

Article

Fad or trend? Rethinking the sustainability of connected health

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Abstract: Policymakers, academics, and industry players have been focused on determining whether connected health (CH) is a fad or a trend by looking at its sustainability. Although the significance of innovation in healthcare is gradually rising, a definitive identification and systematic comprehension of the core drivers, structure, content, and pattern of innovation in CH are missing. To bridge this gap, this study re-examines and analyses CH from the perspectives of its industrial chain and structure, to assess its future prospects and sustainability by focusing on how its structures and participants act in the ecosystem. This study involves an inductive theory building approach based on multi-stage, semi-structured interviews (n=60 in total). The results indicate that the core drivers, constituents, and components of CH need to be identified and restructured. A valid discourse, which is missing in the current literature, should be proposed with regard to the sustainability of CH. A sustainable business model innovation (BMI) system and the methods employed to achieve sustainability are suggested to discover indicators for future success. This study enriches the current CH understanding from a technology perspective and suggests some implications for practitioners as well as policymakers to enhance sustainable development in the healthcare sector.

Keywords: sustainability; connected health; fad; trend; value; business model innovation; ageing society; telehealthcare; and Taiwan

1. Introduction

Due to the adversities encountered by an ageing society, connected health (CH) is emerging as an alternative technological measure that allows healthcare to be provided remotely, to increase efficiency, cost-effectiveness, and satisfaction for healthcare recipients [1,2]. However, there is a controversy regarding whether CH is a fad or a trend, which has led to an increased focus on its business sustainability [3,4,5,6,7]. In this study, the sustainability of CH is defined as the ability to exist, be self-sufficient, and coexist in an ecosystem, wherein the exploitation of resources, direction of investments, orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations [8,9].

Business sustainability often confirms the need for change and innovation in companies' current business model (BM) [10,11]. This is apparent in a novel discourse regarding CH, with increasing concern about sustaining businesses. CH is proposed as a promising, effective solution to ageing population issues in healthcare; however, its performance and outcomes are still controversial, despite the fact that it has been practised for decades [12,13]. As such, it is important to understand what is preventing the full effectiveness of CH.

This study aims to rethink and discuss the industrial chain and structure of CH to assess its future and sustainability. It focuses on how its structures and participants act in the ecosystem to bridge the gaps in business sustainability. In fact, whether its structure is loosely or tightly coupled and whether its participants are active may affect CH's sustainability. The review and analysis in this

study found that the root causes of CH unsustainability are the lack of core drivers of business sustainability, appropriate content structures, and patterns of innovation. This study contributes to the existing literature by exploring the nature of CH in the Taiwanese context to discover crucial elements of sustaining CH business. The key findings suggest a rethinking of the business model innovation (BMI) in CH and subsequent analysis, integration, and redefinition of its elements. This study then develops a Value-Centric Business Model Innovation System (VCBMIS) as a solution; however, the analysis of its underlying patterns is left to future research.

2. Literature Review

Connected health applications are efficient solutions to improve health care services [14,15]. This study references the essential literature to identify the knowledge gaps within CH and aims to define a reusable requirements repository for sustainable, connected health applications based on the innovation of business model elements. The literature review of this study adopted the convergence and business model innovation concept to provide a concise and up-to-date review that accounts for the influence of technology and social phenomena [16]. Current literature on CH implementation is emergent and has illustrated how technology enables a more connected healthcare system; specifically, the improvement of healthcare accessibility, cost-effectiveness, and quality of life [17,18,19,20]. Nevertheless, there are many unexplored areas relating to business sustainability in terms of quality, cost, increased technology, and future development in CH [21]. In general, critical issues can be summarized as follows: cost (finance) [22,23], infrastructure [24,25], technology [22,26], business sustainability [27], and collaboration and integration [28,29]. There are divergent interests between CH industries, the government, and consumer stakeholders in CH in relation to these issues, with the key issue being CH's sustainability [30,31].

2.1. Current status and issues in CH

In this study, CH is an umbrella term for the family of applied healthcare solution technologies that aim to alleviate shortages of healthcare professionals while controlling cost, increasing efficiency, and maintaining quality [22]. Research in CH is timely and relevant; most societies are already deep into an era characterized by an ageing population and multiplying healthcare needs. An initial review of CH in this study reveals that most research focused on its performance in terms of cost-effectiveness and efficiency [1, 3, 6, 14, 22]. This study further explores the relationship between technology and wellness and the optimization of this relationship within the macro environment.

In brief, CH arose as a result of three factors. First, there is a tendency to pursue excellence in healthcare, such as by promoting and monitoring quality, efficiency, safety, and customer service [32,33]. Health professionals and institutions desire better access, quality, and efficiency of care [34,35]. Second, costs are rapidly increasing due to the ageing population, an increase in chronic conditions, better survival rates among patients fighting serious diseases, and longer lifespans [36,37]. The healthcare economy has thus become more dynamic than in the past [38]. Third, increasing provider shortages and other relevant challenges, such as the geographic dispersion of families and troubling ethnic disparities in the provision and quality of care, are very significant concerns [39]. A further source of pressure in healthcare is the demand for better service by paying customers. The development of consumerism in healthcare may be a catalyst for patient-centric healthcare [40,41,42]. These factors together have created a stronger impetus to force innovation, both from inside and outside the system.

Issues affecting the development of CH

An overview of CH implementation in the US and EU illustrates how technology enables a more connected healthcare system and its societal benefits [22,43]. Healthcare services can thereby be extended to distant populations with significant cost-saving outcomes for certain chronic conditions [44]. Quality improvement and fewer or less severe caregiver shortages are evident. These benefits overlap in improvements to healthcare accessibility, cost-effectiveness, and quality [32,33,34,35].

Many international CH pilot schemes show application feasibility; however, the cost saving is not significant. The universally successful implementation of CH care remains an open issue [45]. This lack of evidence in support of sustainable CH suggests that some challenges remain, despite the evidence of application benefits from the US and the EU.

Although the significance of innovation in healthcare is gradually rising, a definitive identification and systematic comprehension of the core drivers, structure, content, and pattern of innovation in CH are still missing. Researchers still need to bridge this gap. This study reviews innovation methods to identify appropriate means to design and clarify an innovation pattern in CH.

2.2. Innovation methods

First, selecting an appropriate innovation type depends on an organization's aims and objectives. The literature indicates that the main issues in healthcare systems generally concern cost, quality, and accessibility. Indeed, innovation does play a significant role in sustaining growth and economic development [46], which makes the selection of innovation methods more critical to success. The literature review also suggests that the issues in CH are relevant to the lack of innovation in BMs [47]. Thus, it is essential to identify an appropriate innovation type and method to resolve these issues. This study adopts disruptive innovation because the ineffectiveness of traditional methods in healthcare increases the need for different solutions. Healthcare is relatively conservative compared to other business sectors, although numerous innovations have existed for decades, with much sustaining innovation to reduce the risk of failure [48,49]. These innovations focus solely on allocating and managing health resources [47,50]. Consequently, the outcomes of innovation do not translate into satisfying results.

Second, the confined application in technology innovation limits its effectiveness. Over the past 30 years, the demand for innovative treatments and equipment to improve the quality of life often increased health expenditures significantly [51,52]. Although many innovations have been applied, they mainly evolved to be employed in products, services, and processes. Consequently, they serve only limited outcomes and may not always help reduce cost while maintaining quality. Reaching such aims seems to require a broader application of technological innovation.

Third, any fundamental and effective changes will involve the healthcare system's stakeholders [47]. To make healthcare innovation effective, industry players, funding, public policy, technology, customers, and accountability all have essential roles [53]. Because the healthcare sector is a complex mix of multiple stakeholders and cross-departments, it requires a more radical level of innovation to address these diverse requirements successfully.

Finally, there is evidence on how to apply disruptive innovation to healthcare in a manner that has already been proven to be feasible and has contributed to effective healthcare [54,55,56]. The telemedicine-based institution, one of the CH models, is indeed a disruptive BM for diagnostic activities and supports the argument that disruptive innovation can work in healthcare with significant outcomes [57]. Therefore, disruptive innovation is suitable for this study because it is more likely to meet the objectives of enabling more affordable, accessible, and efficient healthcare while maintaining quality.

The nature of disruptive innovation and its beneficial adaptation to healthcare is of considerable interest in this study. Most innovations focus on technology since innovation was initially the responsibility of the Research and Development departments [58]. Although technological innovation is remarkable and representative, as many companies have succeeded with innovative BMs that depend on advanced technology, it is not in itself the primary purpose of innovation. Moreover, Christensen, Grossman, and Hwang (2009) believe that "disruptive innovation" can permeate to firms' or hospitals' BMs, which contributes to both the affordability and quality of healthcare [47].

The use of innovation in this study focuses on the need to rethink the BM in the CH ecosystem by changing the role of the customer and the industrial chain structure, which may fundamentally and radically alter the approach [58]. This makes this study different from other studies that merely summarize and analyse the current BMs in CH. According to Chesbrough (2007), the BM mediates

the technical and economic domains, and therefore, it may be meaningful to investigate the liaison between technological development and economic impacts in healthcare through the BMI [59]. In short, the BM can be a vehicle for delivering innovation while being an element of innovation simultaneously.

3. Research Methodology

This study employed an exploratory approach based on multi-stage, semi-structured interviews (n=60 in total) to address the study's aim and research question. The research question is whether connected health (CH) is a fad or a trend from the perspective of sustainability. Factors of core drivers, structure, content and pattern of innovation are considered as review protocols to rethink its sustainability. A better understanding of an emergent discourse, such as CH, through a qualitative methodology exploring its nature by insightful inputs, wider discussion, and synthesis of diverse opinions can be facilitated to bridge the knowledge gaps in the literature [60].

3.1. Research Method

Taiwan was selected for the case study exploring the development of CH sustainability and the phenomena of population ageing, as this case has experienced significant progress in its core activities. These include its complete CH business ecosystem, including the maturity of information communication technologies (ICT) applied in healthcare and an integrated healthcare system. Through asking 'what' and 'how' questions, a single multi-stage case-study approach aims to explore rich contextual information rather than generalizing principles to a population [61]. A diverse CH ecosystem of stakeholders including academia, industry, and the government were interviewed to enrich the understanding of how CH can be improved. Multi-stage interviews were conducted to enhance the depth of the research through iterative data collection.

3.2. Research Design

Although Taiwan's case is typical for studying the sustainability of CH, time and distance with regard to collecting and analysing, qualitative data posed a challenge. In order to overcome these issues, several innovative methods to manage data collection were proposed. The principle of agile methodology was used in data collection for its high efficiency with regard to rapid feedback from respondents and adaptability to a fast-changing environment. This methodology fulfils the flexibility characteristic of qualitative research, as suggested by Yin [62].

3.3. Data collection

In this study, the data were collected in a multi-stage setting to progress and adapt to the multi-dimensional nature of the CH ecosystem. First, pilot interviews (n=16) were conducted with relevant influencers in the CH debate to explore the phenomenon. Key influencing stakeholders in the Taiwanese CH ecosystem were identified in this phase. Second, based on the pilot stage findings and analysis, and in line with an agile approach, stage one interviews (n=22) were conducted with designated stakeholder groupings (CH healthcare policy-makers and CH delivery firms). The stage two interviews (n=22) were conducted one year later and addressed the gaps identified in stage one and two interviews. This was done to discover systematic problems in CH over time and to review longitudinal changes since the two stages of interviews. These interviews probed the CH problems discovered in the literature, including cost, infrastructure, technology, business sustainability, business model, and collaboration- and communication-related issues.

3.4. Data analysis

The data analysis strategy covers both a thematic and systematic approach to qualitative analysis. The former was organized via deep familiarization with the data collected, leading to the development of major themes. The latter was using NVIVO 10 software through word frequencies to identify key themes. The data were analysed by grouping words or sentences from interviews

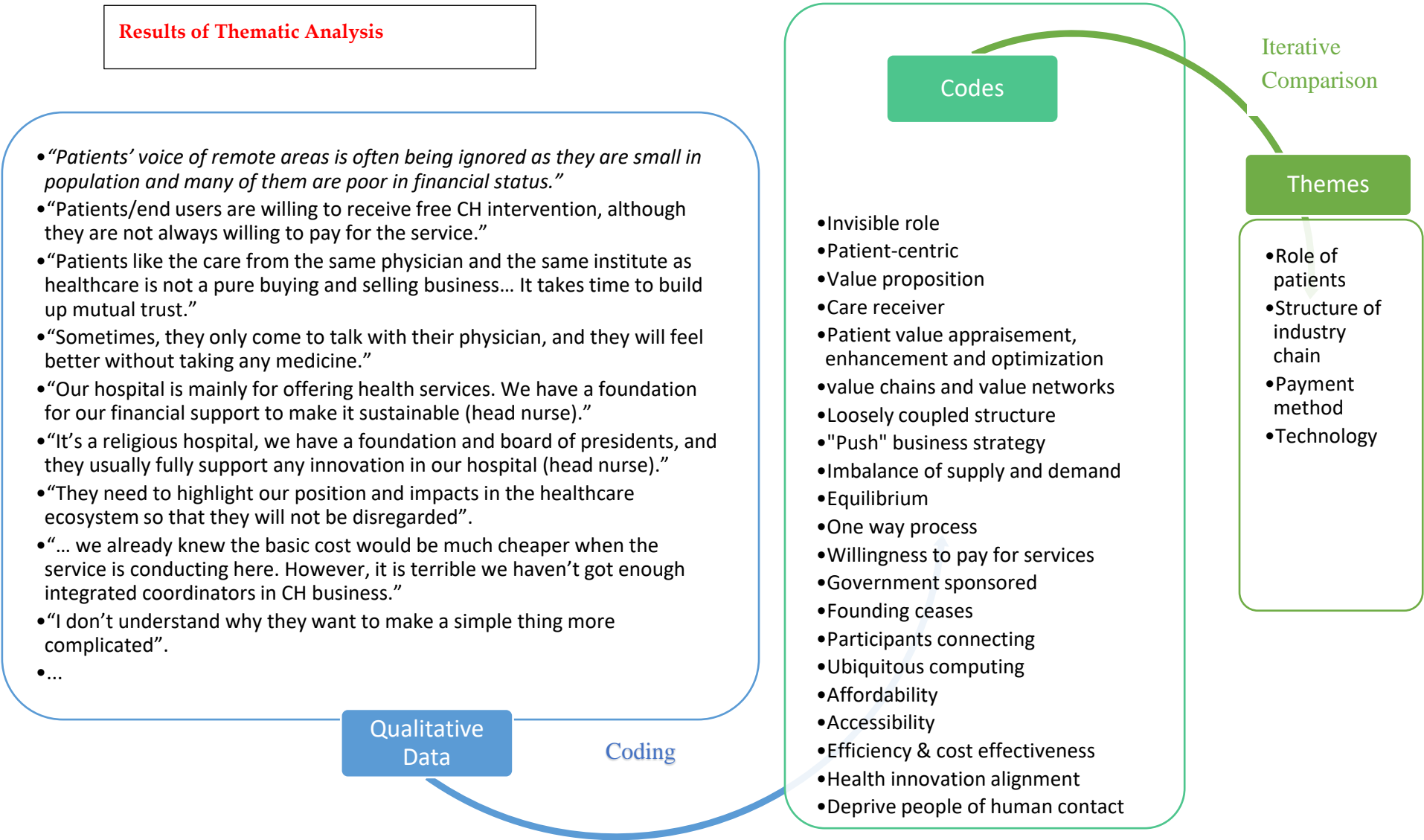
through word frequency, followed by a more in-depth statistical analysis, which is an approach to present qualitative content in a quantitative way and then to include the development of “quality” through quantitative changes. Therefore, content analysis and coding can be considered a method of researching content to clarify the meaning behind the content in an objective and systematic way [62]. This analysis adopted a grounded approach. Initially, coded data and themes that were drawn out might change rapidly. The number of new themes emerging gradually diminished and the number of refinements to themes reduced when approaching (theory) saturation. These processes followed the steps of “describe”, “classify”, and “connect”, in line with the literature and applied a constant comparison analysis technique to ensure the quality of data analysis. Data collection and analysis were iterated and reflected parallels to the collection of data until saturation occurred. In addition, the constant referral of up-to-date literature contributed to the data analysis [62].

3.5. *Validity*

As far as the reliability and validity are concerned, the agile methodology (multi-stage) to the data collection and data triangulation are applied to ensure the research quality. The data collected were summarized, confirmed, and discussed in the subsequent interviews until the final interview to ensure reliability and validity. The strengths of this method are that the main interview contents can be confirmed and corrected quickly by experts in the CH ecosystem. This approach created an environment of a virtual focus group in each interview; bias can be minimized by debate and confirmation within each interview, meaning that not only can this approach obtain the insights of brainstorming but it can also diminish the bias and disadvantages of a focus group [62,63,64].

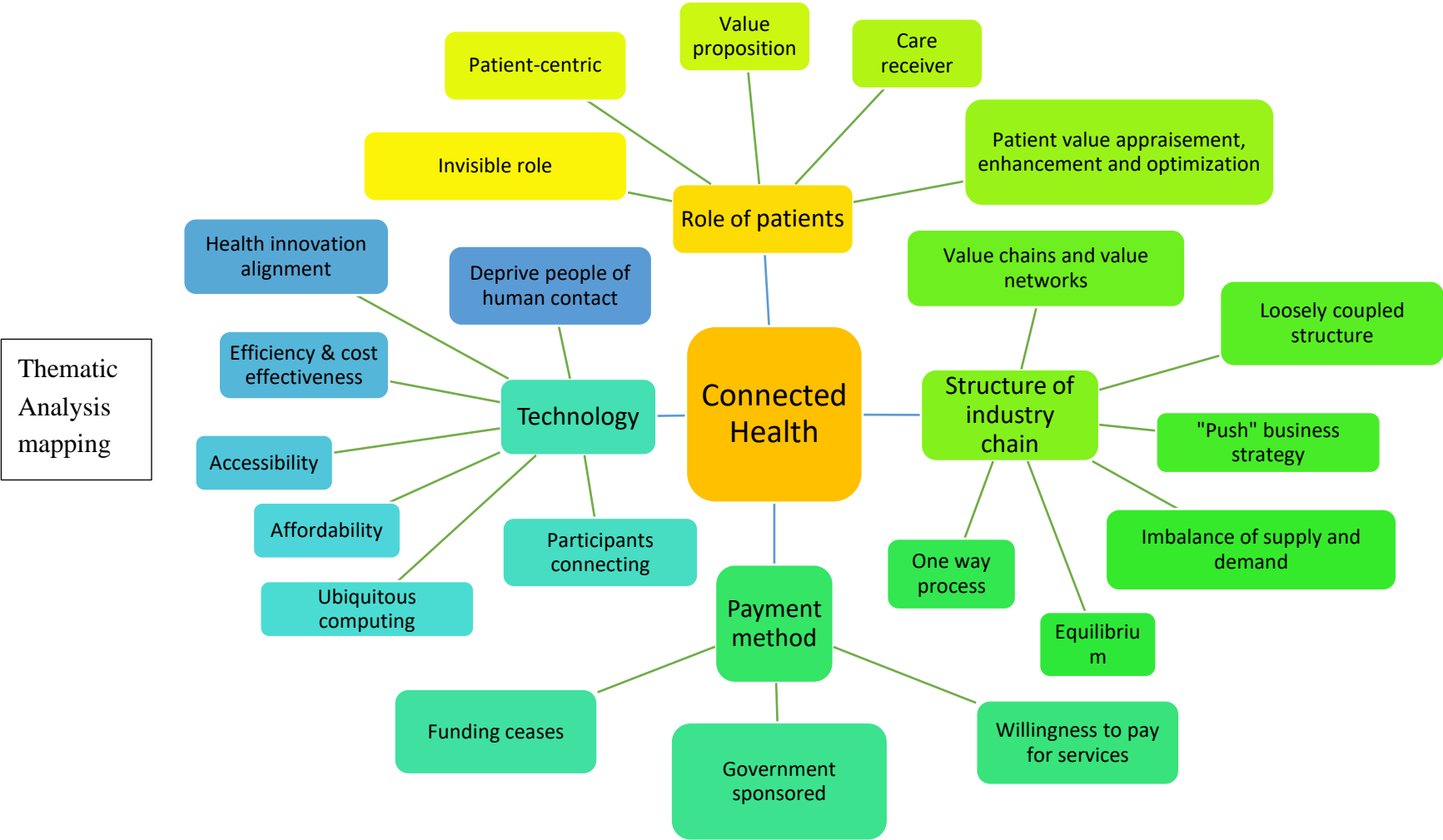
4. Results

This section summarizes the results of the interview analysis according to thematic analysis as shown in Figure 1, 2. In brief, the pilot interview confirmed the need for CH research and provided indications to improve interviews in the next stage. The two subsequent stages of interview results are presented as following sub-section. CH’s adaption is divided on the merits of the outcomes. Indeed, CH can contribute to efficiency and cost-effective of health delivery. The motivation and incentives for remote residents to adapt CH are concerned. This may suggest that the current assumptions in CH are problematic because they cannot address business sustainability. As far as business sustainability is concerned, essential components of a business model are employed to display the results. They are classified into patients’ roles, industry chain structure, payment, and technology because they are indicated as critical areas related to CH’s sustainability.



1

2 **Figure 1. Results of Thematic Analysis**



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4 Figure 2. Thematic Analysis mappi

4.1 Role of patients

Figure 1. and Figure 2. illustrate how interview data is coded and interactively compared into themes. Terms such as invisible role, patient-centric model, value proposition, care receiver and patient value appraisal, enhancement and optimization are coded to show the characteristics of the role of patients in the CH ecosystem. Patients seem to be invisible stakeholders or passive participants in the CH ecosystem, despite their indispensable role. It is seen that patients' role in the healthcare is essential but often being ignored. As they have little power in influencing people and decision making. Although patients have not yet been interviewed in this study due to ethic concerns, their views can be reflected through health professionals and caregivers to let them not so marginalized in the healthcare ecosystem.

"Patients' voice of remote areas is often being ignored as they are small in population and many of them are poor in financial status." (General Physician)

According to the respondents, patients tend to stick to the physician and caregivers that they are familiar with. Therefore, CH may be a promising implementation for them to stay "ageing in place." Patients in remote areas follow the principles of "ageing in place": feeling comfortable growing old in their hometown. Therefore, they are not willing to travel to a famous hospital to see physicians that they are not acquainted with. Care services that are offered by someone that they trust and rely on may be more effective than fancy technologies and luxury facilities.

"Patients like the care from the same physician and the same institute as healthcare is not a pure buying and selling business... It takes time to build up mutual trust." (General Physician)

"Sometimes, they only come to talk with their physician, and they will feel better without taking any medicine." (General Physician)

Apparently, both industry leaders and policymakers are more interested in those who can bring financial benefits to them. Therefore, the infrastructure of CH becomes barriers as the scale of economics is hard to be met in remote areas.

"Patients/end users are willing to receive free CH intervention, although they are not always willing to pay for the service." (Sales Manager)

Strategies of playing a role for remote residents in the healthcare ecosystem is to increase or enhance their importance through their wisdom. Using the resources of remote areas to build up unique competitiveness through differentiation strategies. More and more health care professionals seek to employ media and public relations to connect with people through their storytelling. These may be a good start to break through the dilemma of remote health care.

“They need to highlight our position and impacts in the healthcare ecosystem so that they will not be disregarded”. (General Physician)

“Why customers can only be consumers? Why they can’t be suppliers or even stakeholders? (General manager)”

4.2 Structure of industry chain

The codes of equilibrium, value chains, value networks, one-way process, loosely coupled structure, "push" business strategy, imbalance of supply and demand are integrated and merged into the theme of industry chain structure as shown in Figure 1, 2. Companies use value chains and value networks to assist the supply chain between the company and the customer. In the case of CH, customers' value is mainly considered as providing profits for companies. Once, their potential customers are not willing to pay for the service, it will affect the structure of industry chain. As far as industrial players are concerned, many companies jumped broadly and blindly into CH's businesses without identifying business fad or trend. Consequently, only a few of them can survive eventually. Those who identify the market gaps and feature on a good connection with academia, government and industry are more likely to succeed in market competitions.

“We offer free trial of three months for customers, but many of them return it to us within this period of time, as they would like to try but do not want to pay and we have no control over it.” (Sales Manager)

“Many products and services for remote health emerge in the market but patients do not feel like they need them. Consequently, it results an imbalance of supply and demand, which makes many companies hard to survive...(General Manager)

“Without good relationship with academia, government and industry, you will be hard to survive in the connected health market.” (General Manager)

“Many patients in remote areas have low purchase capability, and they do not have royalty to connected health's products, so they do not have strong connection with providers.” (Sales Manager)

As for healthcare facilitators, some institutions can manager CH better and better after they experienced the learning curve, while the others are still struggling. On the contrary, some urban institutions are emergent for the demand from customers. They usually demonstrate their ambitions and impressive performance in CH. Their expectation is to help their customers can receive health service anytime and anywhere.

“We notice that some companies cannot offer user-friendly products as they do not have sufficient feedbacks from customers...”(Head nurse)

“We hope our patients can obtain full-time services. They can get help whenever they need it. ”(Head nurse)

4.3 Payment

The theme of payment method converges the codes of “findings cease”, “government sponsored” and “willingness to pay for services” as shown in Figure 1 and Figure 2. It is seen that

CH is feasible and desirable in remote areas of Taiwan during pilot schemes sponsored by government. However, when governmental funding ceased, the issues of payment method are becoming a concern. In fact, those who are in need of CH tend to have low purchase capability in CH's products and services. Therefore, most of institutions engaged with CH are supported by foundations.

"Some remote residents are elderly people living alone, and they are struggling in living, it is hard for them to pay for the remote services." (Nurse)

"Our hospital is mainly for offering health services. We have a foundation for our financial support to make it sustainable (Head nurse)."

"It's a religious hospital, we have a foundation and board of presidents, and they usually fully support any innovation in our hospital (Head nurse)."

4.4 Technology

Technology is identified as an important theme according to Figure 1 and Figure 2. The results indicate technology can facilitate the quality of efficiency and cost-effective to users and serve accessibility during the pilot schemes. What is concerned are the issues of systems integration and cross-department communication. These factors may reduce the intention of technology acceptance and adaptability. Communication and collaboration are significant challenges in CH. The collaboration and communication-related issues obtain the highest scores, which suggests that they are the most important concerns for interviewees. According to the data collection, collaboration, and communication-related issues are considered to be the most significant in CH.

"... we already knew the basic cost would be much cheaper when the service is conducting here. However, it is terrible we haven't got enough integrated coordinators in CH business (General physician, director of a health centre)."

"I don't understand why they want to make a simple thing more complicated" (Nurse 1).

The results also suggest that technology should be employed to connect people and deliver health and care rather than for only increasing efficiency and reducing cost. Connected care and cross-generation interaction may motivate caregivers and receivers. Overall, the interview results imply that a collaboration that uses technology and an appropriate BM may be significant in future healthcare delivery. These indicate that a holistic CH industry blueprint and vision are important in boosting and engineering CH ecosystems in Taiwan. The case study illustrates the need to identify the driver, structure, content, and pattern of the CH innovation system, which will be discussed in more depth in the following section.

"What I see technology is not about how efficient it can serve but how it can do to connect people from isolation...For me, technology is here to connect, not to deprive people of human contact." (IT director)

5. Discussion

Table 1 shows the limitations and potential solutions according to the results. This section rethinks CH according to patients' roles, industry chain structure, payment, and technology because the data analysis indicates that these key areas are relevant to CH's sustainability [65, 66,67,68]. Both the literature review and case study data suggest that the current assumptions in CH may be problematic because they cannot address CH business sustainability [69, 70,71]. The constructions of CH will be analysed, integrated, and redefined as an innovative business model. This can be seen from CH's business model, and these four areas are essential components of its business model. Thus, there is a need to rethink these four key areas.

Table 1. Connected health's limits and possible solutions

Connected health's Business model components	CH's Limits	Solutions
Patient's role	<ul style="list-style-type: none"> • Invisible role • Care receiver • Resources consumer 	<ul style="list-style-type: none"> • Patient-centric • Value creator • Value contributor
Structure of industry chain	<ul style="list-style-type: none"> • Loosely coupled structure • "Push" business strategy • Imbalance of supply and demand • One -way process 	<ul style="list-style-type: none"> • Tightly coupled structure • Push & pull strategy • Equilibrium • Two-way cycle
Payment method	<ul style="list-style-type: none"> • Unwilling to pay for services • Government sponsored • Funding ceases 	<ul style="list-style-type: none"> • Willing to exchange for services • Business model innovation • Value-exchange
Technology	<ul style="list-style-type: none"> • Ubiquitous computing • Low technology adaptivity • Health innovation alignment • Deprive people of human contact 	<ul style="list-style-type: none"> • Anytime, anywhere, accessibility • Efficiency & cost effectiveness • Affordability • Participants connecting

5.1. Rethinking the role of patients/participants

The results of the data analysis offer several important implications. First, patients/end users are willing to receive free CH intervention, although they are not always willing to pay for the service. This phenomenon suggests that their physical health may not be as attractive as their financial concerns [47,65,66]. As such, this suggests that there may be a need to increase CH ecosystem's attractiveness.

Second, patients take the role of passive service receivers in CH. The traditional care approach is ingrained in healthcare professionals or trained staff. Most health services centre on health professionals rather than patients, although demographic changes and chronic disease management trends have encouraged the implementation of a patient-centric approach [65,72]. Patient empowerment only occurs when healthcare professionals acknowledge that patients would like to have more control in their daily care and have autonomous self-management [73,74]. The effectiveness of empowering patients may be influenced by its implementation approach [75].

Third, although patient empowerment is one of the vital objectives of CH, how to activate patients' roles in the CH ecosystem still remains to be explored [76]. The literature also suggests that it is important to consider factors ranging from individual sensitivity to cultural differences [77]. The

patient-centric concept is growing more important, but a strong motivation for patients to take an active role in the CH ecosystem is still a challenge. The current CH assumptions seek to empower patients by encouraging them to monitor their own health. The literature contains multiple and overlapping meanings of the terms of empowerment, engagement, enablement, participation, involvement, and activation in patient self-care and shared decision-making [78]. This shared decision-making concept comes from the increasing focus on the strategic patient-provider partnership concept [77]. However, the data analysis shows that patients’ motivation decreases with time, which suggests that this assumption might need to be reconsidered.

Finally, according to the literature review and data analysis, most CH products and services focus on how to serve patients, rather than emphasizing on providing them with value, suggesting a need for practitioners to focus more on patient value. In contrast, BM research widely discusses “value” from the perspective of business suppliers who offer products or services to their target market. This concept defines value as products or services that a company expects to create for the target market segment (TMS). In a BM, the value proposition (VP) plays a crucial role in driving all elements in the model. It is important to consider whether this role (an influential role such as that of the VP) can be found in the CH ecosystem and whether patients should be care-receivers only or can be more active in the CH environment. To resolve these issues, it is important to rethink patients’ role from that of service receivers to one that can add value to society. In this case, the patient value will be appraised, enhanced, and optimized.

5.2. Rethinking the structure of industry chain

The literature review also indicates that the value in a BM normally refers to the company’s VP, which the company uses in exchange for revenue from customers [67]. Companies use value chains and value networks to assist the supply chain between the company and the customer as shown in Figure 6. In this case, customers’ value is mainly considered as providing profits for companies. Although there are some studies indicating the importance of customer inputs in improving or designing products, there is little information on how customers can offer value more actively. In the context of CH, customers are usually referred to as patients. The patient’s role in the CH supply chain is mainly the receiver of the provider’s product. The current BM in terms of the CH attributes and industry chain structure tends to be a “push” business strategy with a loosely coupled structure, which may lead to unsustainability in the CH ecosystem. The following sections discuss these tendencies further [47].

Rethinking the industry chain and payment method can be supported by the relationship between supply and demand in the microenvironment, as shown in Figure 3. In this diagram, “A” refers to the service provider representing the supplier and “B” refers to the service receiver representing the customer or demanding party. “A” delivers to “B” through different economic activities and service payments. “B” will somehow become a service provider to “C” in a different economic activity. This cycle is repeated until it returns to “A”, which ultimately balances the cycle of supply and demand. That is to say, the demand and supply balance are met under the condition that consumers are both demanders and suppliers simultaneously in different contexts [79].

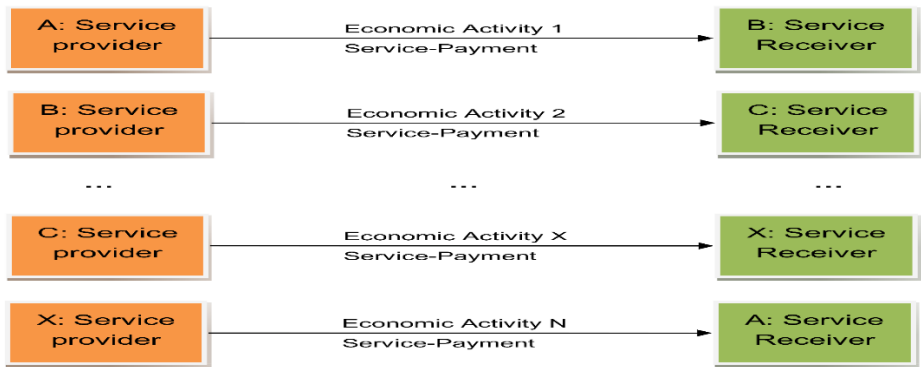


Figure 3. Macroeconomic supply and demand from A’s VP.

In the context of CH, the TMS only has the role of customers, which results in an imbalance between supply and demand, leading to unsustainability. CH targets older people, chronically ill patients, and patients in remote areas who supply very little but demand a lot, making CH unsustainable, unless the consumers are both demanders and suppliers. To achieve this goal, it is necessary to create a mechanism serving as a driving force that can reward both the suppliers and demanders.

The current CH business is driven by the internal decision and the relationship between buy and sell contracts, rather than what the market needs. The issue is that the company manufactures products based on its market predictions since an incorrect prediction can create a surplus or shortage of goods. In this case, the pull strategy is ideal. Receivers or end-users drive the need for innovation [80]. The manufacturing strategy and end-users' value must be incorporated, especially within CH; this represents a change in the BM. Thus, reviewing patients' roles reveals the need for both strategies – push and pull.

In the CH BM, communication between suppliers and customers seem to be simple rather than complex (Figure 4) since its service supply chain tends to go in a single direction. The supplier offers VPs to the TMS. However, there is no requirement for a return in the other direction. Moreover, the business strategy tends to be a push strategy rather than a pull strategy. Because CH businesses are based on forecast demand and are relatively new, they often adopt a push strategy for their products to generate exposure and a retail channel. Although a successful strategy will usually consist of both push and pull promotional methods, for a new marketer, persuading outlets to purchase and stock products, raising brand awareness, or building valuable word of mouth referrals are essential, thus creating the push strategy.

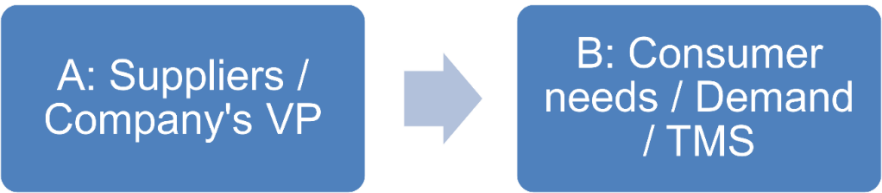


Figure 4. Unsustainable macroeconomic CH process.

In this CH case, the equilibrium of supply and demand may be only partial because the lack of intermediate economic activities causes an imbalance. Thus, there is a gap to bridge in order to make CH businesses sustainable. In fact, all elements in the microenvironment should be a communication cycle at both ends, as shown in Figure 5. There is no return direction communication in the CH structure, which may cause unsustainability. Therefore, it is essential to create a more reciprocal system to keep the balance of supply and demand in the CH ecosystem, meaning there is a need to change the current concept of and structure in the TMS in the CH context. By making these changes, the one-way process will become a two-way cycle, which should significantly increase sustainability. This requires a cooperative model, in which proper solutions can be found for these fundamental issues in CH.

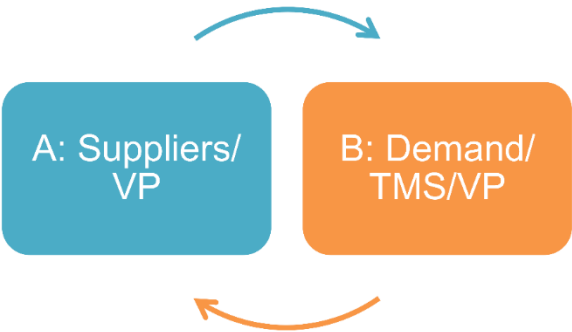


Figure 5. Sustainable CH cycle.

Figure 6 provides an illustration of the interaction of elements in the CH context [82]. The company offers its VP to the TMS and delivers them through the value chains (VC) and value networks (VN) in the company's competitive strategy (CS) with reasonable profits, or cost and margin (C/M). Yet, it cannot solve the loose connection within the relationship of CH stakeholders.

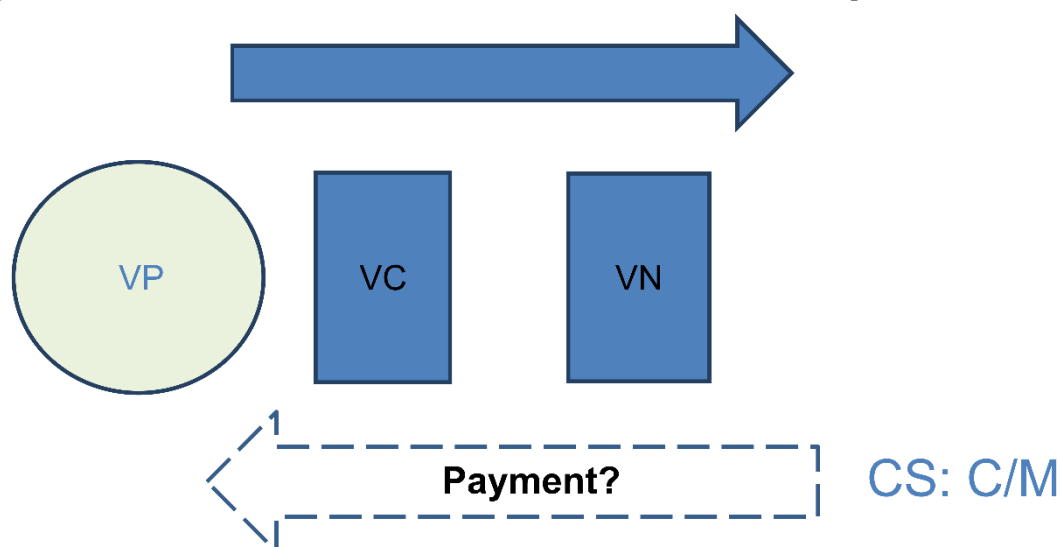


Figure 6. Conventional CH BM (source: [82]).

CH attributes

Apart from the issue of supply and demand, CH has loose connections, which implies that there are no permanent or fixed connections between the players and stakeholders, as shown in Figure 7. This figure illustrates the relationship of connected health target market segment (CHTMS) among academia, industry and government, wherein these connections are presented using dotted lines. The connections indicate that either party can withdraw from the model at any time due to the loose structure of CH (dotted lines in Figure 7). Obviously, all participants in the CH business tend to pursue their interests rather than work for a common interest or value based on patients. Although it appears to be similar to the quadruple helix model that academia, industry, and government use to interact with citizenry/community and foster economic and social development, Figure 7 highlights a different focus to pursue. When compared to the quadruple helix model, the figure demonstrated CH's characteristics and discusses its driving force, while the former concerns more about the relationship among its elements. Specifically, Figure 7 is a customized network for CH to portray its value chain; however, the quadruple helix model describes a network of relationships among four stakeholders in terms of knowledge diffusion in general. While the quadruple helix model refers to the relationship between value creation activities and knowledge transfer, Figure 7 further delves into the need for a driving force in the system. Therefore, Figure 7 distinguishes itself from the quadruple helix model by providing a unique model that can explain the network relationship in CH's ecosystem. As shown in Figure 7, the dotted lines connecting all the stakeholders imply a need to shift from loose to tight structures that are strengthened by the value chain. It is also suggested that creating a valuable attraction or value proposition that can attract all participants is necessary. Based on the fundamental knowledge mentioned earlier, a proposal can be constructed for determining how and what a sustainable BM for CH can be. To elucidate these issues, the following section discusses the method proposed for discovering the main drivers for creating value and maintaining a sustainable BM.

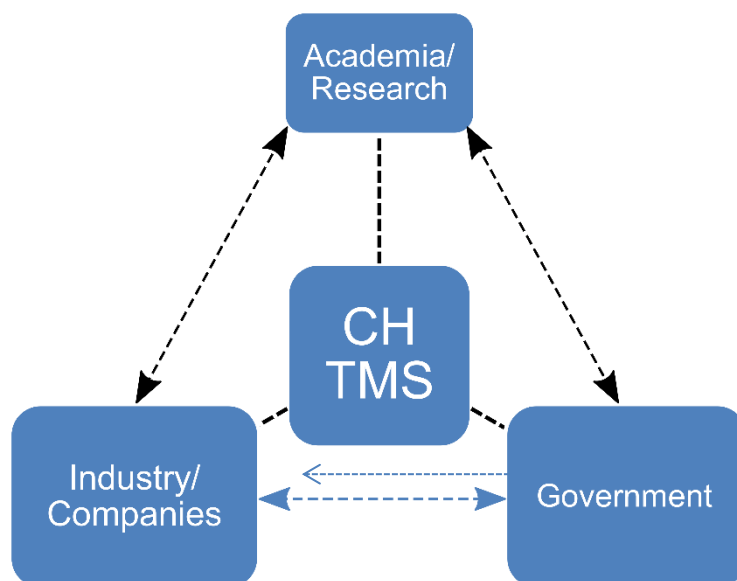


Figure 7. Relationship among CH players/ stakeholders (author's analysis).

5.3. Rethinking the payment method

In the stage of initiating CH models, CH pilot schemes are usually sponsored by governments [81,82]. Although many pilot schemes can show significant results for controlling chronic conditions, the issues regarding cost emerge after funding ceases, which eventually leads to business sustainability issues [67,69,70,71]. Thus, the current assumptions about payment methods must be reconsidered. Current CH business models also suggest that the payment method is based on the products or services provided. In this case, the TMS pays for the VP that the company offers. However, in the context of CH, the TMS is usually a socially vulnerable group, and it may be a challenge for businesses to maintain their willingness to pay for the service. Nevertheless, in the current CH model, if they are not willing to pay the premium, CH businesses will encounter sustainability challenges. Therefore, there may be a need to rethink the potential options to make it sustainable.

5.4. Rethinking technology

Information technology (IT) plays a major role in connecting all participants in the CH ecosystem and makes the delivery of the VP in the value network more efficient [79, 83]. The literature review revealed how technology changes many aspects of business practices [16,83,84,85]. The Internet has converted many processes from a long process to a digital one, and many things are constantly digitized at every touchpoint. Consumers, thus, increasingly use technology to track behaviour in their daily lives. Additionally, ubiquitous computing can contribute to the growth in the ranks of a quantified self-treating community. This digital disruption can help people obtain detailed information about their surroundings in a more affordable and accessible way. Technology has proven to be an effective way to make these vital connections, which otherwise might not exist. Technology should not be a robotic mechanical isolator that deprives people of human contact.

In short, there is still confusion when it comes to the role of technology. Technology can help achieve efficiency and cost-effectiveness, although it can do more, as both the literature review and interviewees imply that the disruptive nature of technology can leverage challenges by converging and disrupting complex process to make things more affordable [16,47, 85]. Therefore, the focus should be on not just what technology can do but also on how people can use technology to align healthcare innovation & software requirements [86].

5.5. Analysing, integrating, and redefining the BM elements

Rethinking CH highlights the value of the TMS and the need for BMI in CH practice. It also suggests that conventional BM needs to change to keep CH sustainable. Although there are no standard elements in a BM, all elements should address the VP, such as what it is, how to deliver it, and how to transform it into profits [48,59]. The elements of Chesbrough’s BM are employed as an example to analyse CH BM because these elements are both a value-centric and well-known concept [16,48]. These elements include the VP and establishing unique sources for the value chain (VC) and value network (VN), which are dominated by the CS, including a reasonable C/M. Thus, the VP is delivered to the TMS (Figure 8). Although there are six roles in Chesbrough’s BM, they occupy different positions in each microenvironment.

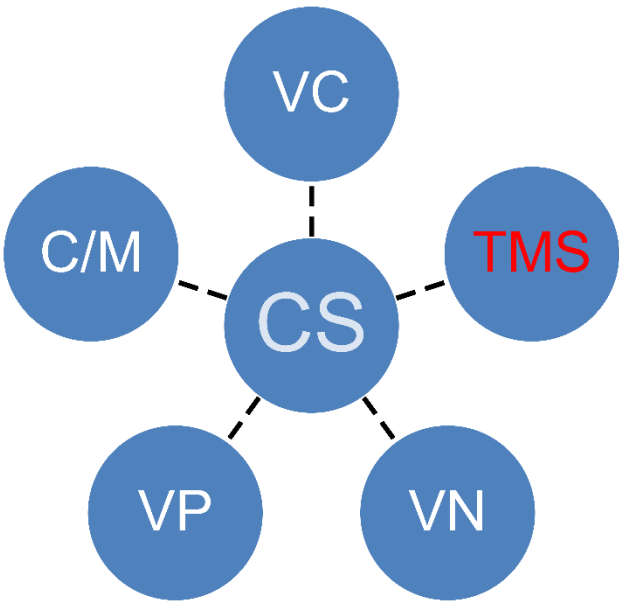


Figure 8. BM elements.

5.5.1. Integrating and redefining VPs and the TMS

Reimagining the TMS patients’ role as no longer simply passive receivers but also as potential product and service providers implies a change in the TMS in the current CH system. Consequently, the TMS is gradually becoming the “value proposer” with a shift toward customer-centricity. There is a tendency to optimize the total benefits for product and service providers and the TMS/end users. Therefore, this study proposes integrating VP and the TMS to illustrate this tendency. In Figure 9, VP and TMS are first integrated into “value” because they include and reflect the value of the TMS. The VP in Chesbrough’s BM refers to offering products or services from which companies can create value for users or customers (the TMS) [48]. One is the value proposed by firms and the other is the value receiver in the BM. Value is the similarity that connects these two elements. Value can be considered as a driver to activate the industry chain and create attraction among CH participants and stakeholders.



Figure 9. Merging the VP and TMS.

5.5.2. Integrating and redefining the CS and C/M

This study integrates CS and C/M into BMI to reflect the common purpose of generating revenue via a specified and strategic mechanism referring to key success factors for smart and connected health software solution [86, 87]. BMI here refers to an innovative mechanism for a business that is strategic, creative, and influential in creating revenue and competitiveness. Rethinking the payment method is also relevant for a company's CS because this also meets the aim of gaining profit from their TMS. However, in the CH environment, the TMS can be a vulnerable group that has a limited paying capability, which causes a contradiction. Thus, innovative payment methods are required to make a CH business sustainable.



Figure 10. Merging CS and C/M.

5.5.3. Integrating and redefining the VC and VN

VC and VN are integrated into “technology” because they act as channels or networks that technology can activate (Figure 11). Rethinking technology means that reimagining how people use technology to serve their goals is essential. Technology can accommodate many business activities, and it is becoming increasingly efficient and cost-effective. Its disruptive nature enables more affordable and accessible delivery of products or services while maintaining quality.



Figure 11. Merging VC and VN.

The VC and VN previously functioned through contracts, logistics, and cash flow. Interests in the VC were allocated through contract agreements, which were carried out via logistics and payment. The VN covers logistics networks and industrial networks (suppliers, manufacturers, brands, distributors, and retailers). In the current CH system, service providers can unite all roles in the industrial network. The flow of logistics has transformed into information flow, and cash flow has become a virtual cash flow. Both information flow and virtual cash flow are entirely delivered through information networks. Therefore, the VC and VN have emerged as a service information network that includes hardware manufacturers, software developers, Internet providers, sensor vendors, and electronic payment systems, which can be contained within the technology domain. With the development of technology, such as big data and cloud computing, this kind of integration is likely to speed up.

6. Recommendation: The Value-centric Business Model Innovation System in CH

Although previous studies have examined health professional-centred and patient-centred services and the technology push concept, no previous study has integrated the driver, structure, content, and patterns. Therefore, there is a need for a BMI system that can bridge these gaps. The proposed convergence concept in this study is similar to that of the Razorfish model [16], where creativity, media, and technological innovation are rapidly converging within the business environment. Technological advances act as a catalyst for convergence. According to Lord and Velez, the convergence concept means the combination of marketing and technology, which this study

translates from the integration of Chesbrough’s BM elements into value, BMI, and technology to generate an effective innovation system in CH.

6.1. Strategies and processes

This section demonstrates how value, BMI, and technology can merge into a CH innovation system. Given the requirement of balancing supply and demand in the CH environment to implement CH effectively, the convergence concept needs observations of the complex combinations and their interactions in the intersections of the strategy and business processes. Roles within the CH ecosystem must have tight connections to act effectively. However, the collective interest in CH is obscured, resulting in the loose connection among the participants due to self-interest. To encourage collaboration in an economic environment, it is essential to allocate the participants’ interests, and their roles must be mutually beneficial for sustainability. Value can be created through the process of re-engineering and measuring incentives.

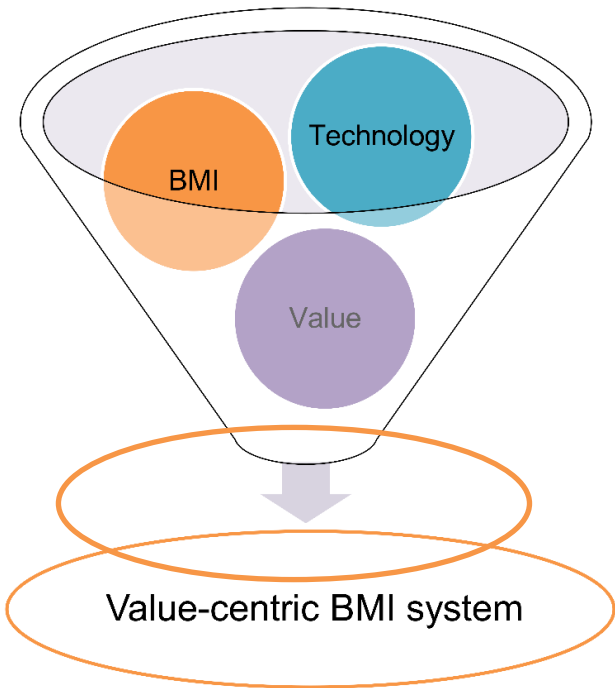


Figure 12. Convergence Model 1.

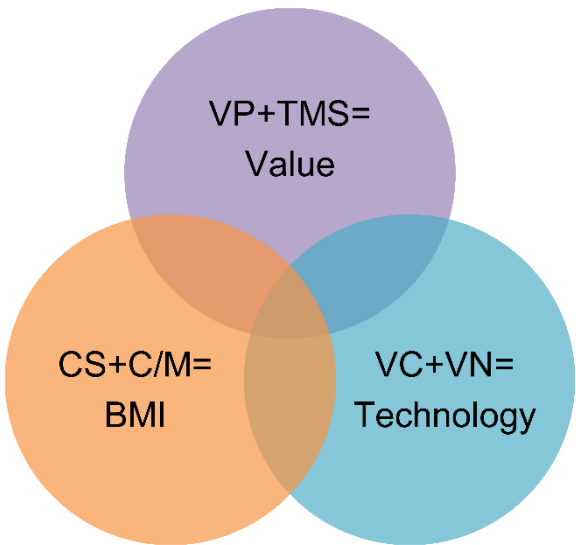


Figure 13. Convergence Model 2.

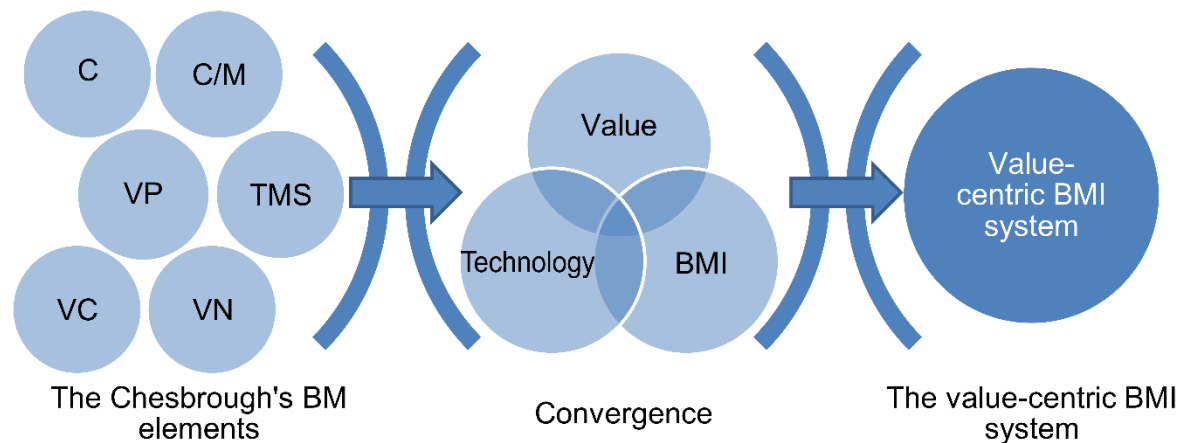


Figure 14. Convergence.

Figure 14 shows the convergence of value, BMI, and technology into a VCBMIS, which can be represented sequentially. This innovation system simplifies and integrates the essential elements in a BM to overcome the overemphasis on the details of conventional BM elements. As the literature review indicates, the existing research seems to underline strong cases that may not be repeatable. Re-engineering and the convergence concept enable the duplication of success.

6.2. Relationships between value, BMI, and Technology

In this value-centric innovation system, BMI plays a role of strategy, with technology as tools to address the objective of value [88]. Here, value-centric approach indicates the significance of value in this system. Many successful BMs eventually encounter problems with sustainability, and the root cause of these problems is the lack of a driving force at the core of the model. It is important to have a driver in a system to keep it focused and energetic [89,90,91].

The collaboration of these three elements can be described using the metaphor of “cooking a meal”. The current products and services are designed based on the companies’ assumptions of customers’ needs, which is not a sustainable solution. To highlight the nutrition of the meal, it is important to emphasize the ingredients and suggests solutions based on knowing the “what” and “how” of the B. This study contributes by highlighting the need to know the “whats” in addition to the “hows” and “whys”, of the M.

Although value is the core of this system, it will not be very powerful without the inputs of creative culture, innovative spirit, and advanced technologies. Especially in dealing with systematic failure in healthcare, it is not possible to ignore the systematic architecture. Thus, the value provides the vision and power to reconfigure the elements of the BMI system using technology as a key tool.

BMI should be strategic and innovative so that the firm can decide whether to take the role of a leader or a follower [91]. In terms of the challenges of an ageing population, many seek to invent products for older adults, particularly those with chronic conditions. However, Murata believes that creating job opportunities for older adults is the key to entering this market [92]. In terms of strategic management of business model innovation, the concept of competitor-alliance must be applied, meaning that if it is impossible to conquer competitors, then forming an alliance or a partnership is an option to turn the competitors into stakeholders [93]. This study focuses on the possibilities of transferring consumers of resources into benefits-sharing stakeholders; value, technology, and BMI are essential to achieving this goal [94].

Technologies are not only tools for delivering value, but also allow a leading role for BMI in the market through innovative business approaches for the unfulfilled promises of health information technology [95]. This is the real value of applying technology and clinical pathway support systems [96]. Technologies have disrupted the function of a conventional BM, leading to its essential reconfiguration. The key to success is making the best use of current technologies in tandem with the

convergence concept in developing a more sustainable BMI. In addition, innovation requires team spirit and individual genius. This value-centric system requires the integration of the three individual elements of value, BMI, and technology to achieve sustainability.

7. Conclusions

CH is proposed to manage challenges faced in an ageing society and to sustain the medical care system. However, whether it is a fad or a trend is still debatable. This study offers insights that help build a sustainable system that will benefit both patients and society through rethinking CH's structure and participants in the ecosystem. It provides opportunities for differentiation that respond to the challenges of shortened life cycles and sustains competitive advantages.

This study also suggests that academics should be proactive in finding new ways to improve the structure of the supply chains/driving forces behind BMI in the CH context, while practitioners should not base the service BM on technology-orientated products that they develop. Moreover, the service supply chain must first represent customer value needs in the context of innovation users and industry should synthesize their offerings with their target segment's contributions. Furthermore, technology should be applied to promote and deliver care to the TMS rather than creating isolation. Lastly, governments should take the lead in building a platform allowing the integration of relevant databases between all participants and monitor financial engagement in such platform to ensure that it appropriately protects the rights of each party, thus reducing ethical concerns through the imposed policies. This system can help guide CH business strategies and applications based on value categorization, which the authors plan to develop in future work.

Author Contributions: Conceptualization, S. C.C; Data curation, S. C.C; Formal analysis, S. C.C; Funding acquisition, S. C.C; Investigation, S. C.C; Methodology, S. C.C; Software, C.L.; **Author Contributions:** Conceptualization, S. C.C; Data curation, S. C.C; Formal analysis, S. C.C; Funding acquisition, S. C.C; Investigation, S. C.C; Methodology, S. C.C; Software, C.L.; Supervision, R.D.; Validation, C.L.; Visualization, C.L.; Writing – original draft, S. C.C

Funding: This research was funded by the Huaqiao University High-level Talent Research Startup Project and The Straits Postdoctoral Fellowship Funding Program in 2018, Fujing Financial office no. [2017] 32, grant number 605 50X18137 and “The APC was funded by Huaqiao University.

Acknowledgements: This research was supported by Academic: Ulster University; industry: Far EasTone Telecommunications and Huede technology; health sector: Taoyuan Fu Hsing Township Health station, Changhua Christian Hospital Telecare Health service center, Show-Chwan Hospital, Taiwan University Hospital Telehealth Centre, and Mennonite Christian Hospital.

Conflicts of Interest: The authors declare no conflict of interest.

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