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# Developing Multiple Evaluation Frameworks in an Older Adults Care Information System Project: A Case Study from Taiwan

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## Abstract

Many hospital managers agree that they can copy their successful experience in the medical center through implementing the information system (IS) successfully in the older adults care institution. However, these facilities are not the same care model as general hospitals. In addition, the scales of operation in older adults care institution are often rather small and they cannot undertake IS project with a high failure risk. Thus, the same standards for evaluating a successful implementation cannot be guaranteed for both types of institutions. A suitable system evaluation framework before the whole system migrates is very important, especially in the older adults care institution with low informatization levels. The goal of this study is emphasized by developing an innovative system project and its' multiple evaluation framework in our case which turned to be a research-action, study participant comprising whole staffs and its residents of the older adults care village of biggest health care group in Taiwan. The results describe our resulting functional design of the system, multiple evaluation framework phases, and several challenges, difficulties or attentions. The contribution of this study is our project design and practical feasibility and execution of its evaluation methodology to an older adults care institution.

**Keywords:** Older adults care information system, system evaluation framework, Information system implementation

## Key Practitioner Message

- Introducing an information system for older adults care institution in a holistic care concept helps practitioners to improve the work effectiveness of health care teams.
- Perceptions regarding the comprehensible and practical evaluation method of the information system for the older adults' institution might be the important topics for health care professionals.
- Both personal satisfaction and organization benefit of the caregivers and residents might be affects the successful implementation

## Introduction and Background

The aging of society has become an important issue, leading not only to pressure in small families from a shortage of care workers, but also to increase in expenses for elderly welfare and medical care. Thus, older adults care is being gradually replaced with community care. The increasing demand for this type of older adults care institution within such a short period of time illustrates the shortage of care workers in institutions, which may cause a lower efficiency in services and a decrease in medical quality. To improve the quality of older adults care in aging country and resolve the issue of labor shortages in older adults care institutions, the government proposed a program for constructing an integrated informa-

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tion system for caring older adults by information technology, with all system functions designed on the concept of "holistic care." Based on this concept, the five keys points for older adults support are independence, involvement, self-realization, care, and dignity. Ideally, this concept should concentrate on giving personalized care for recipients under the fundamental framework of nursing care after caretaker interaction (Hurlock-Chorostecki, 1999).

In the field of health information, most medical institutions believe that information systems can help reduce clinical mistakes, increase care efficiency, and support healthcare decisions (Bates et al., 2001; Moehr, 2002). However, a number of medical institutions believe that implementing an information system may lead to significant failure risks (e.g., spend high costs and long implementation times but IT project with high failure rates). In both research and practice in the field of medical healthcare, it is believed that conducting evaluations before implementing an information system is very important. Although evidence has shown that implementing a modern information system can indeed help an enterprise make significant and efficient improvements, for the successful adoption of integrated information systems, it is still necessary to understand the efficient usage of an information system.

Most previous evaluation reports have focused on the differences in data between expected and actual results post system implementation, and determine how successful a system has been in achieving its expected goals. However, a number of systems have failed for many other reasons, particularly user resistance. Several studies have indicated that it is inappropriate to not include user acceptance in system-evaluation methods (Kaplan, 2001). In addition, some studies have suggested that systems can be optimized based on user feedback (Sinchenko, Westbrook, Tipper, Mathie, & Coiera, 2003). The measurement methods used to evaluate whether an information system has been successfully implemented have been changing, from methods regarding technical issues to those regarding manpower and organizations issues, and from objective methods to subjective methods (Ammenwerth & de Keizer, 2005). During the past 15 years, the most popular issue in the field of information management has been to determine whether an information system has been successfully implemented based on user feedback. Several evaluation methods based on theory and subjective user perceptions have been introduced (Aggelidis & Chatzoglou, 2009; Elske Ammenwerth, Iller, & Mahler, 2006; Brender, Ammenwerth, Nykanen, & Talmon, 2006; Chang, Chang, Wu, & Huang, 2014; Jen & Chao, 2008; Lee, Mills, Bausell, & Lu, 2008; Tsiknakis & Kouroubali, 2009; Tung, Chang, & Chou, 2008; Yu, Li, & Gagnon, 2009). Although these social-science based evaluation models have been widely applied in the healthcare field, according to some studies, the evaluation methods used for hospital information systems (HIS) are still confusing and lack in specificity (Gremy, Fessler, & Bonnin, 1999; Yusof, Papazafeiropoulou, Paul, & Stergioulas, 2008).

Besides, previous studies have been stated that social negotiations (such as the pre-sale development phase or finding support from stakeholders) are key factors to the successful implementation of an information system in hospital (Berg, 2001; Greenhalgh, Potts, Wong, Bark, & Swinglehurst, 2009; Sittig & Singh, 2010). The reason for this requirement is also happened in the institution of older adults care, most users are not involved in the discussions before a new system is implemented, and are compelled to use the new system after its implementation. User environments for those forced to use a system, and for users who have been involved in the system development, are quite different (Garcia-Smith & Effken, 2013). In addition, a lack of sufficient consideration regarding clinical situations and whether a patient's health conditions can be improved may lead to ideas deviating from the original expectations of this field.

Facilities for older adult chronic care are not the same as general hospitals for acute care. The same standards for evaluating a successful implementation cannot be guaranteed for both types of institutions. The physiological conditions of the older adults are better than the patients in the acute hospital. Thus, the focus of older adults facilities is usually on keeping the vital signs of the patients' stable and providing overall comprehensive care. Furthermore, the scale of operation in older adults care facilities are often rather small; therefore, investment efficiency is a very important issue. Evaluation methods should also consider the cost of investing in an information system.

### Purpose of the Study

In this study, we proposed a proper and practical evaluation framework to evaluate the implemented one information systems for the older adults care facilities in a real case. We assumed all the older adult person in our case can act by themselves, therefore, we can collected the residents' perceptions, the health conditions of them, and the cost improvements as evaluation factors of the framework. Furthermore, in our opinion, a good information system for the older adults care institution can stick to the core value of care, it should be used to help caretakers complete their nursing tasks and satisfy the older adults living in such facilities, no matter in mentally or physiologically. The purposes of this study include the following:

(1) To develop an information system for older adults care institution in a holistic care concept, called the ubiquitous healthcare system (UCARE system);

(2) To propose a comprehensible and practical evaluation method for information systems for the elderly; thus, our study can be considered as a means to enhance current research frames and practical methods;

(3) To evaluate the cost benefit for and organization, caretaker's satisfaction, and illustrate how the health conditions of an institution's residents are improved by the system.

## Method

The U-CARE system project spend one and half year and it was developed based on the concept of OOAD (Object-Oriented Analysis and Design technical approach), using UML (Unified Modeling Language) as the syntax for requests. All sub-systems are interconnected. To reduce the complexity of relationships among the sub-systems, we adopted SOA (Service-Oriented architecture) as our system architecture. For the purpose of ubiquitous care, we constructed our system in a Web-based environment. Microsoft .Net 3.0 on an IIS7.0 environment is used as the system development platform. ASPX and C# are used as the programming languages. The programming team tested each unit after its programming phase was completed, and created the related testing records. During the unit tests, each module of the system was tested separately to capture any errors within the module and confirm its internal consistency and logical correctness.

The long-term U-CARE information system described in this study was designed from the perspective of integration. Data from various working processes were integrated across the different sub-systems. Therefore, guaranteeing the quality of the system is very important. Otherwise, missing data may lead to errors in the functions of other sub-systems.

The most common measurement methods adopted in most studies regarding the prediction of whether an information system will be successfully implemented are based on user satisfaction post-implementation. However, the health-care industry is a type of service industry. In older adults care institution, in particular, most residents can take care of themselves and have the right to choose whether they want to move into the facility. Therefore, there is a lack of a sufficient empirical base for cases solely determined by subjective caretaker satisfaction. For this study, we conducted a satisfaction survey regarding our system and interviews to retrieve informa-

tion on subjective perceptions, provided several complete training courses for the system to control the quality of our survey data, and adopted a quasi-experiment method to measure the differences related to the medical staff and the residents between the pre- and post-implementations of the system. These differences include the health conditions of the residents, the time costs spent on the job to the staffs, and the improvements in efficiency. Figure 1 shows the system evaluation framework designed for this study. Therefore, there are hypotheses developed according to the research model.

H1: Personal satisfaction the caregivers on using UCARE system positively affects the successful implementation

H1: Personal satisfaction of the residents on using UCARE system positively affects the successful implementation

H2: Organization benefit of the caregivers on using UCARE system positively affects the successful implementation

H2: Organization benefit of the residents on using UCARE system positively affects the successful implementation

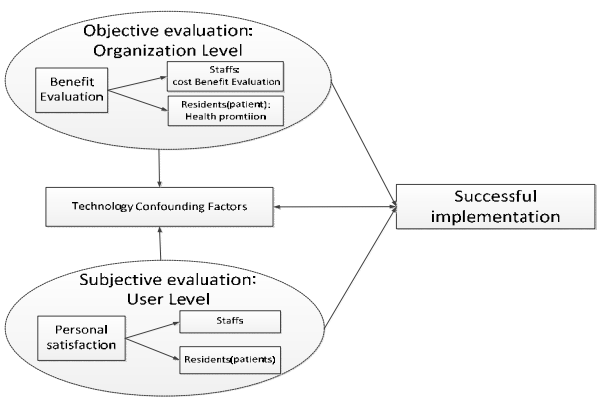


**Figure 1:** Evaluation framework

## Participants

For this study, we interviewed both the nursing staff and residents of the largest older adults care institution in Taiwan, the Chang Gun Health and Culture Village, owned by Chang Gung Group. Two groups of participants took part in this survey. The first group is made up of staff members working at the institution. To objectively determine the degree of improvement after the system was implemented, data of the actual time spent on paperwork by the staff members before the system was implemented were collected. After the system was implemented, these data were compared with the data on the time spent using the proposed system for the same tasks. Through these comparisons, we discussed whether the implementation of the system can improve the working efficiency and save time spent on paperwork, allowing residents to be better cared for and the overall quality of care to be improved. A total of 20 questionnaires were obtained from the survey with the staff members of the institution. All of the participating caretakers were female, aged 25 to 40 (μ = 31.5), and with a college/university degree or higher. The second group surveyed was made up of residents in the institution. The characteristics of the both groups are shown in Table 1.

**Table 1:** Characteristics of the resident and caregiver participants (n = 273)

| Residents | | Demographics | | Caregivers | |
|---|---|---|---|---|---|
| n | % | | % | n | |
| 117 | 42.90% | Gender | Male | 10.00% | 2 |
| 156 | 57.10% | | Female | 90.00% | 18 |
| - | - | Age | 20-29 | 55.00% | 11 |
| - | - | | 30-39 | 40.00% | 8 |
| - | - | | 40-49 | 5.00% | 1 |
| - | - | | 50 above | - | - |
| 78 | 28.57% | | 75 or below | - | - |
| 66 | 24.18% | | 75-79 | - | - |
| 83 | 30.40% | | 80-84 | - | - |
| 46 | 16.85% | | 85 above | - | - |
| 6 | 2.20% | Education | Illiterate | - | - |
| 41 | 15.02% | | Elementary school | - | - |
| 30 | 10.99% | | Junior high school | - | - |
| 61 | 22.34% | | Senior high school | - | - |
| 135 | 49.45% | | College / University | 100.00% | 20 |

## Data Collection

Before developing and implementing the proposed system, we already knew that the medical staff members working in nursing facilities have quite limited computer competence, a lack of computer experience, and little knowledge on closely integrated computer concepts (Hsu, Hou, Chang, & Yen, 2009). Very few caretakers have used a medical care system before, let alone older adults. Therefore, before the system implementation, we spend two mouths to give them a computer competence educational training course and assigned member of study group to help them identify their true needs, and learn how to integrate information and which solutions are the best. This kind of competence is a key to successfully developing such a system. Thus, to make sure that our system could be smoothly developed, for every sub-system there was a responsible system analyst familiar with the field of medical care in this project. These system analysts designed and provided certain training courses after the system was completed. The contents of these courses covered all system functions and information needed to be collected for an evaluation. The paper-based data of the activities of some of the residents and users during the pre-test were also collected; allowing the data collection and comparison procedures to be performed and smoothly completed after the system was implemented.

## Subjective Measurement

This system was designed to evaluate through various methods whether the U-CARE system can actually meet user demands. The first method adopted was an information quality evaluation method used by our predecessors to evaluate whether an information system has been successfully implemented. According to DeLone and Mclean (2003), information quality refers to the quality of outputs the information system procedures, which can be in the form of reports or online screens. They also mentioned the most measures of information quality are from the perspective of the user the information system and are subjective measures. It refers to measure of information and data for desired characteristics as the quality of output from a system included accuracy, precision currency, reliability completeness, conciseness, accessibility, adaptability, relevance, understandability, meaningfulness, timeliness, comparability and format. For information to be effective in the care institution, it also possess the characteristics and must be easy to understand and consistent outputs.

In this study, the method of this part is mainly based on user satisfaction after the system has been implemented and is quite a mature method. And the theoretical structure of the evaluation theory is shown in Figure 2.

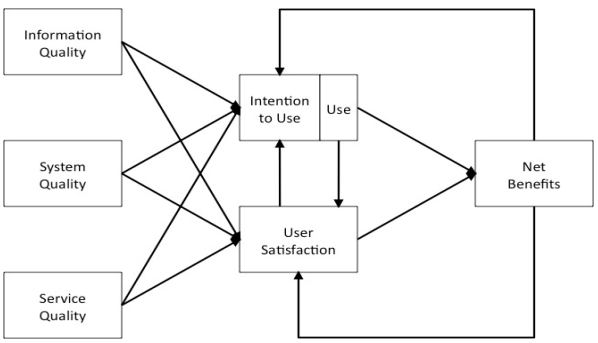


**Figure 2:** Updated Information System Success Model (Delone & McLean, 2003)

*Long Term Information System Satisfaction Questionnaire (LTIS):* For the present study, we developed a survey tool called the Long Term Information System Satisfaction Questionnaire (LTIS) to measure subjective satisfaction from the angle of residents and caretakers based on the Information System Success Model and the characteristics of long-term care institutions. The residents construct covered service quality, system quality, information quality, user acceptance of the interface, and satisfaction with the sub-systems. The caretakers construct covered the influences on the organization and individuals. To make sure the participants could answer the questions correctly, the interviewers conducting this study first explained to how to fill out the

**Table 2:** The major components of items

| | The major components of items |
|---|---|
| System quality | To ask about the consistency, logic, reaction time of each sub-system |
| Data quality | To ask about the reliability, correctness, completeness of each sub-system |
| Service quality | To use the main sub-functions of each sub-system as the question items to collect opinions, and understand whether the data integration can adequately meet with the actual demands |
| User interface | The acceptance of residents and users of the operation, graphics, and multi-media |
| Organizational Impact | To use the influences of various organizational performance to express the agreement on whether the system can contribute to the work performance |

questionnaire step-by-step before starting. Every item was designed as 3-5 structural questions. There were no negatively worded questions. The key points for the evaluation of the questionnaire are summarized in Table 2. The items in the measurement tool were five-point scale where 1 = strongly disagree and 5 = strongly agree. Cronbach's Alpha of each construct of the satisfaction scale used in this study was over 0.7, indicating the good reliability and validity of this measurement tool.

### Objective Measurement

When conducting the system evaluation, one of the most important items among the objective data was the time consumption. First, to reduce any errors caused by the number of measurements taken and the number of people measured, after the paper-based operations to be compared were selected, the researchers measured the actual operation time of all staff members and used the averages as the time required for the paper-based operations. In addition, to avoid differences in the actual efficiency caused by the learning curve of the operations during the online phase within a short period of time, this study also provided sufficient system operation training courses, and the actual time required for the operations was measured one week after actual use to make sure the study sufficiently strict and rigorous.

### Data analysis

The questionnaire used in this study was designed based on studies related to the successful implementation of other information systems (Delone & McLean, 2002). The translation was checked by two professors with a degree in management information systems field to make sure it was accurate. The participants of the pilot-test were also the nursing staff and residents of the institution. The demographic data collected included the participants' gender, occupation, experience with computers, and age. The compared differences in the seven selected operations and degrees of improvements in the residents' health and effective of staff between the pre- and post-implementations of the system were also presented.

## Results

The U-CARE system was designed based on the concept of "holistic care," which has been promoted in the medical field, stressing the provision of patient-centered medical care for the sick as well as providing correct and effective prevention methods, allowing care recipients to become healthy and satisfied physically, mentally, and spiritually. Thus, this study first defined the five main target needs in healthcare for the older adults based on the above-mentioned ideal:

1. *Physiological Needs:* Related items include medication requirements, chronic disease control, non-planned reception of medical treatment, health scale, and daily physiological measurements.

**Table 3:** Subsystems design of U-CARE system by IPO model

| Needs | Input | Process | Output |
|---|---|---|---|
| Physiological needs | Physiological data collection sub-system | Health education sub-system | Multimedia center sub-system, abnormal event notification sub-system, abnormal event tracking sub-system, health condition analysis sub-system |
| Mental needs | Health evaluation input sub-system | Activity arrangement sub-system | |
| Dietetic needs | Diet recommendation sub-system | Life reminder and information query sub-system | |
| Home needs | – | | |
| Exercise needs | Indoor activity recording sub-system | | |

2. *Mental Needs:* Related items include a resident's interpersonal interactions and mental scale.
3. *Dietetic Needs:* Related items include nutrition evaluation scale, medication condition, and proper amount of nutrients.
4. *Home Needs:* Related items include the reception of guidance in terms of general health knowledge and the viewing of health education films.
5. *Sport Needs:* Related items include the amount of exercise, and the number of exercises conducted and their frequency.

For this study, we designed the U-CARE sub-systems according to the constructs of the planning described above. In the field of information systems, the famous IPO model proposed by McGrath (1984) has often been used to study issues related to group system interactions. The same viewpoint can also be used to modify the structure of a long-term care information system. This study adopted the five healthcare needs as their base, and three additional aspects, i.e., input, process, and output, as the thinking logics, for the design of 11 sub-systems (see Table 3).

The input sub-systems can be divided into a physiological data collection subsystem (IPPHS), health assessment entry subsystem (IPHAS), diet recommendation subsystem (IPDRS), and recording subsystem of indoor activities (IPIAS). The IPPHS can complete the physiological measurements through the use of many sensors and computers, and send the data to the system database. The IPHAS combines nursing care information with health assessment information: IPDRS using POS (point of sale) machines, which combine nutritional information with data on the ancillary restaurants of the institution to allow the ordering results of the older adults to be stored in the system, records the correlations between the nutrients they have consumed and their original diseases, actively reminding the older adults of their dietary recommendations or fasting menus. Finally, IPIAS can automatically record the limb movements of the residents through sensors installed inside the classrooms and activity areas, and store such information in the database to help the health care workers understand the amount of exercise the older adults are receiving.

In addition, the process subsystems can be divided into a health education subsystem (PCHES), activity arrangement subsystem (PCAAS), and information notification subsystem (PCNOS). The PCHES enabled older adult residents to see their own personal database on their medicine intake, daily dining information, and health education learning systems. The PCAAS could recommend suitable instituted group activities based on their interests and goodness-of-fit to improve their social skills and mental health. The PCNOS was used to remind them of dietary announcements, family visiting hours, and the exercise schedule.

In the process part of the sub-systems of UCARE, include the health education sub-sys-

tem, activity arrangement sub-system, and information notification sub-system. With the health education sub-system, the older adult residents could check their own medication records in the database in their own rooms, information regarding their daily meals, and other health-education related information. With the activity arrangement sub-system, the social skills and mental health of the older adult residents could be improved based on their hobbies and adequacy. In addition, the life reminder and information query sub-system offered daily life reminders, family visitation reminders, and exercise reminders.

Finally, output mainly includes the multimedia center subsystem in the resident's rooms (OPMDA), which provided many types of information to the older adult residents. In addition, there was a notice subsystem (OPNOS) and a tracking subsystem for abnormal situations (OPTRS), as well as a health status analysis subsystem (OPANS). The OPTRS reporting system let the nursing staff know about any abnormal situations by tracking abnormalities that can reduce the unplanned older adults medical treatment happened suddenly. OPANS provided multiple radar charts to analyze the health status of the older adults residents when their families came to visit, and is an approach for showing their health status in a timely fashion. Last, the most important sub-system for output is the multimedia center sub-system, which was available in the older adult residents' rooms and provided many types of information to them. In addition, there was also an abnormal event reminder and tracking sub-system, and a health-information analysis sub-system. The abnormal event reminder and tracking sub-system allowed caretakers to determine any abnormalities of the older adult residents and track them to reduce the number of such unplanned situations. The health information analysis sub-system offered various radar charts to present the analysis results of the health conditions of the older adult residents when their families visited. This function allowed the institution to show the health conditions of the older adults residents in real-time.

In terms of use, the proposed system contains 11 subsystems, but because they were designed based on the overall care of the residents, some of these subsystems were processed in the background, and the necessary information was sent as intermediary files among the different subsystems. Using the concept of a life gateway distributed in each resident's room as an information center, the storage of personal health information, as well as a bridge of communication among the older adult residents and their primary doctors and friends, was the responsibility of the gateway.

The system used the residents' IDs to connect all information stored in the database. This system tied in the care procedures, and used a nursing assessment taken when the residents were first hospitalized as the starting point; after moving into the hospital, the older adult residents could use digital physiological measurement devices to measure their vital signs. These devices retrieved their physiological information, such as their heartbeat, blood pressure, and blood sugar level, and through wireless networks, they could transmit the data on their measured vital signs to the life gateway to build complete personal records of their physiological parameters. In addition, the system could collect various types of assessment data from all kinds of mobile devices, POS, and input by the health care crew from their workstations in the institutions, and store the data in the U-CARE database. The health care crew could also store videos of activities and health education in the database in advance allowing the system to deliver the information to the residents. The residents could use their personal multimedia center to see their personalized data extracted from the database, including their health information, health education multimedia, dietary records, list of the institution's

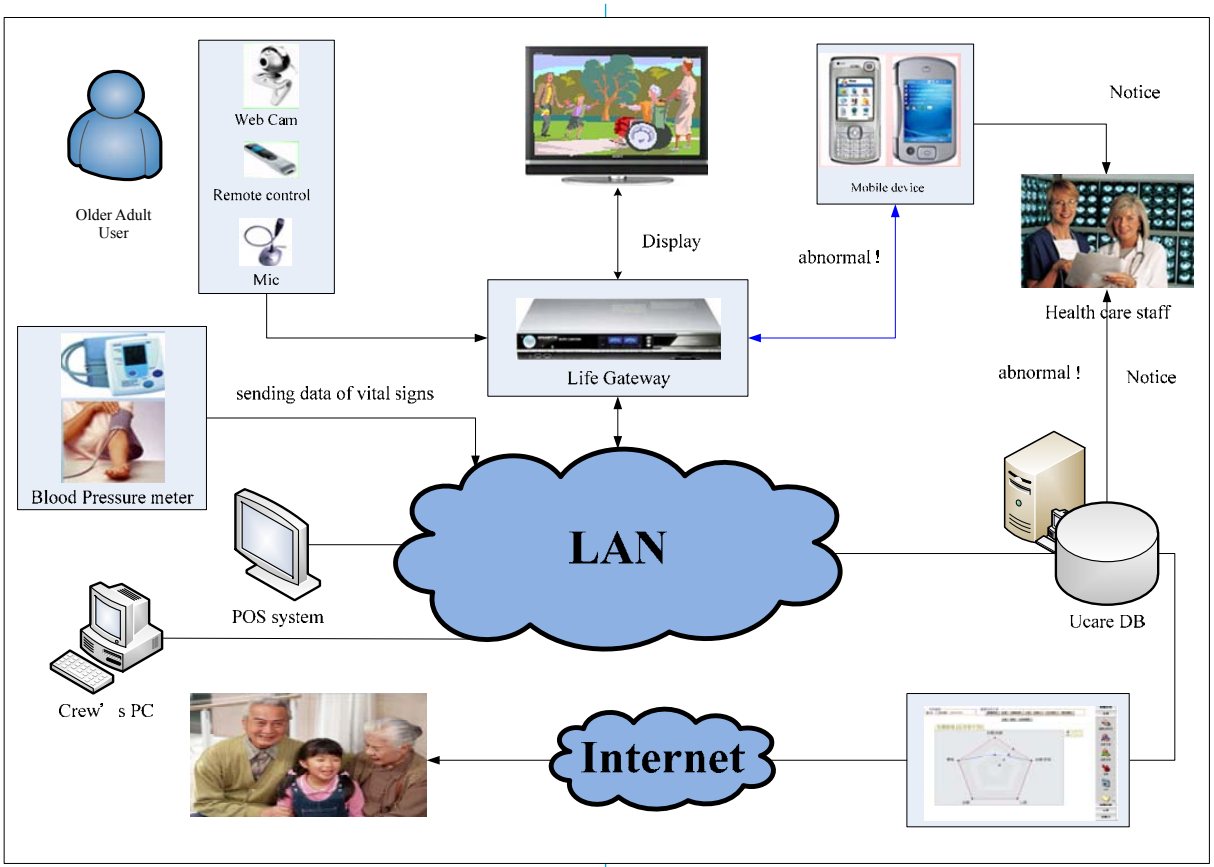


**Figure 3:** U-CARE system integration scenario

activities, their records of participation, and personal life suggestions.

Of course, through the proposed system, caretakers could check each resident's overall trend in their health condition, and get involved when their personalized health records showed an abnormality after receiving an active notification from the system. Lastly, families of the older adult residents could log into the system through the Internet and check the summarized care information of their loved ones, which was presented using radar charts, allowing the families to see their overall health conditions in terms of their physiological and mental condition, diet, home life, and exercise level. This means that the proposed system integrates data from various aspects based on the concept of holistic care. In this way, the families of the older adult residents did not need to worry about being able to access the health status of the loved ones. Figure 3 shows the integration of the proposed U-CARE system.

## Discussion

The U-CARE system discussed in this study is a typical long-term institutional care information system. The two main types of users of this system are nursing personnel and residents. The new LTISQ questionnaire was redesigned into an online MySurvey questionnaire. After it was completed, it was emailed to the nursing personnel. They were asked to set up the MySurvey online questionnaire system, fill in the questionnaire, and submit their responses. To collect the feedback of residents regarding their feelings when using the proposed system, because their TVs are all-in-one units with Internet functionality, when they turned on their TV, the default main page was displayed on the screen. They could select the functions they wanted to use from the page, including watching TV, listing the available activities, and retrieving their health education information. The questionnaire was also registered in the media center in paper format, allowing the researchers and the

system development team to collect the personal survey information the residents filled in using their system screens. The following section describes the results of the subjective evaluations of the residents and system users and their objective measurements.

*The evaluation result of the individual-level subjective satisfaction*

The results from the satisfaction scale are summarized below based on the two types of participants: First, the results from the nursing personnel are listed in Table 4. In terms of system quality, information quality, and whether there was a positive effect on their organization, the responses from the nursing personnel were all positive. The nursing personnel were quite satisfied (75.3%) with the service quality of the subsystem functions, with an average score of at least 5% higher than those of the other aspects. One possible reason for this is that the nurses had previously participated in the system requirement phase and system analysis phase for the purpose of confirming the specific requirements. However, their satisfaction with the interface operation was rather low (58.4%) because their information literacy was not high and they needed to accumulate more experience to improve their operation of the interface, which was brand new to them. In addition, according to the opinions of the nursing personnel, among the sub-functions provided, those that were the most helpful for care giving were customized health education, automatic collection of health information, and comprehensive health analysis used for fast communication with the family members. In addition, the scores given by the nursing personnel on improving their working efficiency and reducing working time were above 80%, meaning subjectively that the nursing personnel agreed that the U-CARE system can help them to save time spent on paperwork, and that they could use this time to improve their care for the residents.

Besides, the results from the residents themselves are also shown in Table 4. The residents were satisfied with the system performance in terms of system service, data service, and the service quality of each function. The results were similar to those of the nursing personnel. The highest score given by the residents was for service quality, which was 5% higher than the score given by the nursing personnel. This means that designing systems for nursing homes by integrating the body, mind, and soul is a good way to meet the actual requirements of the residents. However, because the residents are older people with low information literacy and are not familiar with how to operate a computer, their score given to the user interface was rather low (51.33%). Among the sub-functions provided, the residents believed the most helpful ones were the medication reminder and comprehensive health analysis. The residents were satisfied with the customized health education they received through the media center subsystem in their room, and the automatic display of their abnormal health conditions. They could get a sense of achievement by increasing their self-care without the nursing personnel, and by learning more medical knowledge to reduce lack of care related knowledge.

*The evaluation results on the actual benefits of the system at the organizational level*

**Table 4:** Result of the individual-level subjective satisfaction

| Construct | Satisfaction | |
|---|---|---|
| | Nursing personnel μ (%) | Resident μ (%) |
| System Quality | 68.44 | 69.25 |
| Data Quality | 69.78 | 62.07 |
| Service Quality | 75.30 | 80.80 |
| User interface | 58.40 | 51.33 |
| Organizational Impact | 70.57 | - |

**Table 5:** Compared different of selected operations after the system implementation

| Operation | Before Implementation (Paper-Based) | After Implementation (System –Based) |
|---|---|---|
| Health consulting and guidance | Proper instructions for resident health were selected through data comparisons by men. Arranging time for one-on-one health education and evaluation after education with residents was also done by men | Nursing personnel could directly set up connections between residents' health conditions and health education, and personalized materials would be assigned automatically for reading. Residents could read assigned materials through the media center at home and then fill the evaluation questionnaire afterwards to assess the effect of the health education. |
| Physiologic measurement | Nursing personnel had to record residents' self-measured values and check if there was anything abnormal through comparisons. Also, they had to find residents without measurements one by one to look for reasons and track them | After residents' measurements were done, the system could notify nursing personnel immediately of abnormal residents so they could put those residents on the high-risk list and start to monitor their conditions. If there were residents who did not complete measurements, the system could notify them through the media center. The system could also present hospital analysis data and trends to improve efficiency. |
| Life and health scale evaluation | Similar to physiologic measurement, nursing personnel needed to personally perform measurements for 9 scales including ADL and conduct interviews with residents one by one annually. It was time consuming. | Based on the concept of scheduling, interview time was defined. The system could send out notifications and perform measurements based on the schedule to save labor. |
| Emergency medical service | Nursing personnel had to actively identify residents who were not feeling well and determined whether to send them to hospitals. If a resident was hospitalized, his related information had to be recorded manually, with all the processes being put down in writing on the shift report sheet. | Through daily measurements, residents with abnormal health conditions could be identified earlier. During an outpatient visit, related recent health records could be summarized and provided to the doctor as references, in order to find unusual conditions as soon as possible for early treatments. |
| Medicine delivery service | Medicines were separated and put in medicine boxes manually. And residents who had problems following doctors' advices were reminded manually one by one to take medication. | The system would automatically remind residents to take medication. Residents could press the reply button after actually taking their medication as confirmation. In case of any questions related to medication, residents could access the pharmacopoeia in the system to inquire about appearances, dosages, applicable diseases, and doctors' reminders related to certain medicines, to avoid taking medication improperly. |
| Vaccination | Residents were notified manually to have outpatient visits. Also outpatient visit schedules were arranged manually and results were documented manually. It took a lot of time and efforts. | All events were pre-set through scheduling and all required information was generated automatically. |
| Guidance of diet | Dietitians hired by institutions could only passively provide interventions to abnormal patients. Manually tracking was time consuming. And it was difficult to clearly know how residents' actual diet conditions were. | Dietitians could set up the relationships between nutrition of foods and drinks on menus and diseases in advance, so that residents could get personalized suggestions on menus. They could change their diet habits through personalized suggestions and reminders. |

This section presents the objective views on the improvements made for organizations or individuals using the U-CARE system. The evaluations were based on the system effects, including changes in the working procedures, influences on manpower and time costs, and organizational effects after the system was completed.

In the first part, the seven operations with the highest frequencies of occurrence in the work of the nursing personnel are compared in Table 5: health consultations and guidance, physiological measurements, life-and health -scale evaluations, emergency medical services, medicine delivery service, flu shots, and diet guidance. The actual operation time was measured to determine whether labor costs were reduced. The calculation of labor costs in this study was based on the average salary and working days of the nursing personnel in

Taiwan. The effects from completing each of these operations on the organizations after the system implementation were calculated. The improvement methods for the operating procedures after the system implementation are presented one by one below. As a whole, the cost analysis shows that a system using U-CARE provides a cost-effective alternative to paper-based operation job lists, particularly in the operation of diet guidance, physiological measurements, and life and health scale evaluation. Table 5 lists a comparison of the job lists for before and after the system implementation and Table 6 lists the time and cost savings.

The second part is related to the residents' actual health conditions. The U-CARE system integrates various types of healthcare information of the residents. Through this medium, the residents' health literacy can be improved indirectly, allowing the residents to measure their own physiological state, participate in their own health care, and reduce their chances of hospitalization to serve the purposes of measuring physiologic information, caring about one's own health, and reducing chances of hospitalization. Therefore, three indexes are selected which including the rate of blood-pressure self-measurements, the rate of blood-sugar self-measurements, and the rate of unplanned transfers for hospitalization, to determine whether the health of the residents at the studied institution had improved after the system was implemented. The results showed that, after the system was implemented, the rate of blood pressure self-measurements increased by 3%, the rate of blood-sugar self-measurements increased by 5.3%, and the rate of unplanned transfers for hospitalization decreased by 0.022%. Hence, implementing the UCARE system can help residents value their own health care more and improve their overall health quality. It was also proved that the UCARE system implementation has a positive effect on nursing institutions. A summary of the difference pre and post implementation is listed in Table 7.

## Conclusion

Faced with the advent of an aging society and the trend toward smaller families, it is becoming necessary to have foster institutions take care of older adults' family members rather the families themselves. Nevertheless, there are too many paperwork and too heavy workload, some patient problem identifications or evaluations were ignored which bring many near misses or medical errors of nursing personnel were happened in older adults care institution or nursing homes. In Taiwan, the government has developed various IT systems to solve the problem of manpower shortage in

**Table 6**: Comparison of the time spent on various task before/after the system implementation

| Operations | Before system implementation (min)a | After system implementation (min)b | a-b min(%) | Labor cost saved |
|---|---|---|---|---|
| Health consulting and guidance | 55.50 | 11.50 | 44.00 (79.28) | 172.48 |
| Physiologic measurement | 84.50 | 10.25 | 74.25 (87.80) | 291.06 |
| Life and heath scale evaluation | 113.50 | 63.66 | 49.84 (43.91) | 195.37 |
| Emergency medical service | 100.50 | 73.66 | 26.84 (26.71) | 105.21 |
| Medicine delivery service | 95.00 | 80.00 | 15.00 (15.79) | 58.80 |
| Vaccination | 89.40 | 57.00 | 32.40 (36.20) | 127.00 |
| Guidance of diet | 120.00 | 28.00 | 92.00 (76.67) | 360.64 |
| Total | 658.40 | 324.07 | 1759.93 (84.40) | 1310.57 |

**Table 7:** Compared between the index pre and post implementation

| Index of resident's health management | Before the system implementation | After the system implementation | Difference |
|---|---|---|---|
| Rate of blood pressure self-measurement | 86.70% | 90.00% | +3.30% |
| Rate of blood sugar self-measurement | 87.70% | 93.00% | +5.30% |
| Rate of unplanned transfer for hospitalization | .10% | .07% | -.03% |

these institution, and one such system is the UCARE system described herein. However, the information system implement projects are still high rate failure especially in the health care related institution.

A good long-term information system can not only meet the demands of end users, but also achieve the goal of IT implementation in organizations before sufficient scientific-based subjective and objective evaluations can be conducted. In particular, older adults care in nursing homes has focused on a solution to the problem of resident care, and evaluated how well an information system can change the health of the nursing home residents. In addition, the cost is another point of concern because the scale of a nursing home is smaller than that of a general hospital. Therefore, the development of a reasonable and practical evaluation approach for older adults care institution or nursing homes is needed.

It was not long ago when IT implemented in the field of heath care. Such implementation in older adults care institutions has just begun. Compared with large hospital, small institutions like older adults care institutions are rather to get the IT systems to help increase efficacy of their work. However, it is insufficient to gauge system effectiveness with focus solely on managers and end-user satisfaction, similar to previously conducted research. It would be more reasonable to take into account objective data, such as actual improvement measures based on cost and health improvements, in evaluations and comparisons.

As a whole, the contributions of this study include: providing a diversified way to evaluate a system's successful implementation in a nursing institution for the elderly; introducing the functions of the implemented system in a holistic way in the evaluated institution; performing actual measurements and evaluations of subjective satisfaction and objective data, and lastly, proving that a satisfactory system can efficiently help nursing personnel save time on paperwork-based operations, reduce mistakes and errors, and manage the health care of the older adult residents in a more efficient way. Although IT implementation in the fields of nursing and healthcare has been rather late compared with acute medical institutions, this study will allow future researchers to have an enhanced understanding of this field.

Despite this study showed competitive multiple evaluation framework is very important and helpful for evaluating an integrated application system in a nursing institution. There were still some limitations during the system implementation. (1) The nursing personnel in the case institution were used to operating their own personal computers, and thus had some problems accepting the integrated information system. Consequently, they possessed a lack of confidence in using computer-based operations over paper-based operations. (2) During the implementation, it took time to test the system, and the willingness of the some nursing personnel were influenced for their increasing workload, maybe it influenced measurement results. (3) The institution's willingness to implement the system was influenced by their real investment quantity. (4) The security of the residents' personal information was a key factor for promoting the system.

## Conflict of Interests

The authors declare that there is no conflict of interests or any source of finding in the article.

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