Received 12 June 2016
Revised 1 November 2016
Accepted 8 November 2016

Applying DEMATEL to assess TRIZ's inventive principles for resolving contradictions in the long-term care cloud system

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Abstract

Purpose – The purpose of this paper is to find the key innovative principles for evaluating the long-term care (LTC) cloud system by exploring contradictory and complex points in its development.
Design/methodology/approach – The theory of inventive problem solving (TRIZ) and the decision-making trial and evaluation laboratory (DEMATEL) approaches are integrated to resolve complex contradictions in the system. The heuristic reasoning of TRIZ is applied to obtain innovation principles for an LTC cloud mining system. However, the importance and feasibility of these innovative principles require further assessment. In this study, DEMATEL is employed to clarify the complex relationships among the principles and evaluate their key influences.
Findings – This paper identifies six primary contradictions and derives 25 innovative principles for the resolution of these conflicts. Further analysis confirms three key innovative principles. First, the government should consider the overall planning of the cloud system platform, followed by the participation of other medical and LTC institutions. Second, the information capability of LTC institutions should be unified by recording the pathology data of care recipients to create an information exchange system. Third, LTC institutions should act in cooperation with medical institutions to provide professional medical capabilities.
Originality/value – The contributions of this paper are two-fold. First, this study provides an integrated methodology integrating the TRIZ and DEMATEL approaches to resolve LTC problems. Second, this research identifies the key innovative principles for developing an LTC cloud system in Taiwan.

Keywords DEMATEL, TRIZ, Health care, Cloud system, Long-term care (LTC)

Paper type Research paper

1. Introduction

Medical and technological advances have gradually extended average life expectancy, resulting in a significant yearly increase in the ratio of elderly in the population. In 2012, the US Population Reference Bureau noted an increase in the world's elderly to more than 564 million people (Ministry of Health and Welfare (MOHW), 2013). In other words, this segment of the population increased by 100 million over a 12-year period. Health care for the elderly has become a common global issue, with long-term care (LTC) becoming increasingly important. To help meet this challenge, in 2012, Taiwan's MOHW proposed the health cloud project, taking advantage of cloud computing, comprising a medical cloud, care cloud and wellness cloud. The medical cloud aims to improve the service performance of medical institutions by connecting the medical care services of different medical institutions through exchanges of medical e-records exchanges. The care cloud aims to promote early prevention and early treatment, and convey individualized preventive health care information to the public. The wellness cloud targets residents in remote areas and the elderly who are often isolated, and aims to offer remote care and home-care by establishing a common care IT platform for care-giving institutions (MOHW, 2013). Under the premise of LTC, the cloud system offers

The study is supported by a research grant from the Ministry of Science and Technology, Taiwan, Republic of China (MOST 104-2221-E-008 -046).

Industrial Management & Data Systems
Vol. 117 No. 6, 2017
pp. 1244-1262
© Emerald Publishing Limited
0263-5577
DOI 10.1108/IMDS-06-2016-0212

resource sharing capability, as well as waste and cost reduction, instant accessibility to medical expertise and services by LTC operators and care-givers, reduction in the number of return hospital visits, and access to the critical time window for treatment during emergencies. The cloud system also raises complex technological and social issues such as the necessity for modification of inadequate legal provisions, changes to the doctor-patient relationship when offering remote care, concerns about system leaks endangering patient privacy, and administrative contradictions between government and medical institutions. Thus, the operational model of the cloud system must be re-defined.

There has already been much scholarly discussion of health care issues such as the legal issues in telemedicine (Dierks, 2000), management of telediagnosis (Phillips *et al.*, 2002), the acceptant of health care professionals of remote e-health care (Richards *et al.*, 2005), the use of the theory of inventive problem solving (TRIZ) to develop innovative IT technology mechanisms related to Taiwan's health care services (Yang and Hsiao, 2009), the feasibility of the remote application of patient data (Lane and Schur, 2010), the appropriateness of telemedicine and technical limitations (Gardiner and Hartzell, 2012) and the factors affecting the consumer's willingness to adopt wearable technology for healthcare (Gao *et al.*, 2015). However, none of these studies have dealt with the adaption of the cloud system to LTC. To successfully develop a cloud LTC system, contradictions within the system must be resolved and inherent benefits established. This can best be done through examination from a system perspective of the complex relationship between technological and social issues.

The TRIZ provides an innovative basis for problem solving. Its theoretical framework originates from the principle of abstraction, already widely used in engineering, mathematics and medicine (Kaplan, 2005). This principle is applied using past experience to convert abstract issues into an operational system. Specific computational methods are then applied to obtain answers to the abstract domain, followed by the application of heuristic reasoning to real world scenarios. Usually the conversion can be achieved through trial and error in the same or similar scenarios which can significantly increase efficiency and accuracy. Since its development, the systematic TRIZ approach has provided quick and efficient problem-solving capability, and it can be applied to solving complex social science issues, such as those involved in the LTC cloud system. However, Ilevbare *et al.* (2013) noted that although the ideal final result (IFR) of TRIZ is more definitive in technological applications, objective quantification and pre-analysis is more difficult in the complex relationships of social disciplines.

This study uses TRIZ heuristic reasoning to derive innovative principles for the LTC cloud system which are used to further clarify the complex relationship results from contradictory problems which cross departments in the LTC cloud system, such as medical management agencies and other LTC institutions, and to determine the extent of influence among the innovative principles, and which principles exert the most critical influence. For example, the operational needs between the medical management agencies and the LTC institutions create a flow of information. The LTC institutions only provide limited business information to medical management agencies, but access to detailed operational information from these institutions would facilitate management. Methods such as multiple criteria decision making (MCDM), interpretative structural modeling (ISM), fuzzy structural modeling (FSM) and the decision-making trial and evaluation laboratory (DEMATEL) can be used to determine the degree of influence among criteria. For example, Govindan *et al.* (2010) used ISM to explore supplier development criteria for the automobile industry. However, ISM can only determine whether a relationship among the criteria exists, but not the degree of influence. FSM is less commonly used in social sciences. On the other hand, the DEMATEL not only measures the relationship and degree of influence among the criteria, but the computation process is simple. The proposed criteria for the application of the DEMATEL have been demonstrated in past studies. For example, Lu *et al.* (2014) extracted the criteria based on a literature review. However, the LTC cloud system involves a complex social system with a number of prospective issues, which means that the principles for its operation cannot be obtained from a literature review. This is why TRIZ is applied in this study to find the principles for the operation of the LTC cloud system. The TRIZ and DEMATEL methods have been applied to resolve other problems. For example, Hajime *et al.* (2005) used TRIZ and quality function deployment to resolve fundamental conflicts in design and then applied DEMATEL to evaluate an innovative product development process. However, there is little reference in the literature as to how to extend this approach to solving a complex social system involving a number of issues such as LTC. The DEMATEL is incorporated to assess the innovative principles of the LTC cloud system and formulate countermeasures for overcoming contradictions, thereby making the LTC cloud system feasible.

2. Literature review

Health care systems around the world are generally divided into three types: national health services, such as in England; free markets, such as in the USA; or social insurance systems, such as in Germany and Taiwan. In 1995, Taiwan implemented the national health insurance system, which is a mandatory insurance policy managed by a government agency, namely, the Ministry of Health and Welfare, National Health Insurance Administration. Its provisions are based on the national medical insurance policies spelled out in the additional articles of the constitution of the Republic of China. This medical care system is similar to Canada's current system.

A cloud platform would offer the advantages of accelerating the timeliness of medical care, facilitating the sharing of medical resources thereby saving medical costs. Through the expertise of medical personnel, care-givers in LTC institutions can reduce the number of return visits to hospitals, and access more immediate treatment during emergencies, and also Hsu (2017) suggested the applications of telemedicine and LTC should be connected to cloud databases. However, the construction of an LTC cloud system also involves complex technological and multi-dimensional social issues. There are a number of issues that have been addressed in past healthcare and LTC studies which are summarized in Table I.

Most studies about LTC and health care have focused on specific topic, such as protection of patient privacy (Meyer *et al.*, 1998), healthcare information systems (Yang and Hsiao, 2009; Huang *et al.*, 2012; Su *et al.*, 2015; Mgozi and Weeks, 2015; Althebyan *et al.*, 2016; Al-Shaqi *et al.*, 2016), LTC management and strategies (Li, 2009; Patrick, 2011; Chou *et al.*, 2015; Hsu, 2017), laws and policy issues related to LTC (Chen *et al.*, 2012). Studies providing integrated discussion about this topic have been rare. Therefore, here we try to provide and integrate discussion about multiple aspects of the problems across organizations by using TRIZ and DEMATEL.

3. Research method

We first describe the TRIZ tools, and the process for resolving contradictions. The DEMATEL application and computation steps are then described.

3.1 The TRIZ method

The acronym TRIZ (Teorija Rezhenija Izobretatelskih Zadach) is derived from the Russian term for Theory of Inventive Problem Solving. The method was constructed in 1946 by Genrich Altshuller and his team through extensive study of global patent research, review of the literature and analysis of information from more than one million patents (Kaplan, 2005). The basic theory of innovation founded on dialectical materialism and system theory has since then developed into a set of relational systems for classifying problems and corresponding problem-solving for specific issues. The TRIZ is mainly used in engineering and technical problem solving and for the development of innovative and

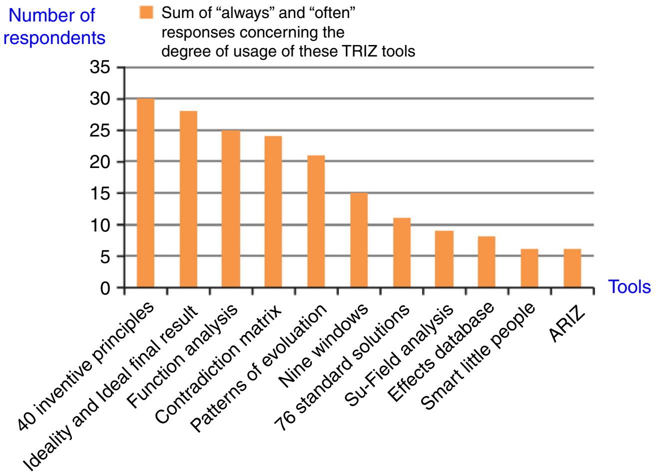
Authors (year)	Issues
Meyer *et al.* (1998)	Explored the patient's perspective on the privacy of telecare e-medical records
Yang and Hsiao (2009)	Used the TRIZ to develop innovative IT technology mechanisms for Taiwan's health care services
Li (2009)	Discussed the LTC institution management problem
Patrick (2011)	Combined hospital and community strategies for patients' LTC
Chen *et al.* (2012)	Pointed out legal and policy problems for the LTC institutions
Huang *et al.* (2012)	Explored information and communication applications in LTC
Lin *et al.* (2014)	To investigate the psychometric properties and relationships of perceived service quality, perceived value and overall satisfaction for residents with respect to their LTC institutions
Meijer *et al.* (2015)	Explained the declining rates of institutional LTC in the Netherlands
Su *et al.* (2015)	To explore the caregiver willingness of e-care cloud system using in a long-term caring institution in Southern Taiwan
Mgozi and Weeks (2015)	To describe the challenges and solutions necessary to enable cloud computing ecosystem within the health sector
Chou *et al.* (2015)	To examine the factors associated with the four LTC models including institutional care, community and home-based care, live-in migrant care and family care, and using the Andersen model for analysis
Driessen *et al.* (2016)	To survey USA of nursing home (NH) physicians and advanced practice providers to quantify provider perceptions and desired functionality of telemedicine in NHs to reduce potentially avoidable hospitalizations (PAHs)
Althebyan *et al.* (2016)	To propose an e-healthcare monitoring system that is efficiently integrating many emerging technologies such as mobile computing, edge computing, wearable sensors, cloud computing and big data techniques
Al-Shaqi *et al.* (2016)	This study is aimed at a comprehensive and critical review of the frameworks and sensor systems used in various ambient assisted living systems, as well as their objectives and relationships with care and clinical systems
Hsu (2017)	To enhance information transfer rate and storage capacity to improve communication between medical staffs and patients in LTC and telemedicine

Table I.
Studies related to healthcare and LTC

technical strategies (prediction and planning), and is less commonly used in management issues or other disciplines such as arts and culture, books and writing, translation, process improvement, teaching, training, logistics, business models, sports and government (Ilevbare *et al.*, 2013).

The TRIZ serves as a thinking process tool and a problem-solving technique to help inventors think innovatively rather than rely on conventional thinking (Wang *et al.*, 2010). In recent years, it has led to the development of numerous different tools and techniques, briefly summarized as follows: 40 inventive principles, ideality and IFR, function analysis, contradiction matrix, patterns of evolution, nine windows, 76 standard solutions, substance field (su-field) analysis, effects database, smart little people and algorithm for inventive problem solving (ARIZ). Based on these tools, Ilevbare *et al.* (2013) circulated questionnaires to scholars and received 40 complete responses. The results of that investigation are illustrated in Figure 1, in which the horizontal axis represents the tools frequently used and the vertical axis represents the number of respondents who always or often use these tools.

Compared to the single issue problem-solving approach used in the application of TRIZ in engineering, social systems contain a more complex composition of problems. Hence, in this study, we integrate the contradiction matrix with su-field analysis to solve the problem of systematic contradictions, as shown in Figure 2. By disassembling the systematic problems into different individual issues, each problem is separately approached using the TRIZ contradiction matrix to obtain detailed solutions, and these are then consolidated into a complete set of system solutions.



Source: Ilevbare *et al*. (2013)

Figure 1.
Degree of usage of the TRIZ tools

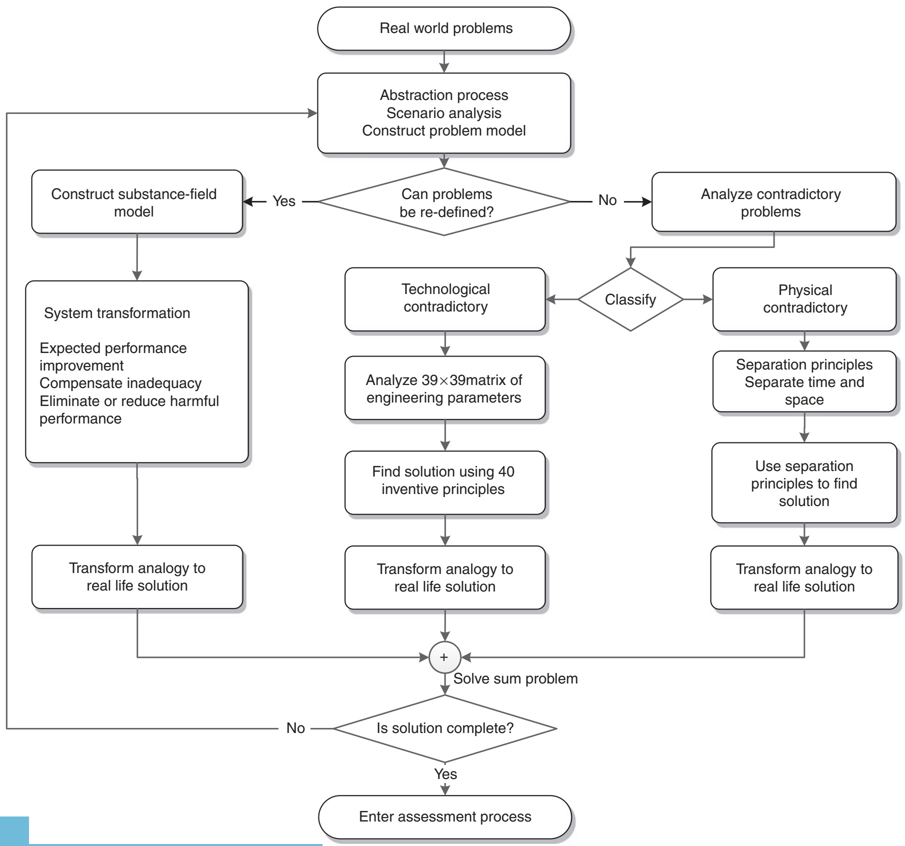


Figure 2.
TRIZ process for resolving contradictions

3.2 The DEMATEL method

The DEMATEL was developed by the Battelle Institute in Geneva, Switzerland between 1972 and 1976 for exploring and solving complex and interrelated groups of problems. By clarifying the nature of the problems, strategies can be enhanced. In addition, the characteristics of the target incident can determine the relationship among the variables and reveal the limiting impact of these characteristics (Tzeng *et al.*, 2007). Using the DEMATEL, a visual representation is then finally constructed also called the personal will diagram.

Nowadays, the DEMATEL is widely used for examining key factors, causal relationships and social complexities in areas such as hospital service quality, corporate decision-making and management, and supply chain planning. For example, Shieh *et al.* (2010) used the DEMATEL to analyze the key factors for success in hospital service quality; Lin *et al.* (2011) used this method to examine core competencies and causal relationships in IC design companies; while Zhou *et al.* (2011) used the fuzzy DEMATEL to define critical success factors in crisis management; Lee *et al.* (2011) used the DEMATEL and ANP to analyze decision-making factors in stock investment; Hsu *et al.* (2012) used the MCDM model, combining DANP with VIKOR, to solve the recycled materials vendor selection problem; Lin (2013) applied fuzzy DEMATEL to evaluate green supply chain management (GSCM) practices; Hsu *et al.* (2013) developed GSCM by using the DEMATEL to select suppliers based on their carbon emission management models; Liu *et al.* (2015) used the MCDM model to assess medical waste treatment technologies; Govindan *et al.* (2015) used the DEMATEL with intuitionistic fuzzy sets to handle causal relationships between GSCM practices and performances; and Govindan *et al.* (2016) applied the grey DEMATEL approach to evaluate third-party logistics provider selection.

The steps of the DEMATEL method are described as follows (Hsu *et al.*, 2013; Lee and Lin, 2013):

Step 1: obtain the average relation matrix. A design with a four level comparison scale is required to measure the relationship between principles. Next, experts are asked to make sets of pairwise comparisons in terms of their influence and direction between criteria. Then, similar to the result of these evaluations, the initial data can be gained as a direct-relation matrix that is an $n \times n$ and non-negative answer matrix $\boldsymbol{X}^k = \left[\boldsymbol{X}_{ij}^k\right]$. Thus, $\boldsymbol{X}^1, \boldsymbol{X}^2, \ldots, \boldsymbol{X}^m$ are the answer matrices for each of the M experts, with each element of $\boldsymbol{X}^k$ being an integer denoted by $\boldsymbol{X}_{ij}^k$. The diagonal elements of each answer matrix $\boldsymbol{X}^k$ are all set to 0. All expert opinion scores are averaged m through Equation (1). The average matrix $\boldsymbol{A} = [a_{ij}]$ is denoted as the degree to which criterion i affects criterion j:

$$a_{ij} = \frac{1}{m}\sum_{k=1}^{m} x_{ij}^k \tag{1}$$

Step 2: compute the normalized initial direct-relation matrix. The normalized initial direct-relation matrix $\boldsymbol{D}$ is obtained by normalizing the average matrix $\boldsymbol{A}$ as in the following equations:

Let:

$$z = \max\left(\max_{1 \leqslant i \leqslant n}\sum_{j=1}^{n} a_{ij},\ \max_{1 \leqslant j \leqslant n}\sum_{i=1}^{n} a_{ij}\right); \tag{2}$$

Then:

$$\boldsymbol{D} = \boldsymbol{A}/z. \tag{3}$$

Step 3: calculate the total-relation matrix. The influence of A continuously decreases owing to the indirect effects among the criteria based on the powers of the matrix $\boldsymbol{D}$, e.g., $\boldsymbol{D}^2, \boldsymbol{D}^3, \ldots, \boldsymbol{D}^\infty$

and therefore guarantees convergent solutions to matrix inversion similar to a Markov chain matrix. Note that $\lim_{m\to\infty} \boldsymbol{D}^m = [0]_{n\times n}$ and $\lim_{m\to\infty}(\boldsymbol{D}+\boldsymbol{D}^2+\ldots+\boldsymbol{D}^m) = \boldsymbol{D}(\boldsymbol{I}-\boldsymbol{D})^{-1}$, where 0 is the null $n \times n$ matrix and $\boldsymbol{I}$ is the $n \times n$ identity matrix. The total relation matrix $\boldsymbol{T}$ is a $n \times n$ matrix and defined through Equation (4):

$$T = \lim_{m\to\infty}\left(\boldsymbol{D}+\boldsymbol{D}^2+\cdots+\boldsymbol{D}^m\right) = \boldsymbol{D}(\boldsymbol{I}-\boldsymbol{D})^{-1}, \text{ as } m\to\infty \tag{4}$$

$$\boldsymbol{r}_i = [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1}; \tag{5}$$

$$\boldsymbol{c}_j = [c_j]'_{1\times n} = \left(\sum_{i=1}^{n} t_{ij}\right)'_{1\times n} \tag{6}$$

Step 4: analyze the results. Define t_{ij} $(i, j = 1, 2, \ldots, n)$ as the factors in the total relation matrix. Here, r_i and c_j, respectively, denote the sum of rows and the sum of columns from the total-relation matrix $\boldsymbol{T}$. The sum of the rows and the sum of the columns are separately denoted as vector r_i and vector c_j through Equations (5) and (6). Then, the horizontal axis vector (r_i+c_j), named "Prominence," is made by adding r_i to c_j, to reveal how much importance the criterion has. Similarly, the vertical axis (r_i-c_j), named "Relation," is made by subtracting c_j from r_i, which may divide criteria into a cause group and an effect group. Generally, when (r_i-c_j) is positive, the criterion belongs to the cause group. Otherwise, if the (r_i-c_j) is negative, the criterion belongs to the effect group. The causal diagram can be acquired by mapping the data set of $((r_i+c_j), (r_i-c_j))$, providing valuable insight for making decisions.

4. Evaluate the innovative principles of the LTC cloud system

The assessment of the LTC care cloud system construction is divided into three parts. In section 1, information on issues causing contradiction in system construction are compiled; in section 2, innovative principles for system are derived using TRIZ heuristic reasoning; and in section 3, these innovative principles are assessed using an expert survey approach, where the scores are calculated using the DEMATEL to delineate objective and feasible key innovative principles.

4.1 Contradiction problems with the LTC could system

Constructing a LTC cloud system involves complex relationships between organizations. The contradiction problems, as illustrated in Figure 3, are collected based on the literature review and MOHW (2013) project reports:

(1) Contradiction between medical institutions and care recipients – (A) immediate care and privacy: medical institutions require detailed information about care and care recipients for accurate medical diagnosis, but care recipients may only offer limited information to the cloud system due to privacy or legal concerns.

(2) Contradiction between care recipients and LTC institutions – (B) cost and service issues: care recipients expect professional medical services, but due to limited financial resources, LTC institutions can only provide simple medical services.

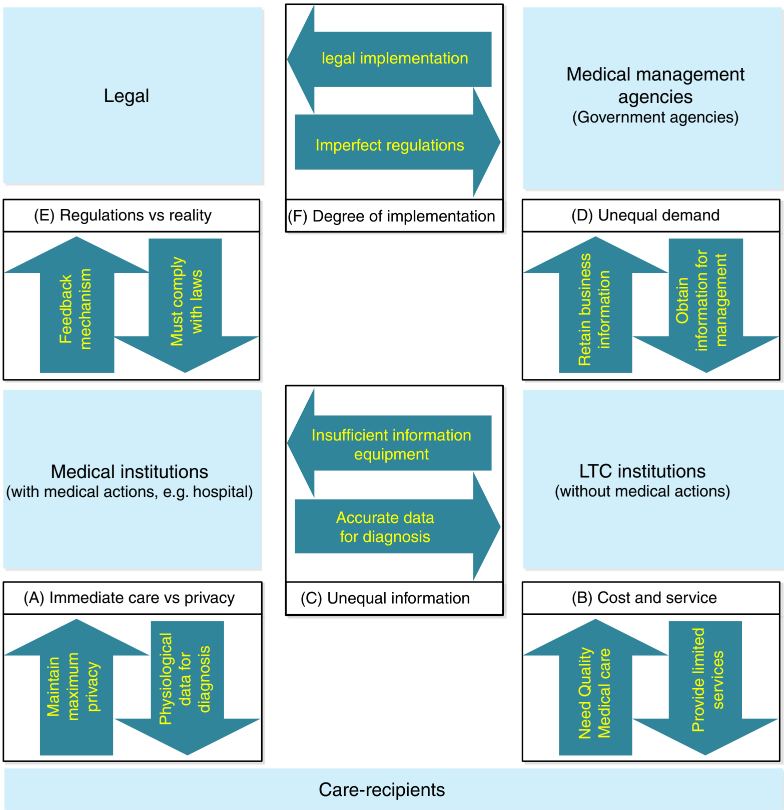


Figure 3.
Problems with the LTC cloud system

(3) Contradiction between LTC institutions and medical institutions – (C) unequal information: due to limited information technology, most LTC institutions can only provide limited physiological data for their care recipients to medical institutions which, on the other hand, require highly accurate physiological data for diagnosis.

(4) Contradiction between medical management agencies and LTC institutions – (D) unequal demand: due to operational needs, LTC institutions are only willing to provide limited business information to medical management agencies which, on the other hand, hope to access detailed operational information from the LTC institutions to facilitate management.

(5) Contradiction between medical institutions and laws – (E) regulations and reality: medical institutions must fully comply with relevant legal mandates to provide cloud services, which would increase the cost of medical care and could result in inadequate medical information that leads to inaccurate diagnoses. In addition, the proposed legal feedback mechanism for medical institutions is not yet in place, resulting in incongruity between regulations and reality.

(6) Contradiction between medical management agencies and laws – (F) degree of implementation: medical management agencies hope to implement all legal provisions, which, on the other hand may be outdated or ambiguous in interpretation and require amendment.

4.2 Application of TRIZ heuristic reasoning to find innovative principles

The premise for constructing an LTC cloud system requires resolving the system's contradiction issues using the TRIZ. In this study, the TRIZ is used to obtain innovative principles for resolving the types of contradiction issues inherent in the LTC cloud system. Figure 3 shows six contradictions A-F in the client-server framework. The derivation of the six primary contradictions A-F is further described below, where the TRIZ parameters and innovative principles are summarized in Tables II-VI. These have been obtained from Kaplan (2005), pp. 39-54:

- Contradiction relationship (A): between medical institutions and care recipients – immediate care and privacy.

This cloud system contradiction is between the need to adequately protect personal privacy while providing adequate physiological data. The TRIZ innovative principles were obtained based on the contradiction matrix, and innovative principles A1-A4 were derived through heuristic reasoning for the cloud LTC (Table II). The contradiction was analyzed from the perspective of care recipients, that is, maximization of privacy while offering the minimal amount of adequate information to medical personal for medical analysis to determine the most appropriate care.

Issues with the LTC cloud system	Innovative principles derived from heuristic reasoning for LTC cloud system
Care recipients wish to maintain maximum privacy but must provide adequate medical and physiological data for medical diagnosis	(A1) Disassemble physiological data to remove identifying information, and then re-integrate when needed during medical treatment without compromising timeliness (A2) Communicate clearly with care recipients and obtain their approval before transmitting data (A3) Code care recipient data that require protection, and re-assemble when needed (A4) Incorporate medical records or statistical data from other similar cases to assist in diagnosis
TRIZ parameters	Innovative principles derived from reasoning for TRIZ
Undesired result (conflict): no. 30 Harmful factors acting on object Features to improve: no. 26 Amount of substance	No. 35 Transformation of physical and chemical states of an object No. 33 Homogeneity No. 29 Use of pneumatic or hydraulic construction No. 31 Use of porous material

Table II.
Innovative principles for medical institutions and care recipients

Issues with the LTC cloud system	Innovative principles derived from heuristic reasoning for the LTC cloud system
To increase profit, LTC institutions must reduce operating costs; but care recipients also need quality medical care	(B1) Based on existing human resources, LTC institutions can develop extra soft services that are non-medical centered, and collaborate or outsource professional medical services (B2) Cooperation between LTC institution and schools for early identification of potential health care provider talents (B3) Incorporate outside LTC personnel for assessment of negligence in internal processes based on their feedback (B4) Direct integration of LTC institutions with medical institutions to access available medical resources
TRIZ parameter	Innovative principles derived from reasoning for TRIZ
Undesired result: (conflict) no. 22 Waste of energy Features to Improve: no. 39 Productivity	No. 28 Replacement of a mechanical system No. 10 Prior action No. 29 Use of pneumatic or hydraulic construction No. 35 Transformation of physical and chemical states of an object

Table III.
Innovative principles for LTC institutions and care recipients

Table IV. Innovative principles for LTC institutions and medical management agencies

Issues with the LTC cloud system	Innovative principles derived from heuristic reasoning for the LTC cloud system
LTC institutions retain business information for operational purposes while medical management agencies require detailed information for management and analytical purposes	(D1) Medical management agencies should regularly test the transparency of the cloud information system and formulate clear basic requirements (D2) LTC institutions should incorporate successful outside experience (D3) Implement partial information by using it only as needed for patients (D4) Encourage patients or help promote unique business models
TRIZ parameters	Innovative principles derived from reasoning for TRIZ
Undesired result (conflict): no. 37 Complexity of control Feature to improve: no. 30 Harmful factors acting on object	No. 19 Periodic action No. 29 Use of pneumatic or hydraulic construction No. 40 Composite materials No. 22 Convert harm into benefit

Table V. Innovative principles for medical institutions and legal requirements

Issues with the LTC cloud system	Innovative principles derived from heuristic reasoning for the LTC cloud system
Medical institutions require detailed physiological information about care recipients, but must fully comply with relevant laws	(E1) Medical institutions obtain physiological data but do not engage in any related medical action (E2) Medical institutions request care recipients to transfer physiological data to the hospital in advance (E3) Medical institutions report to medical management agencies in advance (E4) Medical institutions prepare for possible fines (E5) Medical institutions perform only emergency medical services (E6) Provide regular medical examination for care recipients to accumulate information (E7) Relevant authority to adequately supervise medical management agencies (E8) Care recipients return to hospital for treatment when needed
TRIZ parameter	Innovative principles derived from reasoning for TRIZ
Separation principle	No. 01 Segmentation, No. 09 Prior counter-action, No. 10 Prior action, No. 11 Cushioning in advance, No. 15 Dynamicity, No. 19 Periodic action, No. 21 Rushing through, No. 34 Partial rejection and regeneration

Table VI. Innovative principles for medical management agencies and legal

Issues with the LTC cloud system	Innovative principles derived from heuristic reasoning for the LTC cloud system
Medical management agencies must formulate LTC decrees that are consistent with reality, but, in reality, enforcement and interpretation issues exist	(F1) Clearly define provisions that medical cloud systems must comply with, or medical institutions review and approve system regulations proposed by operators (F2) Item 1: medical management agencies establish and invite relevant departments or personnel to join in a centralized medical cloud platform. Item 2: medical management agencies match the information needed by medical and LTC institutions
TRIZ parameters	Innovative principles derived from reasoning for TRIZ
Undesired result (conflict): no. 37 Complexity of control Feature to improve: no.18 Brightness	No. 32 Changing the color No. 15 Dynamicity

By definition, the "undesirable results," the contradiction parameter in the TRIZ contradiction matrix is no. 30 (harmful factor acting on object) and the parameter for improving this feature is no. 26 (amount of substance), corresponding to no. 35 (transformation of physical and chemical states of an object), no. 33 (homogeneity), no. 29 (use of pneumatic or hydraulic construction) and no. 31 (use of porous material) of the 40 innovative principles. Using heuristic reasoning, the four TRIZ innovative principles for resolving LTC cloud system contradictions in the real world are (A1) disassemble physiological data to remove identifying information, then re-integrate when needed during medical treatment; (A2) communicate clearly with care recipients and obtain their approval before transmitting data; (A3) code care recipient data that require protection, and re-assemble when needed; and (A4) incorporate medical records or statistical data from other similar cases to assist in diagnosis.

As can be seen from the heuristic reasoning, the TRIZ is a real-life problem-solving process where existing bias in professional knowledge may result in discrepancies or feasibility problems. The DEMATEL derived from the MCDM model is used to correct for possible errors due to human bias:

- Contradiction relationship (B): between LTC institutions and care recipients – cost vs service.

To increase profit, LTC institutions must reduce operating costs; however, care recipients also need quality medical care. Hence, the system must be able to enhance the medical care capability of LTC institutions while still reducing cost. This issue is addressed through the TRIZ innovative principles indicated in the contradiction matrix and heuristic reasoning, as shown in B1-B4 in Table III:

- Contradiction relationship (C): between LTC institutions and medical institutions – unequal information.

The comprehensiveness and professionalism of information on pathology and physiology of care recipients in LTC institutions is important for the provision of immediate treatment, and for medical institutions. However, even with the lack of history of the recipients' care or with problematic data, the system is still expected to provide appropriate medical services.

Based on the analysis of the contradiction matrix, the parameter for undesired result is no. 24 (loss of information), and the parameter for improving feature is no. 28 (measurement accuracy). There are no corresponding innovative principles in the contradiction matrix, hence su-field analysis is conducted where substance 1 is comprised of the LTC institutional pathology and physiology records; substance 2 is immediate and correct treatment for care recipients in LTC institutions, and "field" is the evaluation based on the pathology data.

The first method of improvement is to increase the substance to derive innovative principles through heuristic reasoning. Specifically, the principles are (C1) strengthen the pathology records capability of LTC institutions, such as by establishing standard operating procedures that are consistent with medical institution standards, or adopting pathology data systems that are recognized by medical institutions. The second method is enhancing the field effect to derive innovative principles through heuristic reasoning, specifically (C2) directly linking medical institutions to the information system of the LTC institution when providing immediate care. The third method is merging or converting the substance to derive innovative principles through heuristic reasoning, specifically (C3) integrating LTC institutions with medical institutions to enhance their professional medical capability:

- Contradiction relationship (D): between LTC institutions and medical management agencies – unequal demand.

LTC institutions want to retain business information for operational purposes while medical management agencies require detailed information for management and analytical purposes.

Hence the system must allow LTC institutions to provide the least management information while complying with the demands of medical management agencies. The TRIZ innovative principles derived from the contradiction matrix and heuristic reasoning are D1-D4, as shown in Table IV:

- Contradiction relationship (E): between medical institutions and legal – regulations and reality.

To analyze the function of the information systems, the physiological data of all care recipients must be obtained while complying with the relevant laws and regulations. This conflict is a physical (natural) contradiction. Using the separation principle, the innovative principles derived through heuristic reasoning are E1-E8, as shown in Table V:

- Contradiction relationship (F): between medical management agencies and legal – degree of implementation.

Medical management agencies must formulate LTC decrees that are consistent with reality, but in reality, issues with enforcement and interpretation exist. Overall, medical management agencies must manage all the legal aspects of cloud medical services, but the laws may not necessarily be enforceable. Using a contradiction matrix and heuristic reasoning, we obtain the TRIZ innovative principles F1-F2, as shown in Table VI.

4.3 Evaluate steps for the innovative principle

Through TRIZ heuristic reasoning, innovative principles are derived for each contradiction. However, these innovative principles must be ranked. In this study, the DEMATEL method is used to assess the relationship among the key principles, as described below.

Step 1: design a DEMATEL expert questionnaire. The DEMATEL method is used to assess the complex relationships. The innovative principles (criteria) derived from heuristic reasoning are converted into the DEMATEL questionnaire format. In the questionnaire, experts are asked to select a score of 0, 1, 2, 3 or 4 to indicate the degree of influence, where 0 represents no influence, 1 represents low influence, 2 represents median influence, 3 represents high influence, and 4 represents extremely high influence.

Step 2: expert questionnaire survey. The DEMATEL questionnaires were administered to experts in related industrial, academic and public sectors, such as government agencies (e.g. the MOHW and local authorities), medical institutions (hospitals), LTC institutions (nursing homes) and medical academic institutions (universities).

Step 3: compute DEMATEL. The completed DEMATEL expert questionnaires were collected and reviewed. Valid questionnaires were then analyzed according to the DEMATEL steps described in the previous section.

Step 4: results of DEMATEL causal diagram analysis. Results of the DEMATEL computation show a significant causal relationship among the various criteria, and a diagram is constructed to facilitate analysis. The DEMATEL data and causal diagram are integrated to produce a quantified, objective analysis that demonstrates the contribution of this study.

5. Analysis of results

The innovative principles for the LTC cloud system derived from the TRIZ heuristic reasoning process were combined with the DEMATEL results to construct an expert innovative principle questionnaire, which was administered to experts from three major professions, namely, industry professionals (from LTC institutions or medical institutions), governmental authorities and academics. A total of 11 expert questionnaires were individually administered through interviews and the validity of the expert evaluations can be justified based on their professional experience and knowledge related to LTC issue (see Table VII).

First of all, the total relation matrix was computed based on the results of the expert questionnaire. Second, as shown in Table VIII, the (r_i+c_j) and (r_i-c_j) of the criteria were computed from the total relation matrix, and a causal diagram was constructed using (r_i+c_j) and (r_i-c_j) as the coordinates. Third, to obtain the key criteria of influence, we set the threshold value at twice the standard deviation plus the mean value, as was done in

Table VII.
Background of the experts

Experts no.	Organizations	Years of work
1	Taiwan LTC Professional Association	20
2	Institute of Health Policy and Management, National Taiwan University	30
3	Nursing home-1	11
4	Nursing home-2	17
5	Department of Nursing and Health Care, MOHW	10
6	Department of Information Management, National Taipei University of Nursing and Health Sciences	22
7	Department of Public Health, Taoyuan City	18
8	National Taiwan University Hospital Bei-Hu Branch	33
9	Department of Long-Term Care, National Taipei University of Nursing and Health Sciences	30
10	Social and Family Affairs Administration, MOHW	10
11	Nursing home-3	35

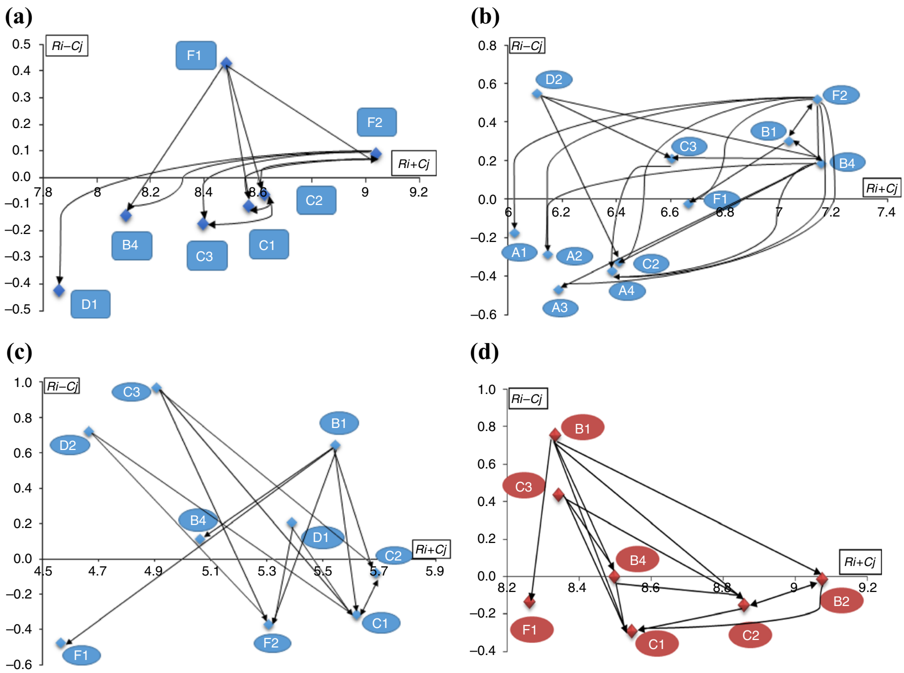
Table VIII.
Comparative DEMATEL results by different groups

Groups	Industry group		Government group		Academic group		Uncategorized group	
No.	r_i+c_j	r_i-c_j	r_i+c_j	r_i-c_j	r_i+c_j	r_i-c_j	r_i+c_j	r_i-c_j
A1	7.56	0.35	6.03	−0.17	3.92	−0.19	7.28	0.03
A2	6.73	−0.50	6.15	−0.29	4.27	−0.64	7.29	−0.63
A3	6.39	−0.72	6.19	−0.47	4.77	−0.68	7.64	−0.67
A4	6.42	−1.42	6.38	−0.37	4.30	−0.40	7.56	−0.77
B1	7.44	0.64	7.04	0.30	5.54	0.65	8.34	0.76
B2	6.49	0.62	3.79	−0.07	2.18	0.40	5.11	0.44
B3	7.10	−0.13	4.41	−0.09	4.28	0.59	6.75	0.18
B4	8.11	−0.14	7.15	0.19	5.06	0.12	8.50	−0.003
C1	8.56	−0.11	5.69	−0.34	5.62	−0.31	8.55	−0.29
C2	8.62	−0.06	6.41	−0.33	5.69	−0.07	8.86	−0.16
C3	8.39	−0.17	6.60	0.21	4.91	0.97	8.34	0.44
D1	7.86	−0.42	4.81	−0.31	5.39	0.21	7.92	−0.13
D2	5.90	0.87	6.11	0.55	4.67	0.73	6.96	0.74
D3	7.00	0.34	6.06	0.18	3.81	−0.02	7.15	0.17
D4	5.19	0.05	4.55	−0.30	3.19	−0.11	5.39	−0.15
E1	6.54	0.21	5.31	0.05	2.82	0.64	5.83	0.60
E2	7.61	0.02	5.46	0.07	4.35	−0.05	7.28	0.11
E3	6.48	0.30	5.75	−0.01	2.78	−0.85	6.21	−0.43
E4	4.52	−0.46	4.77	−0.18	0.03	−0.03	3.51	−0.22
E5	6.82	0.07	4.34	0.08	1.59	0.23	5.28	0.11
E6	7.28	0.06	5.12	0.40	3.62	−0.48	6.49	−0.07
E7	6.15	0.09	5.34	0.23	2.00	0.10	5.48	0.08
E8	7.29	−0.02	4.38	0.14	2.34	0.07	5.62	0.01
F1	8.48	0.43	6.66	−0.02	4.56	−0.47	8.26	−0.14
F2	9.04	0.09	7.14	0.52	5.31	−0.37	9.08	−0.02

Zhu *et al.* (2014). The total relationship matrix was used to select the threshold value below which values were considered to have the least relational impact and thus disregarded. This helped to clearly demonstrate the causal relationship among the criteria. Values above the threshold value were used to plot the causal diagrams, which were divided into industry, government, academic and uncategorized groups, as shown in Figure 4.

As can be seen in Table VIII, considering the significance of innovative principles, as presented in the uncategorized group, the top five principles are identified as F2 > C2 > C1 > B4 > B1 = C3 according to the (r_i+c_j) value, with F2 having the most importance with a value of 9.08, so should be received more attention; B2 is the least important principle with a value of 5.11. Therefore, when constructing the cloud system platform, the public sector should be considered first in the overall planning, followed by the participation of other relevant departments and institutions.

The results of DEMATEL are listed in Table VIII. The relationships between all 25 principles are described. Two indices, (r_i+c_j) and (r_i-c_j), are used to describe the characteristics of the principles. The principles are grouped into a cause cluster when $(r_i-c_j) > 0$ and an effect cluster when $(r_i-c_j) < 0$. In Table VIII and Figure 4, it can be found that the cause principles have an impact on the uncategorized group as also demonstrated in the following analysis. Among all principles in the cause group, B1 has the highest (r_i-c_j) score (0.76) and (r_i+c_j) score (8.34), which means that it has a significant impact on the other principles. On the other hand, of all 25 principles, F2 has the highest (r_i+c_j) score (9.08), which means that it is the most important principle for the LTC cloud system. The (r_i-c_j) score of F2 is −0.02, which means that it is in the effect group. The effect groups tend to be impacted by the other principles.



Notes: (a) Industry group; (b) government group; (c) academic group; (d) uncategorized group

Figure 4.
Causal diagrams for different groups

In the causal diagram (Figure 4), the single headed arrows represent the direction of effect of the principles on others; the double headed arrows represent affects in both directions. For example, F2 directly affects C3, B4 and is mutually affected by C1 and C2, as shown in Figure 4(a). Medical management agencies actively establish medical cloud platform, which combined the data of medical institutions and LTC institutions. This action makes the LTC institutions having the capability of professional medical treatment and saving the cost of the system establishment. B4 directly affects B1, C2, and A4 and is mutually affected by C3, as shown in Figure 4(b). The combination of LTC institutions and medical institutions will reduce the human resource demand and avoid professional medical services outsourced after LTC institutions obtaining the medical resources. C1 and C2 are affected by each other, as shown in Figure 4(c). F2 directly affects C1 and is mutually affected by C2, as shown in Figure 4(d).

In addition, the principles with the coordinates skewed right are the most critical. First, compared to the uncategorized group, results from the industry group show that the top three principles with the greatest critical influence were similar in value, specifically 9.04 for F2, 8.62 for C2, and 8.56 for C1; see Figure 4(a) (industry). Next, compared to the uncategorized group, the government group found B4, with a value of 7.15 to have the most critical influence, followed by the F2 with a value of 7.14 and B1 with a value of 7.04, as shown in Figure 4(b) (government). Third, compared to the uncategorized group, the academic group regarded C2, with a value of 5.69, C1 with a value of 5.62 and B1 with a value of 5.54 as having the most critical influence, as shown in Figure 4(c) (academic). Finally, the combined results of the uncategorized group indicate that criteria (F), (C) and (B) had the key influences, as shown in Figure 4(d) (uncategorized). Furthermore, as shown in Figure 4 (E) was the least influential. As a whole, the results for the uncategorized group, from the most influential to the least influential, are: F2, C2, C1, B4, and C3.

Therefore, when constructing the cloud system platform, the public sector should be considered first in the overall planning, followed by the participation of other relevant departments and institutions, which is principle (F2). Second, the information capability of LTC institutions should be unified by recording the pathology data of care recipients to create an information exchange platform for connection and mutual sharing with medical institutions and medical resources, principle (C1). Third, LTC institutions should cooperate with medical institutions to provide professional medical capabilities, principle (C2). Care recipients are mostly the elderly who often lack mobility, making movement inconvenient. Hence this type of integration could help LTC institutions reduce the need for care recipient visits to outside medical facilities.

(Annotation: we further conducted sensitivity analysis by taking partial expert evaluations to identify the robustness of the DEMATEL results. The results of the comparison reveal no obvious change in the causal diagram.)

6. Conclusion

Current progress in medical technology has increased average human life expectancy and the increased the proportion of the elderly population, making health care and safety for the elderly increasingly important issues. The younger population are more focused on career and child-raising, and correspondingly the need for professional LTC for the elderly has increased. In response to trends in socio-economic development, the number of LTC institutions in the care industry has been increasing. However, the absence of a sound systematic platform and regulations makes governmental supervision of LTC institutions difficult. With advances in information technology, the use of cloud technology for the development of a medical information platform offers new advantages to the health care service industry. The development of an LTC cloud system platform could help the government monitor and manage LTC and medical institutions, and enable these institutions to communicate and exchange information.

However, the construction of such a system involves the resolution of contradictory issues on many levels. This study uses the innovative solution capability of TRIZ heuristic reasoning to generate innovative principles for the development of such a LTC cloud system. However, the feasibility of the resultant principles must be further determined. Hence, the DEMATEL method is adopted to assess the innovative principles based upon the opinions of medical experts. The degree of influence of key factors and the causal relationship among the numerous and complex innovative principles are clarified to determine which are most important. The determination of key innovative principles and prioritization of solutions to contradictory and conflicting issues in the development of the LTC cloud system are of practical value.

The results of this study have management implications. First of all, the medical management agencies should formulate LTC plans that are consistent with reality; however, a gap exists between enforcement and interpretation in practice. Government plays an important role in initiating a centralized cloud medical system platform, and then encouraging the participation of other medical institutions and LTC institution. In contrast, if LTC and medical institutions were to independently construct cloud system platforms, the cost of the construction and maintenance would be astronomical. Moreover, differences in platform function and format might make it difficult to exchange or access information. The information needs of medical institutions and the provision of LTC institutions should be matched by the medical management agency. Second, integrating the medical resources needed for LTC and for medical institutions can conserve medical resources and costs, and facilitate care and medical actions. Finally, in order to close the gap between the expectations of LTC institutions and to reduce operating costs and offer patients quality medical care, it is important that the LTC institutions cooperate with medical institutions to provide professional medical capabilities and case records that result in accurate patient diagnosis and shorter treatment time when linked to the medical systems. Moreover, the relevant data could also be used in academic research. The integration of TRIZ and DEMATEL in this study to resolve complex and contradictory technological and social relationships can also be used as reference for subsequent academic research.

There are two limitations in this study. First, the evaluation of an LTC cloud system is under the national health insurance system of Taiwan. Second, the applicability of LTC cloud system being considering in this study is limited to medical regulation among countries. Two directions suggested for the future research. First, fuzzy theory can be combined with DEMATEL to measure the uncertainty of experts' opinions and the results can be compared with traditional DEMATEL. Besides, the comparison of LTC cloud system based on different healthcare insurance system can be further investigates.

References

Al-Shaqi, R., Mourshed, M. and Rezgui, Y. (2016), "Progress in ambient assisted systems for independent living by the elderly", *Springer Plus*, Vol. 5 No. 1, pp. 1-20.

Althebyan, Q., Yaseen, Q., Jaraweh, Y. and Al-Ayyoub, M. (2016), "Cloud support for large scale e-healthcare systems", *Annals of Telecommunications*, Vol. 71 Nos 9-10, pp. 503-515.

Chen, Z.Y., Wu, S.Y. and Hwang, Y.S. (2012), "Reviewing the implementation of long-term care management in Taiwan", *The Journal of Long-Term Care*, Vol. 16 No. 3, pp. 257-272 (in Chinese).

Chou, Y.C., Kroger, T. and Pu, C.Y. (2015), "Models of long-term care use among older people with disabilities in Taiwan: institutional care, community care, live-in migrant care and family care", *European Journal of Ageing*, Vol. 12 No. 2, pp. 95-104.

Dierks, C. (2000), "Legal aspects of telepathology", *Analytical Cellular Pathology*, Vol. 21 Nos 3-4, pp. 97-99.

Driessen, J., Bonhomme, A., Chang, W., Nace, D.A., Kavalieratos, D., Perera, S. and Handler, S.M. (2016), "Nursing home provider perceptions of telemedicine for reducing potentially avoidable hospitalizations", *Journal of the American Medical Directors Association*, Vol. 17 No. 6, pp. 519-524.

Gao, Y., Li, H. and Luo, Y. (2015), "An empirical study of wearable technology acceptance in healthcare", *Industrial Management & Data Systems*, Vol. 115 No. 9, pp. 1704-1723.

Gardiner, S. and Hartzell, T.L. (2012), "Telemedicine and plastic surgery: a review of its applications, limitations and legal pitfalls", *Journal of Plastic, Reconstructive and Aesthetic Surgery*, Vol. 65 No. 3, pp. e47-e53.

Govindan, K., Kannan, D. and Haq, A.N. (2010), "Analyzing supplier development criteria for an automobile industry", *Industrial Management & Data Systems*, Vol. 110 No. 1, pp. 43-62.

Govindan, K., Khodaverdi, R. and Vafadarnikjoo, A. (2015), "Intuitionistic fuzzy based DEMATEL method for developing green practices and performances in a green supply chain", *Expert Systems with Applications*, Vol. 42 No. 20, pp. 7207-7220.

Govindan, K., Khodaverdi, R. and Vafadarnikjoo, A. (2016), "A grey DEMATEL approach to develop third-party logistics provider selection criteria", *Industrial Management & Data Systems*, Vol. 116 No. 4, pp. 690-722.

Hajime, Y., Kenichi, I. and Hajime, M. (2005), "An innovative product development process for resolving fundamental conflicts", *Journal of the Japan Society for Precision Engineering*, Vol. 71 No. 2, pp. 216-222.

Hsu, W.Y. (2017), "Clustering-based compression connected to cloud databases in telemedicine and long-term care applications", *Telematics and Informatics*, Vol. 34 No. 1, pp. 299-310.

Hsu, C.H., Wang, F.K. and Tzeng, G.H. (2012), "The best vendor selection for conducting the recycled material based on a hybrid MCDM model combining DANP with VIKOR", *Resources, Conservation and Recycling*, Vol. 66, pp. 95-111.

Hsu, C.-W., Kuo, T.C., Chen, S.H. and Hu, A.H. (2013), "Using DEMATEL to develop a carbon management model of supplier selection in green supply chain management", *Journal of Cleaner Production*, Vol. 56, pp. 164-172.

Huang, E.W., Chiou, S.F., Pan, M.L. and Ku, C.K. (2012), "A review of information and communication technologies for long term care applications", *The Journal of Long-Term Care*, Vol. 16 No. 3, pp. 219-235 (in Chinese).

Ilevbare, I.M., Probert, D. and Phaal, R. (2013), "A review of TRIZ, and its benefits and challenges in practice", *Technovation*, Vol. 33 Nos 2-3, pp. 30-37.

Kaplan, S. (2005), *An Introduction to TRIZ – the Russian Theory of Inventive Problem Solving*, Ideation International Inc., Southfield, MI.

Lane, J. and Schur, C. (2010), "Balancing access to health data and privacy: a review of the issues and approaches for the future", *Health Services Research*, Vol. 45 No. 5, pp. 1456-1467.

Lee, P.T.W. and Lin, C.W. (2013), "The cognition map of financial ratios of shipping companies using DEMATEL and MMDE", *Maritime Policy & Management*, Vol. 40 No. 2, pp. 133-145.

Lee, W.S., Huang, A.Y., Chang, Y.Y. and Cheng, C.M. (2011), "Analysis of decision making factors for equity investment by DEMATEL and analytic network process", *Expert Systems with Applications*, Vol. 38 No. 7, pp. 8375-8383.

Li, C.Y. (2009), "Building an institutional long-term care information systems research for a long-term care center", *T.S.M.H Medical & Nursing Journal*, Vol. 15 No. 1, pp. 53-58 (in Chinese).

Lin, J., Hsiao, C.T., Glen, R., Pai, J.Y. and Zeng, S.H. (2014), "Perceived service quality, perceived value, overall satisfaction and happiness of outlook for long-term care institution residents", *Health Expectations*, Vol. 17 No. 3, pp. 311-320.

Lin, R.J. (2013), "Using fuzzy DEMATEL to evaluate the green supply chain management practices", *Journal of Cleaner Production*, Vol. 40, pp. 32-39.

Lin, Y.T., Yang, Y.H., Kang, J.S. and Yu, H.C. (2011), "Using DEMATEL method to explore the core competences and causal effect of the IC design service company: an empirical case study", *Expert Systems with Applications*, Vol. 38 No. 5, pp. 6262-6268.

Liu, H.C., You, J.X., Lu, C. and Chen, Y.Z. (2015), "Evaluating health-care waste treatment technologies using a hybrid multi-criteria decision making model", *Renewable and Sustainable Energy Reviews*, Vol. 41, pp. 932-942.

Lu, M.L., Tzeng, G.H., Cheng, H. and Hsu, C.C. (2014), "Exploring mobile banking service for user behaviour in the intention adoption: using new hybrid MADM model", *Service Business*, Vol. 9 No. 3, pp. 541-565.

Meijer, C., Bakx, P., Doorslaer, E. and Koopmanschap, M. (2015), "Explaining declining rates of institutional LTC use in the Netherlands: a decomposition approach", *Health Economics*, Vol. 24 No. S1, pp. 18-31.

Meyer, F., Lundgren, P.A., de Moor, G. and Fiers, T. (1998), "Determination of user requirements for the secure communication of electronic medical record information", *International Journal of Medical Informatics*, Vol. 49 No. 1, pp. 125-130.

Mgozi, T. and Weeks, R. (2015), "Cloud computing impact on healthcare in South Africa", *24th International Association for Management of Technology Conference: Technology, Innovation and Management for Sustainable Growth, IAMOT, Cape Town, June 8-11*.

Ministry of Health and Welfare (MOHW) (2013), "White paper on population policy", Ministry of Health and Welfare, Taipei (in Chinese).

Patrick, J. (2011), "Access to long-term care: the true cause of hospital congestion?", *Production and Operations Management*, Vol. 20 No. 3, pp. 347-358.

Phillips, C.M., Balch, D., Schanz, S. and Branigan, A. (2002), "Teledermatology: issues in remote diagnosis and management of cutaneous disease", *Current Problems in Dermatology*, Vol. 14 No. 1, pp. 7-38.

Richards, H., King, G., Reid, M., Selvaraj, S., McNicol, I., Brebner, E. and Godden, D. (2005), "Remote working: survey of attitudes to eHealth of doctors and nurses in rural general practices in the United Kingdom", *Family Practice*, Vol. 22 No. 1, pp. 2-7.

Shieh, J.I., Wu, H.H. and Huang, K.K. (2010), "A DEMATEL method in identifying key success factors of hospital service quality", *Knowledge-Based Systems*, Vol. 23 No. 3, pp. 277-282.

Su, C.Y., Chao, C.M., Sun, K.H., Tai, C.F. and Li, C.W. (2015), "Willingness of e-care cloud system using-based on a long-term caring institution in Southern Taiwan", *3rd International Conference on Organe Technologies, ICOT, Hong Kong, December 19-22*.

Tzeng, G., Chiang, C. and Li, C. (2007), "Evaluating intertwined effects in e-learning programs: a novel hybrid MCDM model based on factor analysis and DEMATEL", *Expert Systems with Applications*, Vol. 32 No. 4, pp. 1028-1044.

Wang, M.Y., Chang, D.S. and Kao, C.H. (2010), "Identifying technology trends for R&D planning using TRIZ and text mining", *R&D Management*, Vol. 40 No. 5, pp. 491-509.

Yang, H.L. and Hsiao, S.L. (2009), "Mechanisms of developing innovative IT-enabled services: a case study of Taiwanese healthcare service", *Technovation*, Vol. 29 No. 5, pp. 327-337.

Zhou, Q., Huang, W. and Zhang, Y. (2011), "Identifying critical success factors in emergency management using a fuzzy DEMATEL method", *Safety Science*, Vol. 49 No. 2, pp. 243-252.

Zhu, Q., Sarkis, J. and Lai, K.H. (2014), "Supply chain-based barriers for truck-engine remanufacturing in China", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 68, pp. 103-117.

Appendix

The definitions of the TRIZ tools are as follows:

(1) Contradiction matrix: a matrix of 39 technical parameters that are arranged on vertical and horizontal axes to interact with one another. This matrix is used to point out the inventive principles that can be applied to solve technical contradictions. Patterns of evolution of technical systems – for identifying directions of technological development as explained earlier.

(2) Substance field (Su-field): similar to function analysis, helping to map out the entire system and point exactly to problems without adding unnecessary details.

(3) 40 inventive principles: conceptual solutions to technical and physical contradictions.

(4) Separation principle: for understanding and solving physical contradictions and points at solutions from the inventive principles relevant to the problem.

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