Service Design and the Digital Twin on Healthcare Industry

A Systemic Perspective

Shijie Luo and Yutong Sun
The Savannah College of Art and Design

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Professor: Mauricio Manhaes

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ABSTRACT

Background: Service design has received increasing attention in recent years, especially the application of service design on healthcare. The most significant impact of service design on healthcare is the integration and application of a professional medical team, patients, and available resources to a specific context system. Moreover, service design can also optimize interactions in the service process and facilitate the positive development of relationships. In current cases of healthcare, digital technology is often used. Among different techniques, the digital twin, as a complex multi-physics model integration technology, have been used and effective in the healthcare field. However, there is not much research to combine service design with the value of the digital twin in healthcare.

Purpose: The purpose of this exploratory paper is to discuss the value of using the digital twin in healthcare, especially when applying service-dominant logic into healthcare, and to identify the possible approach to use the digital twin in future healthcare.

Methodology: We chose to use Google Scholar to search the database of literature and used a systematic literature statistical method on the relevant aspects of service design or service-dominant logic, healthcare, and the digital twin, etc. The first step is selecting the keywords in Google Scholar in permutations and look for relevant literature. Secondly, select articles in these pieces of literature that have been cited more than 20 times for reading and research, which these high citations mark the influence and authority of articles in the industry. After selecting, we identified 32 papers of literature as reference materials, and the analysis and conclusions made on this basis. The details of every step are shown in Figure 1. And we conducted 5 in-depth interviews to

validate our insights from literature. From the interview, we came across some interesting opinions and feedback. Based on interview, we did backward research.

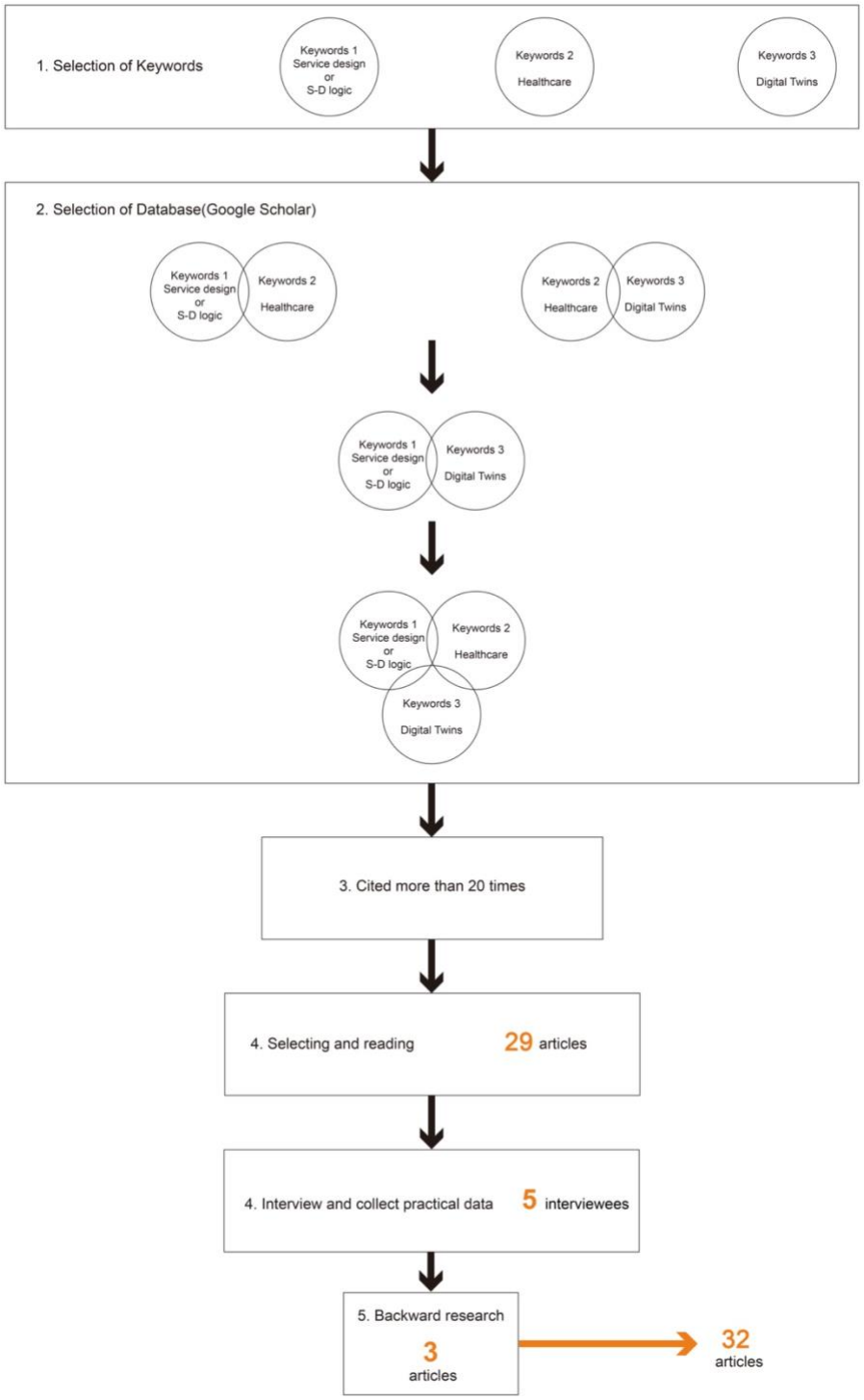

Figure 1.

Findings: The digital twin can be considered as a visible tool to carry service-dominant logic and apply service design to the healthcare industry.

Value: The value of this paper proposed three main area that can apply the digital twin to service design, especially in healthcare industry.

Research Limitation: Founds through searching the literature, although many articles related to the keyword "service design," many of the content did not point to the discipline of service design but stated "design for service." Besides, as a new technology, the digital twin has not had a lot of authoritative research, and its concept is still vague.

KEYWORDS: digital twin, service design, service-dominant logic, healthcare

1. Service Design

1.1 The definition of service design

Service design does not have a rigid definition. As service design is developing, its definition is constantly changing. The main reasons for service design's dynamic definition are because it involves multi-disciplinary integration, technology updates, and stakeholders' needs.

Service design is a complex and new field that combines various disciplines. It follows human-centered design principles, which develop and solve problems from the human perspective as a whole. Confirming the complexity of service design, according to Foglieni et al. (2017), service design is a human-centered design and interdisciplinarity that combines business and IT. Additionally, as technology is innovated, service design also connects with interaction design, branding, participatory design, etc. (Stefan, 2010). Because service design interacts with different disciplines, service designers need to explore solutions from a systematic and comprehensive perspective. Moreover, as these other disciplines have been updated and innovated, service design has become more complicated and diversified.

As Alves and Nunes (2013) claimed, "Service Design is described as the outside-in perspective on service development. More specifically, it is defined as applying design methods and techniques to the design of services." In other words, the continuous development of technology has brought more possibilities to service design. Moreover, the use of technology can improve the accuracy of service design solutions and increase efficiency.

The most purpose of service design is to innovate and identify perceived deficiencies. Stefan (2010) pointed out that service design helps to either innovate or improve services to make them more useful, usable, desirable for clients, as well as more efficient and effective for organizations. To achieve this, designers should understand the needs of users, customers, and organizations as stakeholders. Furthermore, this process is time-consuming and changeable because people's thoughts and relationships will always change with their different social relations, interest relations, etc., and there will be conflicts and contradictions from various stakeholders' perspectives.

Service design utilizes existing design methods and technologies with many disciplines to innovate and provides service systems that are more easy, practical, desirable, efficient and effective for stakeholders.

1.2 The development of Service Design

Service design has slowly developed and became an independent discipline from a supporting function of interactive design and technology in the last twenty years (Toivonen, 2016). After decades of studies, service design has been identified as focusing on innovation and sustainable development and evolves into a unique design discipline that has a set of tools (Pacenti & Sangiorgi, 2010).

In the development of service design, Service-dominant Logic, first proposed by Vargo and Lusch (2006), is a significant theoretical foundation and a crucial framework in service design. In the future, service-dominant logic can continue to develop with service design and advance the general theory of value co-creation from a market

perspective, such as exchange service, integration of resource, value co-creation, and service ecosystems (Vargo & Lusch, 2017).

1.3 The importance of Service Design

Service design has received much attention from society and the market in recent years (Toivonen, 2016), not only because the service industry can provide more employment opportunities and benefits (Chase & Apte, 2007) but also to the increasingly complex social structure. It has led to strong demand for collaboration and value co-creation (Vargo & Lusch, 2017).

In the nineteenth century (Toivonen, 2016), the center of economy and technology development basically revolved around industry and manufacturing. Traditional manufacturing industries and chemical industries provide guarantees for goods processing and the extraction of raw materials. At the same time, automated production has replaced most of the human work, which means that many laborers have been liberated. On this basis, people's demand for goods is more diversified and personalized. Besides, they have higher standards for the purchase experience and after-sales service (Reason et al., 2015). The service industry promotes the sales of goods, user experience, and other aspects of the product to complete the business system. Here, the service industry can meet personal needs and bring more benefits to businesses. Because of the service forms are diverse, and the service industry has more space for development and more plasticity, there are more opportunities for exploration. As Chase and Apte (2006) emphasized, the service industry has become the fastest growing industry in many countries.

Today, in any business model, as the business and social structure become more complex, the importance of interaction manifests between each sector in the trading chain, such as the relationship between service providers, suppliers, and manufacturers. The collaboration between each department becomes the decisive element that will affect the success of the company of business. Sangiorgi (2009) proposed service design from its original connection with the interaction Design

discipline and practice to its current state, which is strongly influenced by the growth of complexity and collaborative nature of service projects and society demands.

In this context, service design has much strength, and it will receive more business and social attention in the future. Service design can be applied the service-dominated logic to the different industries, ultimately achieving value co-creation for all stakeholders, especially in integrating complex social networks such as government, finance, and healthcare.

1.4 Service Design on Healthcare

Due to the meaning of “service design” that could be “design for service” in the past, therefore, we start with keywords combination of “service-dominant logic” and “healthcare” in Google Scholar. Before 2000, there is no relevant result. The number of literature for each year is shown in Figure 2-1.

Since 2000-2019, service design and service-dominant logic has received the attention of experts and scholars. Searching for combination of “service-dominant logic” and “healthcare”, we find 3,930 in total. The turning point is 2008 to 2010, the number had grown quickly and set the base of the domain. After that, the domain of this combination has grown in pace and generally, if comparing with the combination of “service design” and “healthcare”, it is ratio has been keeping grow from none to 1/3.

For the combination of “service design” and “healthcare”, there are 18,017 papers in total. In 2010, the quantity had more than doubled.

It not only shows that service design has received the attention of healthcare, but the continuous growth of data also shows the potential and effectiveness of the combination of the two fields.

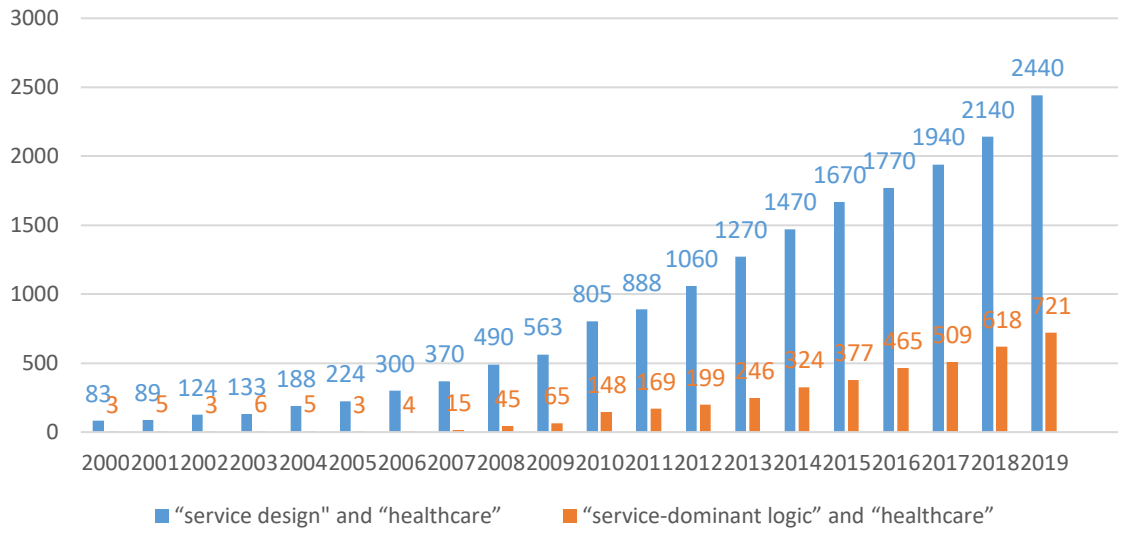

Figure 2-1. The data of literature for each year

In the article, Service Design for Value Networks: Enabling Value Cocreation Interactions in Healthcare (Patrício et al., 2018), the innovation of service design on healthcare is mainly integrating and improving services. The most significant impact of service design on healthcare is the integration and application of a professional medical team, patients, and available resources to a specific context system. Service design can also optimize interactions in each department and facilitate the positive development of relationships, which promotes good co-operation among all stakeholders and achieves value co-creation (Vargo & Lusch, 2017).

2. The Digital Twins

2.1 The Definition of the Digital Twin

The origins of the idea of the digital twin can be traced back to one of Grieves' (2014) presentation about Product Life Management in 2003 at the University of Michigan. With advancing technology, the definition of this concept evolved as well.

For instance, Hochhalter (Hochhalter et al., 2014) proposed that the digital twin is a life management and certification paradigm whereby models and simulations consist of as-built vehicle state, as experienced loads and environment, and other vehicle-specific histories to enable hi-fi modeling of individual aerospace vehicles throughout their service lives. On the other hand, Reifsnider and Majumdar (Reifsnider & Majumdar,

2013) hold the view that the digital twin is a kind of ultra-high-fidelity simulation integrating with an on-board health management system, maintenance history, and historical vehicle and fleet data.

The definition that has been wildly acknowledged by most of the scholars was given by Glasessegen and Stargel in 2012(Glaessgen & Stargel, 2012): the digital twin is an integrated multi-physics, multi-scale, probabilistic simulation of a complex product and uses the best available physical models, sensor updates, etc., to mirror the life of its corresponding twin. Meanwhile, the digital twin consist of three parts: physical product, virtual product, and the relation between physical and virtual products. By summary the description of the digital twin, the characteristics of the digital twin is listed below: (Boschert & Rosen, 2016)

- Real-time reflection: Various types of physical object data should be integrated, and it can keep a real-time mapping of physical objects.
- Interaction and convergence: It exist in and co-evolves with the full lifecycle of physical objects.
- Evolution and iteration: It can describe not only physical objects but also optimize physical objects based on the iterative virtual model.

2.2 The digital twin in healthcare

By searching the quantity of literature about "healthcare" and " the digital twin" in Google Scholar, a total of 645 results are found. The data of literature for each year is shown in Figure 2-2.

It can be seen from this figure that "healthcare" and "the digital twin" began to be noticed by people in some industries in 2016, and it is currently in the process of development.

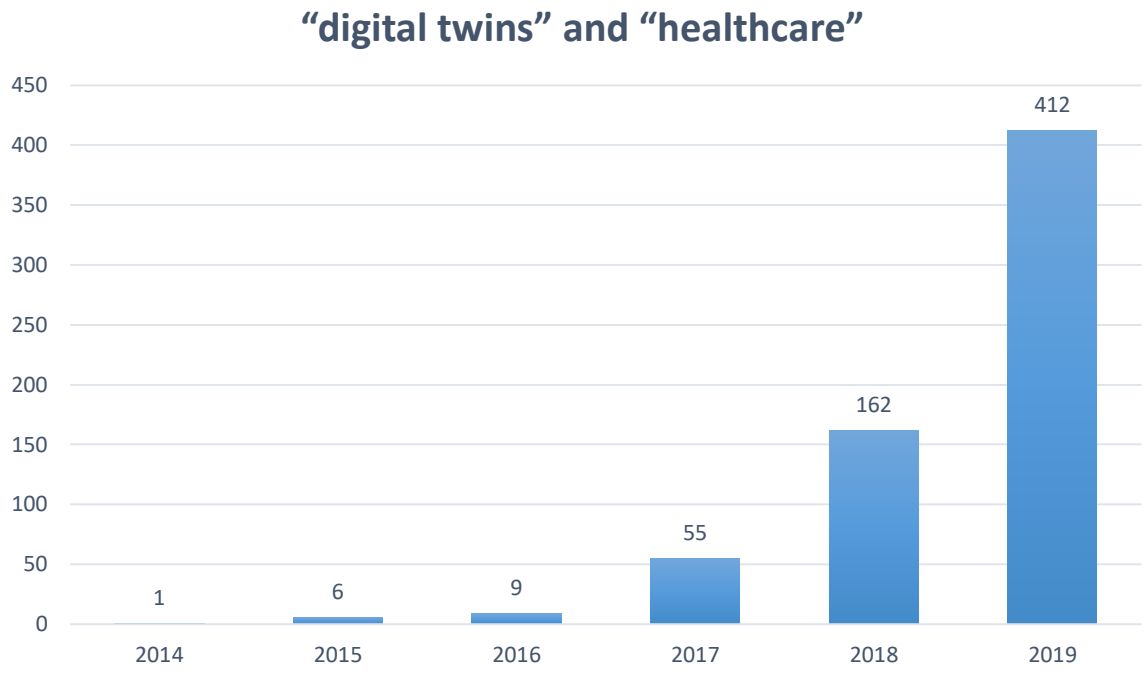

Figure 2-2. The data of literature for each year

3. Service Design and the Digital Twin on Healthcare Industry

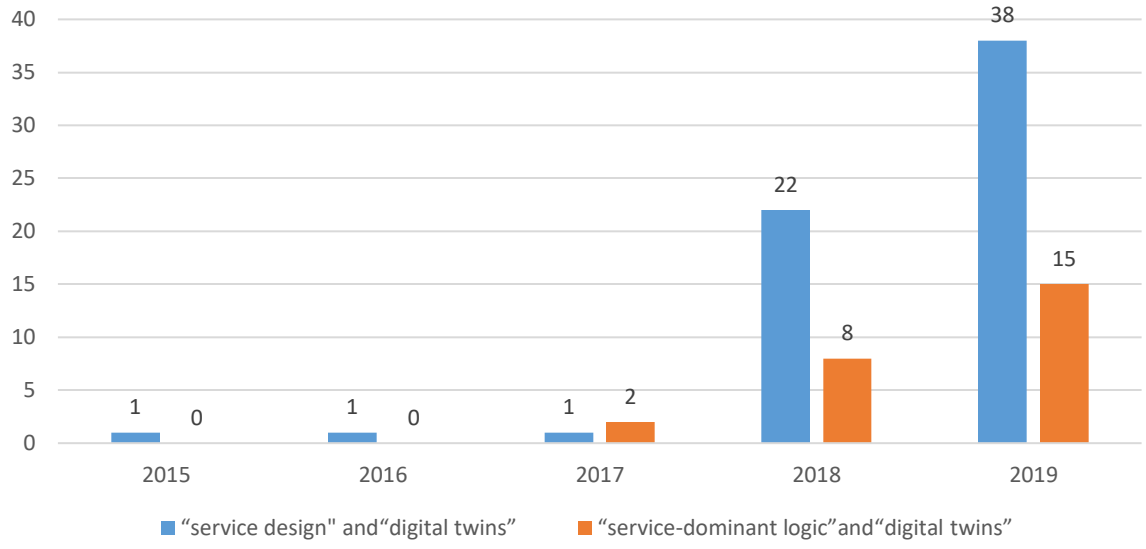

Figure 2-3. The data of literature for each year

The bar chart shows that the literature includes three main contents at the same time: "service design" or "service-dominant logic", "healthcare" and "the digital twin" as the main contents.

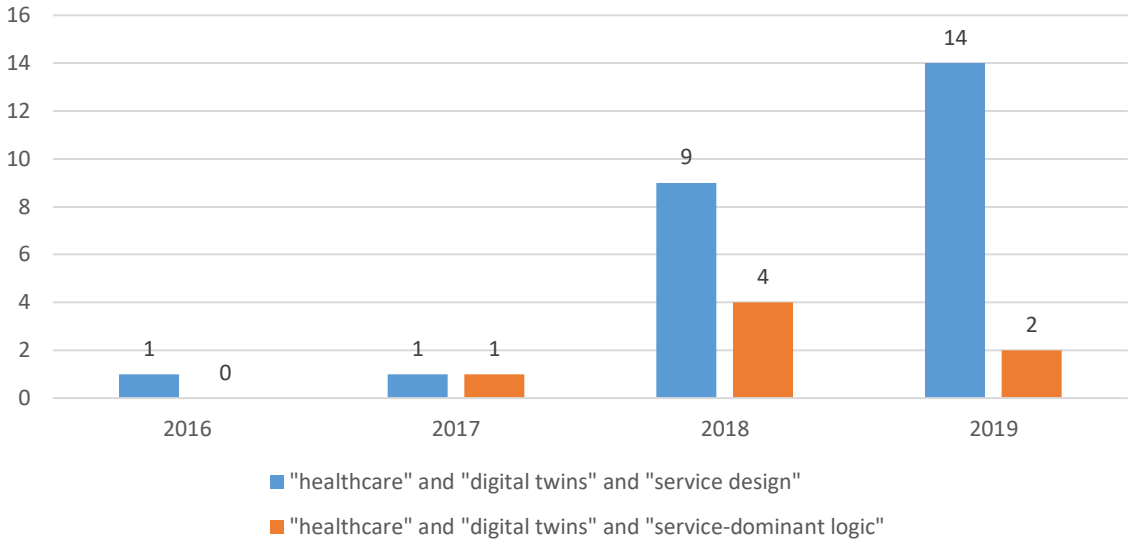

Figure 2-4. The data of literature for each year

For combination of “healthcare”, “digital twins” and “service design”, a total of 25 articles are shown. And it only takes 3.8% of the quantity of combination without “service design”, 0.005‰ of the quantity of combination without “digital twins”. It shows that there is not enough research and studies between the three fields together, and the connection of three is still in its infancy.

According to (Kindström & Kowalkowski, 2014), the service part of the industry is continuously growing and makes up a substantial part of employment and the domestic product. When it comes to the healthcare industry, the company and caregiver pay more attention to the service part. The focus of healthcare-related firms' value creation, thus, shifts from offering and manufacturer to co-creation by firm and customer. Currently, the digital twin is mainly used in product design and service management, manufacturing, product life prediction, and real-time monitoring of equipment in the industry. It is widely acknowledged that the healthcare industry is an industry that heavily relies on data and analytics. Practical information systems conducive to the work of health care professionals, and the keys of data is it's complete and accurate (Häyrinen et al., 2008).

According to Qi and Tao (2018), the process of value creation based on data is very similar to that based on the digital twin. Data and analytics are a crucial part of enabling

the digital twin. According to Tao and Zhang (2017), the integration of the digital twin and services must be addressed in the future. (Liu et al., 2019; Qi et al., 2018) mention the application of the digital twin and how to apply them in the product life cycle. It can provide value in the form of services in product design and engineering, in product operations and usage monitoring, and after-sales services and prognostics and health monitoring of the product.

On the other hand, the healthcare industry is starting to adopt the digital twin in many aspects. For example, for medical staff, it can help researchers to do experiments and testing of medicines in virtual patients to reduce risks and costs. Also, based on the digital twin model, medical experts or doctors do not need to see patients in person. They can determine the symptoms and prescribe treatment plans based on various real-time dynamic data from the digital twin and optimize treatment options through model iteration on a virtual platform. For medical devices organizations, it can do real-time monitoring, structural life prediction, and devices management of the medical devices. For patients, the digital twin can do real-time monitoring of their physiological states through the digital twin and give their information data to patients or their informal caregivers in real-time.

In the medical field, there are very complex interactions among people, medical institutions and business or insurance organizations. In addition, because of the dynamic and uncertain properties of current healthcare systems that can be regarded as a system of systems (SoS) (DeLaurentis & Callaway, 2004; Gorod et al., 2008), it is not very easy for us to research the behavior, patterns, and laws of healthcare systems with real scenarios. Therefore, modeling and simulation provide a good way to deal with healthcare systems. Specifically, simulations in healthcare, such as medical surgery training simulation, and medical auxiliary equipment design simulation, can improve the flexibility of medical research, reduce medical risks, and save costs. Nowadays, research in healthcare simulation mainly focuses on healthcare education using virtual reality simulation, healthcare mechanical simulation, resource allocation optimization and business process simulation, and clinical trial simulation, etc. (Augusto & Xie, 2013; Mendes et al., 2017) However, there are rarely simulation platforms or system for

healthcare that focus on research of behavioral laws, service models and intelligent decision-making of the entire healthcare system to support the rapid construction of realistic healthcare simulation scenarios. To leverage the full potential of the digital twin, we need to exploit different the digital twin archetypes. Most of the analyzed sources (Hartmann et al., 2018; Tao et al., 2018) suggest dividing the digital twin into different levels of hierarchy. The number of the hierarchy lever is from two (Landahl et al., 2018) to six (Tomiyama et al., 2019). However, the most common and comprehensible hierarchy number is three, and mostly referred to: (Tao et al., 2018; Zheng et al., 2018)

- Digital twin as "unit"
- Digital twin as "system"
- Digital twin as "system of systems"

Due to the space limitations, only the digital twin as "system of systems" is discussed below: systematic integration of healthcare institutions

Combining service design and service-dominant logic with the digital twin in actual healthcare institutions has the following three main advantages. First, the digital twin will help to plan the overall environment of healthcare institutions and promote the rational use of medical equipment. Second, the digital twin will make better work arrangements for staff and help to maintain good interaction with patients to ensure their mental health and pleasant experience. Finally, the result of using the digital twin is to enable various departments in the medical system to collaborate, including patients, and achieve value co-creation between any departments.

Siemens, a German multinational company, focuses on the energy, medical, industrial, infrastructure, and urban business, and its electronics and electrical products are pioneers in the global industry. At present, Siemens has developed a workflow simulation effect diagram of the integrated hospital ward management system using the digital twin. Siemens uses 3D computer models to layout the hospital environment and specific clinical environments, such as operating room or accident and emergency. Arranging layouts through the digital twin will improve the total efficiency through specific utilities of different resources. From the perspective of the healthcare staff,

using the digital twin means they can better arrange the time and workflow, thus achieving the purpose of work.

Moreover, healthcare institutions can use the digital twin to make simulations and predictions about different situations that may occur in the future. In other words, the digital twin will predict various unexpected situations that may happen to different patients in the future to anticipate and prepare for them in advance. It not only guarantees the user experience for patients but also lives. Finally, the use of the digital twin in the integration of healthcare institutions will promote the value co-creation for each stakeholder in the healthcare system.

4. Field Study Results

A series of in-depth interviews were conducted in order to validate the findings from the literature. The interviews were analyzed based on the content of the interview and the interviewees' company. The main findings of the interviews are sorted into a rainbow spreadsheet. (Figure 3.) Based on the rainbow spreadsheet, several affinity processes were conducted to find out the insights. These insights here confirm that the digital twin could be a good approach to bring service design and service-dominant logic into the healthcare industry.

The description of five company:

Company A: One of the biggest American for-profit managed health care company, it offers health care products and insurance services.

Company B: a part of Company A, is a pharmacy benefit manager and care services group operating across 150 countries. Company B is Company A technology-focused arm.

Company C: A start-up that only founded within 5 years, Company C is working to connect the dots in social care to improve outcomes and help people stay well for longer. Its connected platform combines sensors and devices to analyze behavior patterns of vulnerable individuals in their homes, before using AI to identify meaningful changes and alert family members and care providers.

Company D：It is an Accountable Care Organization that is committed to delivering high-quality collaborative care is a cost-effective manner.

Company E: It is formerly one of the largest electronics companies in the world, currently focused in the area of health technology, with other divisions being successfully divested.

There were five interviewees in total. After introducing the basic definition of digital twin and related appliance in service design, we asked them some questions, the major questions are listed below:

Q1: What' the most interesting part that you found in "the digital twins and service design"?

Q2: What's your expectation of "the digital twin and service design" in the future?

Q3: What's your worry about "the digital twin and service design" and related technology?

By analyzing the content of the answers, there were few things words grab our attention, and we listed the frequency of these words. Firstly, all of the interviewees mentioned the word “data”, and it has the highest frequency of word, which is 16 times. By combining the word “data”, “predictive”, “intimidate”, “uninformed,” and “trust” and its context, we came up with our first insight: People doubt the accuracy of using digital twin and whether it is safe or can be trusted. Secondly, we combined the word “cost”, “money” and “insurance”, the result indicated that people want to know what’s the cost of using digital twin and what kind of value it can offer. Thirdly, we combined the words “standard” and “regulation” and its context. We concluded that people want to know the specific regulations and standards of the digital twins. What’s more, there was a specific

statement address that we need laws and contract to ensure its safety.

Word	Frequency	%Total	No.Cases	%Cases
Data	16	1.30%	1,2,3,4,5	100%
Cost	5	0.40%	1,2,3	60%
Predictive	4	0.30%	1,2,4	60%
Money	3	0.20%	1,5	40%
Insurance	3	0.20%	1,3	40%
Intimidate	2	0.20%	1,2	40%
Uninformed	2	0.20%	1,2	40%
Trust	2	0.20%	2,4	40%
Standard	2	0.20%	2	20%
Regulation	2	0.20%	1	20%

Figure 3. The data collection of words from the interview

We find telehealth communication can intimidate the uninformed	We think tech can intimidate the uninformed	I give support, facilitate conversations between clients with the goal to help companies to infuse technology	We believe through proper management of ideas, patients can live longer at home	We find RPM lets patients monitor their own programs and gather data easier
All the data we receive is transactional, which is hard for decision makers	We think constant access to patients lowers cost for payer	I find our current healthcare system is not sustainable	We believe due to the difference between healthcare and patient, it is difficult to make specialists available/providers and insurance on the same page	We find top health care priorities are hard to determine
Data takes time to gather, flow from one place to another, and decipher	We think that industry standards can seriously hurt competitors who don't have the tech to match	We find healthcare has grown in costs and complexity, but it's not accomodated by improvements and outcomes	We believe lack of knowledge deters patients from getting help and often results in denial	We find people have dynamic needs to know when and where they want relationship
We want data to be used for early detection, social economic status of patients, satisfaction of population	We feel that most people are not saving for care that is not covered by payers	I think the framework for implementing a product involved: Need, availability, tech, and user effort	We believe provider should be averted of patient health change/improve clinical - tech trust	We want to transform perspective of "healthcare" to a humanizing one
We want RPM to use for long-term and preventative care	We prioritize the mosr intervenable members	I think healthcare systems are independent of United Healthcare	We want data to be used for preventative care	We find the US has very expensive healthcare, and the biggest concern for patients is money
We find patients face obstacles in receiving adequate care & knowing where to go for that care	We desire to make life better through proper management of conditons	We find insurance bonuses are aligned with wants of certain segments of the population	We think data makes predictive care attainable	We want patients to live in-home longer and not to come to the facility when it could be done at home
We wish we received more contextual data	Wwe believe non-vitals can be more valuable than vitals	I think current health care system is not good with monitoring and incentivizing consumers who complied with adherence while dealing with other things		We find RPM should not only be understandable but valuable for user, caretaker, and payer
Safeguards & contracts are important, but inhibit innovations and good user experiences	We want to speed hp re-enablement	We find customer satisfaction to be a big issue for insurance providers		We use current solutions to pick a small solvable issue in healthcare and go for it
We find that patients may not be comfortable with digital healthcare & data sharing	We know home care providers are selling an hour of nurse/care each day	We find you can't do everything for everyone		We must empathizw with every stakeholder and visualize unarticulated needs
We found that educated agents, families, and reducing stress play a key role in patient care	We think families can have reassurance through understanding challenges of elderly and the need of RPMs	We find big health care companies understand their customer wants and needs		We find cocreation with different stakeholders is important, and RPM devices must manage the priorities of them
We find predictive care is unattainable without massive data	We feel that the RPM system is only available to single occupancy users	We find the ways that healthcare is delivered, as well as being ill-informed of prices, are large barriers to preventative care		We call patients to check their condition which is difficult
We want to reduce healthcare cost of and to patients	We find it is really hard to get patients with dementia to sit still	I want intelligence, data, and analytics to drive changes in customer engagement		
We think healthcare isn't proactive enough, too reactive	We think evidence-based conversations increase adherence	I find human nature like cognitive overload and over-optisism is a barrier to preventative care		
We can use simple smart devices to help us gather data more easily	We think active monitoring systems are inconvenient	We feel tremendous frustration to need prior authorization before procedure		
We find providers are frustrated with outdated/non-user friendly technology	We wonder where liability lies in tech because tech companies need clinical trust and support	I find the desires to use RPM are preventative care and long-term care		
We find there are not enough authorititative voices on RPM devices	We find liability is tricky during testing, but ultimately lies with the care professionals	We find preexisting conditions are covered but we need policies to cover more		
We find it's hard to choose proper RPM devices for patients without putting extra burden on the provider	We feel health can be monitored by simple smart devices, so doctors have reassurancd when sending patients home	How can we reduce costs, improve outcomes, rethink opportunities for health care delivery		
We find that RPM is time consuming to implement, takes a lot of effort, and still has issues	We believe monitoring/responding to RPM data is extremely personalized	We find our system is really focused on sick care and not earlier detection		
We find that healthcare is complex and doesn't have clear focus	We are unsure of US custoners and dont yet have personas			
We find communication between insurance, advocates, pharmacies, and providers, helps patients save money	We believe the future industry is in data and analyzation when groups can access an elderly patient's data as needed			
Rules & regulations are too much and changing too quickly, so they are a main obstacle	We think there isan untapped market of elderly who need companionship and social care, but it is not cost-effective because it's almost entirely privately paid for			
We find that the regulation and guidelines need to be updated for new areas	We are not interested in using clinica, health data because we want to look at early detection			
We find it's hard to understand healthcare	We are in an era of 'pre-emptive' care + desire a method of predictive +			

Figure 4. Rainbow spread sheet

5. Ethical Problems

Through interviews, respondents consider the cost of "service design and digital twin on healthcare", which means not only weigh the value-in-exchange but also consider value-in-use (Vargo et al., 2017). Next, With the development of technology and the integration of multiple disciplines, new ethical issues also arise (Bruynseels el at., 2018), such as identifying standards and regulations for using digital twins and guaranteeing the security and accuracy of data.

As of now, society has not looked for strict standards and rules regarding digital twin technology. Most designs often involve ethical issues implicitly rather than provides explicit solutions (Steen, 2011). As Carlsson (2013) said, although service design is a highly ethical discipline, there are few precise approaches to ethical issues.

Under the condition that there is no clear standard specification now, service design and the digital twin in the healthcare industry may cause the following ethical problems (Bruynseels el at., 2018):

a) Lead to new discrimination and a new class.
b) Influence human self-perception.
c) Affect the social perceptions of humans in the future.
d) Create new human standards for "health" and change the genes of humans. Even, it is possible to create humans of non-human nature.

6. Conclusion

When talking about the digital twin, we should be realized that the digital twin is a very complex concept. The digital twin is generated from a service perspective to conceptualize services that create value for a range of actors within the ecosystem. When using the digital twin as a service enabler, we should consider the layer and context of the digital twin and the ethical effect for humans.

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