ensure the sample accurately reflected the population's distribution. This research was reviewed and approved by the ethical committee of the School of Business and Management, Bandung Institute of Technology. All methods were conducted in accordance with relevant guidelines, regulations, and ethical standards. Informed consent was obtained from all participants prior to their completion of the questionnaire. Confidentiality was safeguarded by anonymizing responses and securely storing the data, ensuring that no personally identifiable information was associated with individual responses. Participants also provided consent for the publication of their anonymized data.

Instrument building

The structure of the questionnaire as described in Table 1, encompassed the sociodemographic data of the respondents[33,34,45], their history of medical visits[35,36], their intention to use EHR applications[37,38], familiarity with EHR technology[39,40,46] and their perceptions of value co-creation in EHR systems in terms of resource access, resource sharing, resource integration, and resource recombination[41,42]. A 5 stage adoption was utilized to measure the familiarity with EHR system in their early launch focusing on the decision to adopt new digital technology. A combination of closed and open-ended questions in survey was used to provide a comprehensive understanding of user perceptions and experiences with EHR systems. Table 2 described the definition EHR familiarity stages while Table 3 described the definition as well as dimensions of value co-creation in the EHR.

Face validity and content validity were ensured through evaluation of the instrument by experts. The experts represented various sectors of the penta-helix model, including two experts each from academia and industry, and one expert each from the government, community, and media. The face validity result showed 95% overall agreement from seven experts regarding the questionnaire instrument. The content validity index was assessed using the I-CVI and S-CVI. The result showed an I-CVI score of 0.99, which indicates a high level of expert agreement on the relevance of a specific item. Moreover, the S-CVI score of 0.93 signifies that the overall scale possesses high content validity, with most items being relevant and representative of the construct. Furthermore, a 40-sample pilot test was conducted to ensure the questionnaire's effectiveness, reliability, and validity before the main study. The pilot identified unclear questions, refined wording, and confirmed relevance, resulting in a reliable, unbiased instrument. A result of 0.82 Cronbach Alpha suggested that the items in the survey were highly internally consistent, indicating strong reliability. Based on the pilot test results, final adjustments were made to the survey before it was distributed to the target population. This structured approach ensured that the survey instrument was both reliable and valid, and capable of effectively capturing user perceptions and experiences with EHR systems.

Variables	Definition	Dimensions
Resource access	Ability to utilize or retrieve resources	Completeness of patient personal information & medical history
		Healthcare information quality
		Fast and easy access to EHR system
		Access to healthcare information
Resource sharing	Practice where individuals or organizations make their resources available to others for mutual benefit leading to increase efficiency	Information sharing with healthcare professional
		Communication users/patient with healthcare professional
		Communication between healthcare professional
Resource integration & recombination	Integrate existing and new resource in new way. Use, adapt and combine own resource and other actor's resource to produce new resource.	Patient's self-management of healthcare
		Patient summary integration
		Collaboration between healthcare professional
		Team decision making

Table 3. Value co-creation in HER.

Data analysis

This study utilized clustering analysis to examine underlying patterns, enabling the identification of distinct groups or segments based on common characteristics that exhibit similar behaviors. Unlike classification, which organizes outcomes based on predefined categories or labels, clustering focuses on identifying natural groupings that emerge directly from the data.

In this study, the K-modes clustering algorithm was employed in RStudio. K-modes clustering is specifically designed for categorical data, extending the K-means algorithm used for numerical data. To quantify dissimilarity between data points, the study utilized Gower Distance, which well-suited for mixed or categorical data. Moreover, the optimal number of clusters was determined using the Dunn Index, a metric that evaluates clustering performance by measuring cluster compactness and separation, with higher values indicating better clustering[59]. Based on the result in RStudio, The Dunn Index analysis indicated that three clusters with the highest Dunn Index, indicating clear partitioning into distinct groups. To ensure consistency in cluster membership, the study was run through 100 iterations.

This clustering approach directly addresses the research question by grouping users based on their familiarity with EHR systems and their perceptions of value co-creation. Each identified cluster exhibits distinct characteristics, which were analyzed descriptively to provide insights into user behavior and perceptions related to value co-creation. Furthermore, Chi-Square tests were performed to evaluate the statistical significance of the variables used in forming the clusters, ensuring the robustness of the analysis.

Results

A total of 422 respondents were interviewed for the survey between January and March 2024. The survey respondents consisted of 226 (54%) males and 196 (46%) females in this study. The average age of respondents ranged from 35 to 44 years. The respondents' ages were distributed as follows: 23% were between 18 and 24 years, 25% were between 25 and 34 years, 27% were between 35 and 44 years, 16% were between 45 and 54 years, and 8% were over 55 years. The survey data included responses from four cities/districts in the Bandung Metropolitan Area of West Java. The majority, 43% of respondents came from Kabupaten Bandung and 32% came from Kota Bandung, representing the two most populous cities/districts within the Bandung Metropolitan Area, West Java. The survey was dominated by respondents with a high school education level (35.5%), worked as full-time employees (52.8%), and had an income range between IDR 2,500,000 and 4,000,000 (40%).

Furthermore, in addition to socioeconomic questions, the questionnaire also explored participants' intention to use an EHR application. A positive response was given by 91% of the survey participants regarding their willingness to regularly use an EHR apps. Moreover, this study also examined respondents' medical visits over the past two years. Based on the data, the pattern indicates that more frequent medical visits are associated with a higher level of EHR application. Clinical encounters correspond to an individual's recognition of EHR[48]. Table 4 showed for those who never had a medical visit, the apps familiarity is still on awareness stage. With an increase in medical visits, the proportion of individuals in the Awareness stage declines, indicating that frequent visits promote progression to higher stages. Individuals with 1–2 medical visits demonstrate the highest levels of interest, whereas no visits or more than four are associated with lower interest, suggesting that moderate engagement supports EHR familiarity. The Evaluation stage is predominantly occupied by those with 2–4 visits, highlighting the role of repeated healthcare exposure in encouraging deeper exploration of EHR apps. Additionally, the Trial and Adoption stages see significant growth among individuals with 1–4 visits but decline for those with over four visits, likely due to barriers or fatigue limiting further engagement. In summary, moderate interaction (2–4 visits) is most strongly linked to progressing through all stages, especially Evaluation, Trial, and Adoption, while limited or excessive visits correspond to lower familiarity and adoption rates.

The study utilized the chi-square statistical approach ($\chi 2$) to test the significance of the association between the values of these measures to assess the likelihood of a relationship between two nominal or categorical metrics[60]. Table 5 summarized the results of the pearson chi-square test between the variables and the EHR familiarity stage. All variables are significant except for gender, which is not significant in relation to familiarity.

History of medical visit	Familiarity stage				
	Awareness	Interest	Evaluation	Trial	Adoption
Never	38 (35%)	11 (19%)	4 (5%)	9 (8%)	4 (7%)
1 time in the past 2 years	26 (24%)	19 (32%)	17 (23%)	40 (33%)	13 (22%)
2–4 times in the past 2 years	28 (26%)	19 (32%)	38 (51%)	55 (46%)	36 (60%)
More than 4 times in the past 2 years	17 (16%)	10 (17%)	15 (20%)	16 (13%)	7 (12%)
Total	109 (100%)	59 (100%)	74 (100%)	120 (100%)	60 (100%)

Table 4. Cross tabulation of historical medical visit and EHR apps familiarity stage.

	Value	df	Asymptotic significance (2-sided)
Socioeconomic			
Age	52.582	16	0.000 *
Gender	5.212	4	0.266
Level of education	102.591	24	0.000 *
Occupation	88.641	24	0.000 *
Level of income	29.117	20	0.085 ***
History of medical visit	60.075	12	0.000 *
Intention to use EHR application	40.964	4	0.000 *
Value co-creation: resource access			
Personal information	31.759	12	0.002 **
Medical history	30.583	12	0.002 **
Fulfil the information correctly	26.19	12	0.010 **
Faster and easiness access	45.732	12	0.000 *
Access to healthcare information	36.459	12	0.000 *
Value co-creation: resource sharing			
Information sharing with healthcare professional	49.043	12	0.000 *
Communication between healthcare professionals	39.054	12	0.000 *
Communication with patients	40.544	12	0.000 *
Value co-creation: resource integration and recombination			
Patient self-management of healthcare	31.822	12	0.001 *
Integration the user's entire health history	27.558	12	0.006 **
Collaboration with other Health care professionals	40.584	12	0.000 *
Team decision making	35.418	12	0.000 *

Table 5. Pearson chi-square towards EHR apps familiarity stage.

In addition to gender, this indicates that all the variables tested are likely to be associated. Therefore, regardless of the cluster split, gender did not contribute significantly to the cluster explanation.

Based on the results of the K-modes clustering in RStudio, the 422 respondents were divided into three distinct clusters, each exhibiting unique characteristics as described in Table 6; Fig. 1.

Cluster 1 (high familiarity - positive perception)

The key indicator distinguishing this cluster was the familiarity - trial. This cluster's respondents had almost reached the maximum level of familiarity adoption. This cluster represents middle-aged people between 25 and 34 based on demographic parameters. There were slightly more men in this cluster, and most graduates (about 45%) had higher education levels, with bachelor's, master's, and doctoral degrees. Their typical monthly salary is between IDR 2.5 and 4 million, with half of them working full-time. Additionally, they had two to four medical visits during the last two years. The value co-creation measure shows a pattern in which most respondents are on the right side, indicating a 90% positive response, with more than 64% strongly agreeing with each dimension related to value co-creation in EHR.

Cluster 2 (low familiarity - positive perception)

The primary identifier that set this cluster apart was the familiarity stage - awareness. Most of the respondents only acknowledged the application to a certain extent. Respondents had just learned about the application, often through indirect channels. They might not be actively seeking an EHR application as a solution for healthcare management but have come across information about it. Their demographic profile shows that they are in a younger age group, primarily dominated by females between the ages of 18 and 24. Most of them passed their senior high school program and worked a full-time job most of the time. The average income, which falls between

			Cluster 1	Cluster 2	Cluster 3
Socio-demography	Age	Between 18–24 years old	9 (7%)	77 (34%)	12 (17%)
		Between 25–34 years old	49 (39%)	45 (20%)	13 (19%)
		Between 35–44 years old	23 (18%)	60 (26%)	31 (44%)
		Between 45–54 years old	32 (26%)	28 (12%)	9 (13%)
		Above 55 years old	12 (10%)	17 (7%)	5 (7%)
	Gender	Male	71 (57%)	99 (44%)	56 (80%)
		Female	54 (43%)	128 (56%)	14 (20%)
	Level of education	No school	0 (0%)	1 (0%)	0 (0%)
		Elementary school/junior high school	6 (5%)	34 (15%)	3 (4%)
		Senior high school	31 (25%)	95 (42%)	24 (34%)
		Diploma 3	32 (26%)	51 (22%)	19 (27%)
		Bachelor degree	41 (33%)	31 (14%)	20 (29%)
		Master degree	10 (8%)	11 (5%)	3 (4%)
		Doctoral degree	5 (4%)	4 (2%)	1 (1%)
	Occupation	Students	1 (1%)	14 (6%)	1 (1%)
		Full time employee	74 (59%)	108 (48%)	41 (59%)
		Part time employee	30 (24%)	57 (25%)	15 (21%)
		Housewife	12 (10%)	25 (11%)	5 (7%)
		Retirement	0 (0%)	5 (2%)	2 (3%)
		Others	8 (6%)	17 (7%)	6 (9%)
		Don´t know/do not answer	0 (0%)	1 (0%)	0 (0%)
	Level of income	Less than IDR 1.250.000	15 (12%)	36 (16%)	2 (3%)
		Between IDR 1.250.001–1.750.000	4 (3%)	22 (10%)	1 (1%)
		Between IDR 1.750.001- 2.500.000	13 (10%)	29 (13%)	19 (27%)
		Between IDR 2.500.001–4.000.000	47 (38%)	84 (37%)	38 (54%)
		Between IDR 4.000.001–6.000.000	30 (24%)	42 (19%)	4 (6%)
		More than IDR 6.000.000	16 (13%)	14 (6%)	6 (9%)
History of medical visit		Never	12 (10%)	42 (19%)	12 (17%)
		1 time in the past 2 years	36 (29%)	60 (26%)	19 (27%)
		2–4 times in the past 2 years	53 (42%)	95 (42%)	28 (40%)
		More than 4 times in the past 2 years	24 (19%)	30 (13%)	11 (16%)
Familiarity stage		Awareness	22 (18%)	75 (33%)	12 (17%)
		Interest	18 (14%)	35 (15%)	6 (9%)
		Evaluation	19 (15%)	36 (16%)	19 (27%)
		Trial	41 (33%)	51 (22%)	28 (40%)
		Adoption	25 (20%)	30 (13%)	5 (7%)
Intention to use EHR application		Yes	123 (98%)	201 (89%)	62 (89%)
		No	2 (2%)	26 (11%)	8 (11%)

Table 6. Cluster results based on socioeconomic, history of medical visit, familiarity stage and intention.

IDR 2.5 and 4 million, is therefore similar to that of the respondents in Cluster 1, and the frequency of previous medical visits is also comparable, occurring two to four times every two years. Most respondents that fit this cluster responded positively to the statement-related dimensions of value co-creation in the EHR application. More than 65% of respondents agree to EHR resource access, resource sharing, and resource recombination. Approximately 10% strongly agree, while around 15% of respondents show neutrality, and less than 10% disagree.

Cluster 3 (high familiarity - neutral to negative perception)

The demographic profile indicates that users in Cluster 3 are predominantly middle-aged respondents, primarily male, between the ages of 25 and 34, with a majority of recent senior high school graduates. Most of them work full-time, earning an average between IDR 2.5 and 4 million per month. Their medical history is similar to Clusters 1 and 2, with two to four times visits in the previous two years. The sub-metric that stands out the most for this cluster is the familiarity stage – trial, which is like Cluster 1. This means that the user in this cluster also installed and used the application on a trial basis to test its functionality and fit. However, they are more into neutral statements for most value co-creation dimensions in the EHR application. Approximately 40–80% of the users in cluster 3 pointed out neutral related to resource access to EHR applications. Meanwhile, 50–70% of users pointed out neutrality related to resource sharing, resource integration, and recombination in EHR applications. Neutral refers to a midpoint or middle option that represents neither a positive nor negative stance on the evaluated statement. While around 20–39% of users think disagree related to the value co-creation dimension in

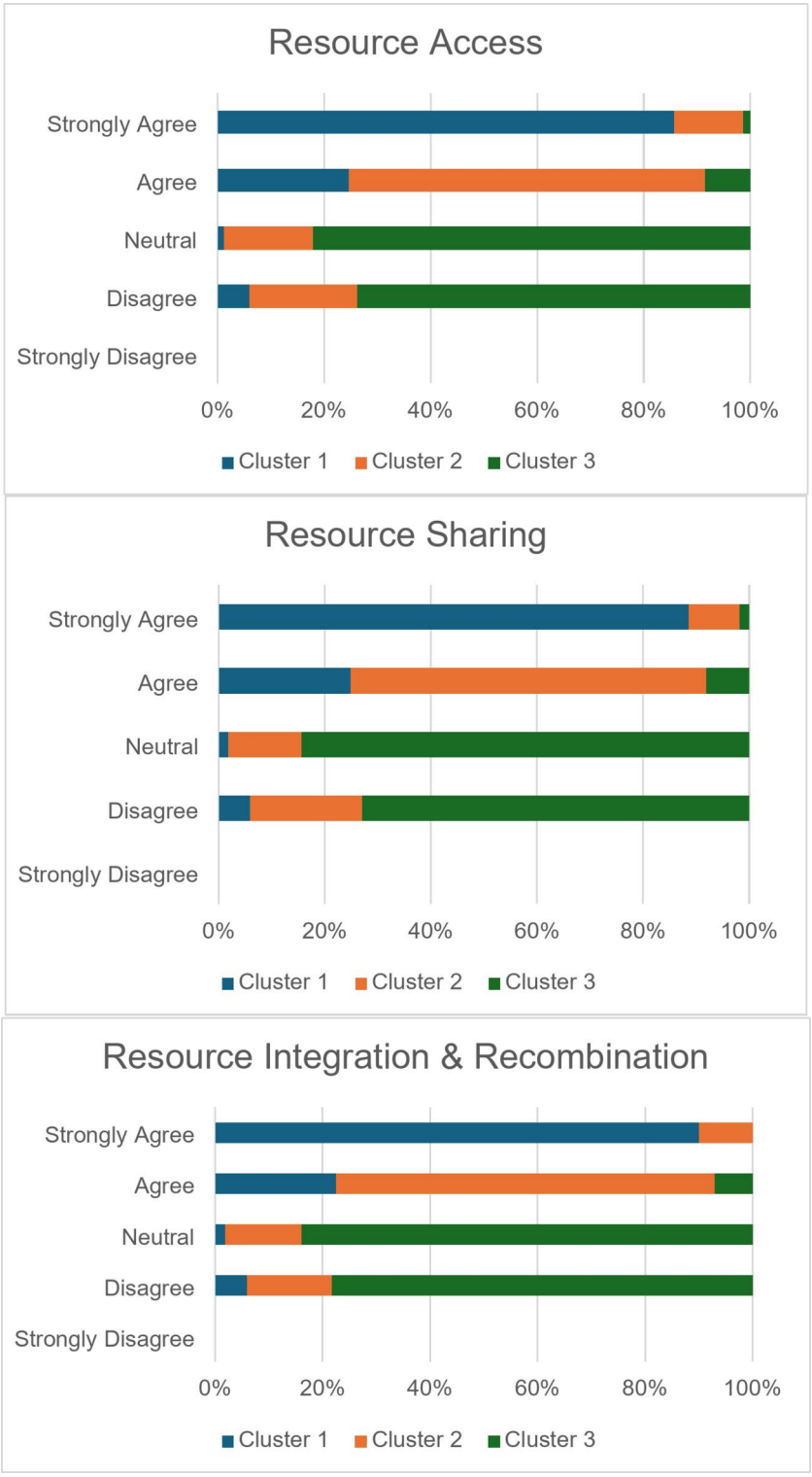

Fig. 1. The perception of value co-creation across three clusters.

the EHR. Users in this cluster oppose statement-related resource access, resource sharing, resource integration, and recombination in EHR. Less than 10% of users in this cluster refer to EHR's positive response-related value co-creation dimensions.

Discussion

The cluster analysis reveals distinct differences among the user groups in terms of their familiarity with EHR systems, socioeconomic factors, and perceptions of value co-creation. In terms of familiarity with the EHR,

Clusters 1 and 3 are in the trial stage, while Cluster 2 is in the awareness stage. Middle-aged individuals dominate Clusters 1 and 3, while younger people (18–24) are mostly in Cluster 2, where the majority have only a senior high school education. Cluster 1 respondents tend to have higher education levels, with 45% holding a degree above a bachelor's, compared to 34% in Cluster 3. This higher education level in Cluster 1 correlates with a 90% positive response towards value co-creation in EHRs. 37% of Cluster 1 earns above the minimum wage, while only 15% of Cluster 3 does. This result underscores how socioeconomic status, such as education and income levels, can shape individuals' abilities and opportunities to participate in value co-creation within healthcare services, including EHR applications.

Among the trialists in Clusters 1 and 3 who have been using the EHR application on a limited basis, there are significant differences in their perceptions of co-creation value in EHR applications. Cluster 3 shows a neutral to potentially negative perception of value co-creation, in contrast to the very positive responses from respondents in Cluster 1. 90% respondent in Cluster 1 supported resource access, recognizing that providing complete personal data could lead to more accurate diagnoses and help prevent medication errors. "With the application, I can monitor my health data. I also can comprehensively consult with the doctor for my medication." Additionally, comprehensive data enables healthcare providers to deliver more effective treatment by having all necessary background information. In contrast, 25% of respondents in cluster 3 expressed dissatisfaction with resource access in EHRs, citing burdensome information requirements, trust issues, and inconvenient login processes. The respondent declared "I am experiencing complicated sign-up verification due to extensive personal data that must be input". "I am afraid that if I provide a lot of personal data, it will be misused for other purposes". Many preferred to provide only basic information due to varying levels of trust[25]. The need for internet access and a smartphone with sufficient memory was also considered costly and inconvenient. The respondent stated "I have never tried the application at all, the application is not compatible and I have limited memory on my phone".

In the EHR setting, after patients gain access to the app, they need to be willing to share their health-related information within the app. Over 90% of Cluster 1 respondents agreed with resource sharing, recognizing its benefits for understanding past treatments and improving care coordination by centralizing health information and streamlining interactions between patients and healthcare professionals. In contrast, most respondents in Cluster 3 were neutral or disagreed, with 20–30% citing concerns about data security and the potential misuse of their health information by third parties for non-healthcare purposes. Protecting user data privacy in healthcare is crucial, with the key challenge being to improve EHR systems to safeguard privacy without sacrificing performance or interoperability[61].

Once users share their health information, the app consolidates data from various sources into a unified EHR. This integration and recombination of resource create a comprehensive health record, enabling effective, coordinated care and informed decision-making by healthcare providers. Resource integration and recombination leverage integrated data to construct a holistic view of a patient's health, enabling healthcare providers to make more informed decisions and offer tailored interventions. Furthermore, by integrating and recombining health information through the application, patients can track their progress and monitor their ongoing health conditions over time. Over 90% of Cluster 1 respondents supported this process, while most of Cluster 3 were neutral, with 21–37% expressing disagreement.

Digital transformation indeed impacts value co-creation processes. Studies indicate that it enhances value-oriented efforts and the understanding of customer expectations[62]. However, digital transformation does not consistently result in positive outcomes for value co-creation[63]. It may also result in value co-destruction[64]. Interactions between participants and resources can sometimes lead to unfavourable outcomes, where exchanges and interactions fail to produce anticipated positive value outcomes[65]. If the service experience does not meet expectations, value co-destruction may result from negative personal experiences, misbehaviour, or deliberate disruption during the service interaction[66]. This may explain the outcomes observed in Cluster 3.

In contrast to Clusters 1 and 3, where respondents have limited EHR experience, Cluster 2 only recognizes the EHR application's existence without direct experience. Despite this, Cluster 2 has a favourable view of value co-creation. Figure 2 shows that Clusters 1 and 3 have entered the joint sphere of value creation, while Cluster 2 has not. The value proposition for a self-managed health EHR application is a critical aspect that helps convert awareness into interest. The unique benefits and advantages of using EHR applications should be communicated[67]. Value is co-created through the dynamic arrangement of resource such as people, technology, information, and organizations which are interconnected both internally and externally through value propositions[68]. A well-defined value proposition that aligns with customer needs and expectations increases the likelihood that customers will perceive value in a product or service[30]. Understanding and recognizing value co-creation involves appreciating the benefits and advantages of the collaborative process between the patient, healthcare provider, and the EHR application.

Research on value co-creation focuses on the "joint sphere," where service providers and customers collaborate to create value through technology[46]. This shared space allows for direct interactions that can enhance or hinder value creation[69]. While digital technology can facilitate co-creation, it also poses challenges that may affect the outcome. This study explores the extended concept of the joint sphere in EHR applications, comprising the healthcare provider sphere, the user sphere, and the EHR application sphere. Initially, patients and providers operate independently. In the joint sphere of the EHR application, the value proposition serves as the starting point, outlining the benefits and advantages that the EHR application promises to deliver to both healthcare providers and patients. To engage in the value co-creation process, healthcare providers and patients must have access to resources and engage in resource sharing. This enables the integration and recombination of resources, making them value-in-use co-creators and emphasizing the practical benefits realized during actual usage. The resources accessed and shared are then integrated and recombined within the joint sphere of EHR application, generating value co-creation.

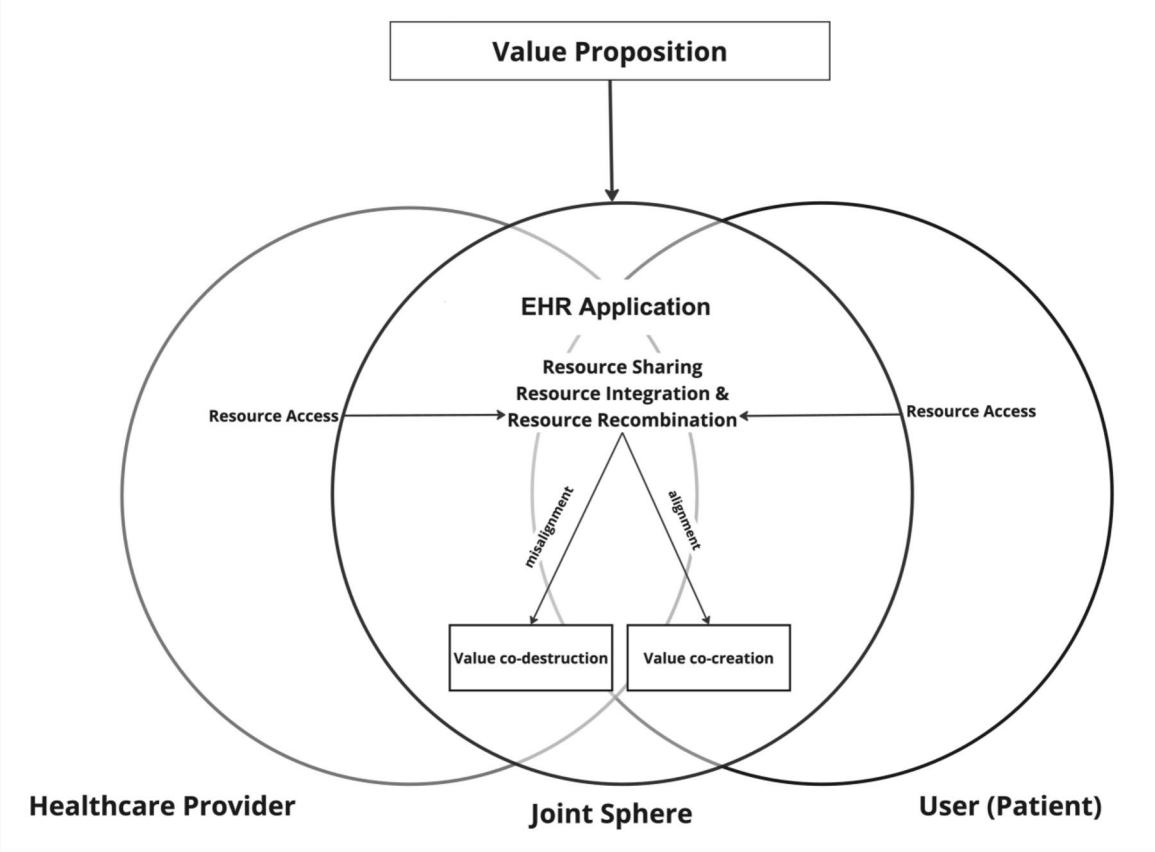

Fig. 2. Potential value co-creation in HER.

The results from Cluster 1 highlight the importance of key factors such as ease of access, system usability, and seamless integration for successful value co-creation. "Through the apps, my health information all in one place". Another user pointed out "Yes it needs several steps to verify the account but it's quite easy". Moreover another user stated "I found that this app is useful, I can show my doctor the history of my blood pressure periodically". When these elements are in alignment, healthcare providers and patients can achieve significant benefits, including better care coordination, improved decision-making, and enhanced healthcare outcomes. This alignment among patients, providers, and the EHR system is crucial to realizing the full potential of value creation. However, the challenges identified in Cluster 3 underscore the barriers that can hinder value co-creation. Some of users pointed out "I don't trust government apps, how if there's a national data leak like before". Another user express that "The apps is still too complicated for me, maybe I am not that tech-savvy". Moreover, "I thought I can easily access the apps, but turns out every time I log in it takes forever to load". Issues such as trust concerns, system complexity, and unmet expectations lead to misalignment, which results in dissatisfaction and can ultimately cause value destruction. These findings emphasize the need for strong alignment between the user, provider, and system to overcome these obstacles. While Cluster 1 demonstrates the benefits of alignment, the difficulties faced by Cluster 3 show how misalignment can prevent the successful realization of value.

In Cluster 1, users who are familiar with EHR systems actively engage in value co-creation processes. To sustain this engagement, it is essential to maintain and improve collaborative features such as interoperability and real-time data sharing. These features ensure that patients have seamless access to their medical information and enable effective communication with healthcare providers[19]. Such strategies allow users to manage their health information efficiently, reinforcing their role as active contributors in the value co-creation process. In contrast, users in Cluster 2, who are less familiar with EHR systems, have a positive outlook on their potential but require support to fully engage. Educational programs and simplified system designs are critical for bridging technological gaps in this group. Patient education initiatives empower users to navigate digital health tools with confidence. For example, the TrentinoSalute + initiative[70] has shown how clear workflows, user-friendly interfaces, and targeted educational resources can increase patient engagement and encourage the adoption of EHR systems. On the other hand, users in Cluster 3, despite their familiarity with EHR systems, hold negative perceptions due to resource misalignment and unmet expectations. For these users, it is important to focus on strategies that prioritize real-time feedback mechanisms[71] to identify and address dissatisfaction effectively. Involving patients in the design and refinement of digital health systems is also critical to ensure that their needs and expectations are met[72]. This approach helps align the system with user priorities, rebuilds trust, and creates an evolving platform that meets user needs over time.

User involvement in value co-creation benefits both users and healthcare providers. When patients update their medical history, symptoms, and other relevant health information within the EHR system, the quality and comprehensiveness of their health records improve. This collaboration ensures that healthcare providers have the most accurate and up-to-date information, leading to better diagnostic accuracy, informed treatment decisions, and improved healthcare outcomes. In today's digital landscape, it is essential to design EHR systems that enable and enhance value co-creation through practical, user-focused features that support collaboration between patients and providers[73].

Conclusion

Drawing from a service science lens, this study examines patient perceptions as factors that facilitate value co-creation through the implementation of EHR. Since value is derived subjectively and contextually by the focal actor, the interaction between actor-to-actor components and the individual dimensions of each actor is crucial for understanding the dynamics of the ongoing value co-creation process. Positioning the patient as the central actor in the healthcare system emphasizes that healthcare should revolve around the patient's needs, preferences, and overall well-being. From the perspective of co-creation in EHR utilization, patients are actively involved in their care, impacting outcomes through their engagement in treatment decisions, adherence to care plans, and self-management of health conditions. Given that the ultimate aim of healthcare services is to enhance patient health and well-being, patients, as the primary beneficiaries, are fundamental to understanding and addressing their experiences and needs.

The result of this study demonstrate that patients or users with different characteristics may perceive EHR differently. The clustering analysis identified three distinct user groups: Cluster 1 (High Familiarity & Positive Perception), Cluster 2 (Low Familiarity & Positive Perception), and Cluster 3 (High Familiarity & Neutral to Negative Perception). In the joint sphere, in which patients and healthcare providers interact through EHR applications, both parties may contribute to value co-creation. Conversely, the value can be diminished or destroyed through these interactions. Negative outcomes can result from misalignments in goals, misunderstandings, operational inefficiencies, or behaviors that disrupt the positive outcomes of service encounters. For value co-creation to succeed, access to resources and active engagement in resource sharing, integration recombination are critical. Resource alignment between users and the system ensures effective collaboration, while misalignment in goals or expectations can obstruct this process, leading to value co-destruction.

This study enhances theoretical understanding by emphasizing the significance of actor-to-actor interaction facilitated by digital technology in value co-creation. It recognizes that value is shaped through the interplay of individual dimensions and perceptions within specific contexts. Moreover, this research demonstrates how patient perceptions and expectations influence the outcomes of interactions enabled by EHRs. Additionally, empirical evidence from this study reveals that value co-creation processes can yield both positive and negative outcomes.

Practically, this study offers healthcare professionals guidelines for effectively managing patient expectations, communicating the benefits of EHR use, and addressing concerns to enhance patient satisfaction and engagement. For governments overseeing EHR applications, this study contributes to understanding how platform features and design principles can facilitate collaborative innovation and value co-creation. This highlights the importance of establishing feedback mechanisms from EHR users to ensure that the system evolves in response to users' needs and concerns. Insights gathered from such feedback can inform policies and services tailored to better serve each population segment. Mass customization in public policy allows governments to move away from one-size-fits-all approaches and deliver more effective and targeted services that improve citizen satisfaction and overall societal outcomes. Feedback from citizens within each segment helps to refine and improve policies over time, ensuring that they remain responsive to evolving needs.

The limitation of this study lies in the qualitative data collected through open-ended questions. While these responses added valuable insights and enriched the clustering analysis by providing additional context to user perspectives, their depth was limited compared to data that could be gathered through methods like interviews or focus groups. Future research should consider incorporating in-depth interviews or focus groups to capture richer user behavior and experiences. Moereover, further research is required to examine the perceptions of healthcare providers, who are also users of EHR system. Understanding these user perceptions is crucial for effective design and implementation of digital value co-creation initiatives that address diverse needs and expectations. Additionally, longitudinal studies are necessary to comprehend how value co-creation within the digital health ecosystem including the roles and interactions between stakeholders, impacts health outcomes over time.

Data availability

Data supporting this study is available from the corresponding author upon reasonable request.

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Author contributions

I.N.R. wrote the manuscript and performed data analysis. G.Y. reviewed and refined the manuscript. M.H.B. constructed the framework. S.S. performed the pilot study and data collection.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to I.N.R.

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