A Novel Public Information System for Mobile Geriatric Medical Services

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ABSTRACT

The public information system (PIS) has long been recognized for its positive impacts on information asset management in mobile health industry. However, the existing PISs of mobile geriatric medical services face several problems: the lack of standardization, unclear business orientation and unknown attributes of the mobile Internet. To solve the problems, this paper constructs a novel PIS for mobile geriatric medical services. Specifically, the matching relation between industrial structure (S) and enterprise cultivation (C) was coupled with the structure–conduct–performance (SCP) paradigm. Through the integration, the PIS was conceptualized based on the non-financial indices of balanced scorecard (BSC). Several hypotheses were put forward on the dimensions of mobile medical industry for the elderly, and then verified through a questionnaire survey and data analysis on SPSS 22.0 and Smart PLS 2.0. The data analysis also proves the good fitting effect of the proposed system. The research findings shed important new light on the optimization and upgrading of mobile medical industry for the elderly.

1. INTRODUCTION

The world population is aging rapidly in recent years, causing a tremendous strain on medical resources for the elderly. Currently, researchers are competing to build a mobile information system that offers efficient medical services, using information technology (IT) [1]. Public information system (PIS) of medical services maximizes the information value, and marks an inevitable trend in IT development [2-4].

With the development of IT, the mobile Internet has been applied to medical and health services, giving birth to mobile medical treatment [5]. By the definition of International Medical Health Organization (IMHO), mobile medical treatment refers to the provision of medical services and exchange of medical data via mobile communication devices, such as personal digital assistant (PDA), smartphone and satellite [6-8]. This novel type of treatment enjoys a good prospect in emergency handling, chronic disease monitoring and solving medical problems in remote areas.

However, mobile wearable devices have limited capacities of computing and storage. Computer technology is needed to collate and analyze the data collected by these devices [9-11]. At present, there are only a few preliminary PISs for enterprises to provide services. Many of them face some operational problems. This calls for reasonable planning and layout design of the PISs to promote resource sharing, enhance service quality and eliminate repetitive work [12, 13].

Previous studies have shown that mobile PISs can greatly facilitate communication and information sharing [14], strengthen industry supervision and contact [15], promote standardized development [16] and lower service cost [17]. Being the key to information integration, the PIS construction brings many benefits: improve the efficiency of information transmission, speed up regional growth in economy, culture and technology, and increase industrial benefits and social efficiency [18].

Through the above analysis, this paper aims to realize the following goals: satisfy the growing health needs of the elderly, and solve the technical problems of mobile medical industry, namely, the lack of a standardized PIS, the unclear service orientations, and the unknown attribute of the mobile Internet. To this end, the authors constructed a PIS for mobile geriatric medical services based on the structure–conduct–performance (SCP) paradigm and non-financial indices from the balanced scorecard (BSC).

2. CONSTRUCTION OF CONCEPTUAL MODEL

2.1 Basic theories

The PIS for mobile medical services have three modules, namely, doctor-patient communication [19, 20], medical data transmission (e.g. patients with hypertension use mobile devices to transfer vital signs information to electronic medical records) [21], and medical sensor monitoring [22] (e.g. some European countries have implanted remote monitoring sensors into cardiac pacemakers of patients with heart failure, and China has applied medical wearable devices to health management).

The PIS for mobile geriatric medical services is an open system. The main components of the system range from front-end recipients of mobile geriatric medical services, middle-end industrial incubator, to backend business incubator and enterprise accelerator. There are many advantages of such a system: promote the communication between end users and manufacturers, enhance the financing ability of mobile geriatric medical industry, attract universities and research institutes to offer technical support and personnel training, provide start-ups with management consulting and counseling,

and improve market, policy and legal services. With unparalleled openness and interactive performance, the PIS for mobile geriatric medical services helps to cluster numerous service providers and service recipients, and realize resource sharing among multiple parties from various places.

Therefore, this paper attempts to build a PIS for mobile geriatric medical services, which enables the industrial incubator to provide comprehensive, effective and commercially valuable services. Considering the various problems with the mobile medical industry (e.g. high cost, long investment cycle and the lack of standardization), the authors introduced the SCP paradigm, a famous model in Industrial Organization Economics, to optimize the system structure.

2.2 SCP-based modelling

The SCP is a syllogistic industrial analysis paradigm established by Bain, Scherer et al. from Harvard University. It is a research model integrating the structure, conduct and performance of the market. Drawing on the theory of modern industry cultivation and business management in China, this paper divides the SCP paradigm into three parts: industrial structure information, enterprise cultivation information and system performance.

(1) Industrial structure information

In China, the business management has a major defect: the weak connection between product service and industrial structure. To solve the problem, this paper presents the matching model of service information chain and industrial structure (Figure 1), mimicking the relation between enterprise cultivation (C) and industrial structure (S).
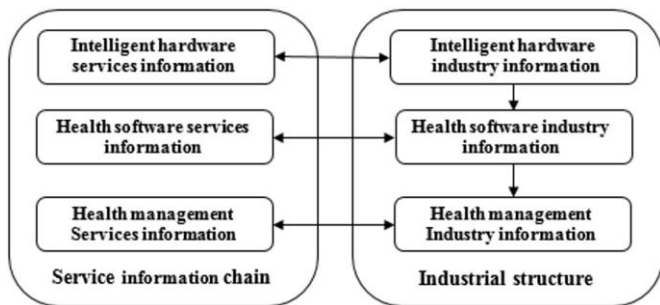

Figure 1. Matching model of service information chain and industrial structure

(2) Enterprise cultivation information

According to the theoretical paradigm of "strategic construct-market behavior-enterprise performance", the active market behavior of a start-up plays an intermediary role between business orientation and innovation performance. In China, enterprise cultivation must adapt to national conditions and conform to the market behavior under the market economy. In this case, an enterprise's acquisition of market information directly relies on its market behavior. Hu et al. [23] held that most start-ups in China imitate the market behavior of existing enterprises. This idea was adopted to replace the market behavior in the traditional SCP model, such that the market behavior is more in line with the actual situation in China. Therefore, enterprise cultivation was considered as a chain of

impacts between incubation of small and medium-sized enterprises (SMEs), enterprise growth, and accelerated cluster.

(3) System performance

In addition to financial index, the BSC contents cover non-financial indices of enterprises, which are measured by learning and growth, internal process and customers [24]. On this basis, this paper decides to measure the performance of the PIS for mobile geriatric medical services with a financial index, the proportion of the mobile geriatric medical industry in GDP, and several non-financial indices: industrial cultivation, process reengineering and users. These non-financial indices are assumed to have a chain of impacts on each other.

(4) Conceptual model

Through the above analysis on the SCP paradigm, the authors developed a conceptual model of the PIS for mobile geriatric medical services (Figure 2).
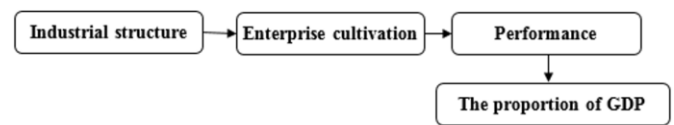

Figure 2. Conceptual model

So far, the authors have integrated the research results on SC matching relation with the SCP paradigm, setting up the matching relationship between service information chain (of the geriatric medical industry) and industrial structure, and then empirically analyzed the impact relation between different parts of the SCP. In fact, the service information chain and the industrial structure in the SCP also have a chain relation (Figure 3).
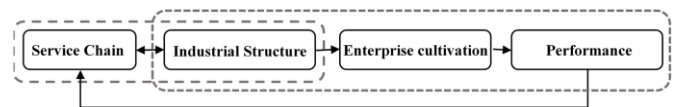

Figure 3. Chain relation model

Considering the features of the geriatric medical industry and the non-financial indices of the BSC, the learning and growth, internal process and customers in the BSC were redefined as industrial cultivation, process reengineering and users. Next, the authors set up the chain impact relation (Figure 4) of the three factors in the dimensions of industrial structure (S), enterprise cultivation (C) and performance.
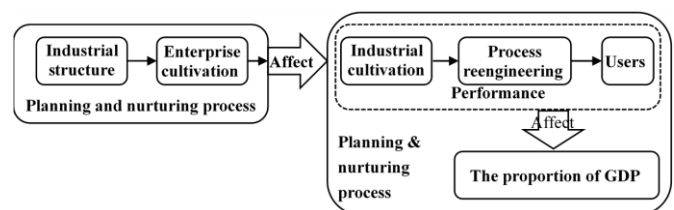

Figure 4. Chain impact relations of enterprise performance

In this way, our conceptual model of the PIS for mobile geriatric medical services (Figure 5) was established based on the integration between CS and the SCP.
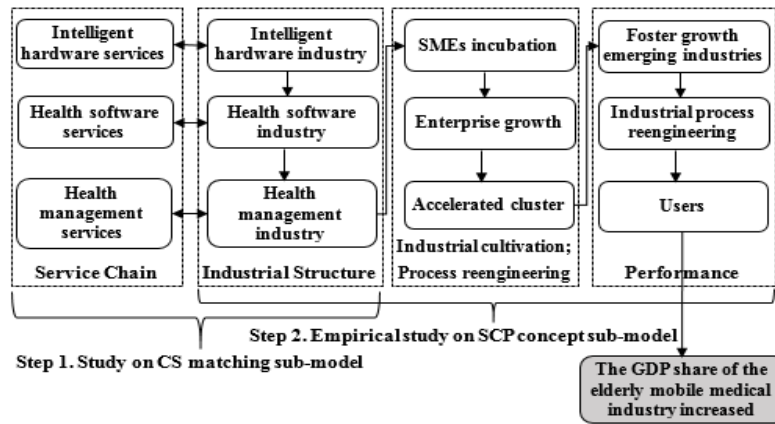
Figure 5. Conceptual model of the PIS for mobile geriatric medical services

3. HYPOTHESES AND DATA ANALYSIS

3.1 Hypotheses

Through the above analysis, it is assumed that the conceptual model of the PIS for mobile geriatric medical services has a positive chain of impacts between different dimensions. The following hypotheses were put forward concerning the chain of impacts:

Hypothesis (H1): Intelligent hardware industry has a positive impact on health software industry.

Hypothesis (H2): Health software industry has a positive impact on health services industry.

Hypothesis (H3): Health management industry has a positive impact on SMEs incubation.

Hypothesis (H4): SMEs incubation has a positive impact on enterprise growth.

Hypothesis (H5): Enterprise growth has a positive impact on accelerated cluster.

Hypothesis (H6): Accelerated cluster has a positive impact on industrial cultivation.

Hypothesis (H7): Industrial cultivation has a positive impact on process reengineering.

Hypothesis (H8): Process reengineering has a positive impact on users.

3.2 Data analysis

The authors conducted a questionnaire survey on well-known elderly health professionals in Zhejiang Province, China, and tested the model on SPSS 22.0 and Smart PLS 2.0. The hypotheses were judged one by one through the analysis on survey data.

The Cronbach's alpha was adopted to check the internal consistency of all variables. The test results are recorded in Table 1 below.

Table 1. The Cronbach's alpha of each variable

Variable	Cronbach's alpha	Number of questions
Intelligent hardware industry	0.814	5
Intelligent software industry	0.826	4
Health services industry	0.728	3
SMEs incubation	0.734	4
Enterprise growth	0.747	4
Accelerated cluster	0.804	5
Industrial cultivation	0.762	4
Process reengineering	0.761	3
Users	0.761	4

The correlations between variables were measured by Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test for sphericity. The test results are displayed in Table 2 below.

Table 2. Results of correlation tests

KMO		.853
Bartlett's spherical degree Approximate chi-square	Bartlett's spherical degree Approximate chi-square	2,874.925
	df	231
	Sig.	.000

The test results show that the KMO value of each variable in our model was 0.853, above the 0.6 threshold, and the significance of Bartlett's chi-square was below 0.05, rejecting the null hypothesis. The variables were significant the Bartlett's test for sphericity, indicating that our research samples have high overall validity. The test results fully support the eight hypotheses (as shown in Table 3 below), a signal of the good performance of the PIS for mobile geriatric medical services.

Table 3. The basic path hypothesis relation test of structural model

Hypothesis	Assumed path relation	Path coefficient	Conclusions
H1	Intelligent hardware industry—> health software industry	0.890***	Valid
H2	Health software industry—>health services industry	0.794***	Valid
H3	Health management industry—>SMEs incubation	0.801***	Valid
H4	SMEs incubation—>enterprise growth	0.819***	Valid
H5	Enterprise growth —>accelerated cluster	0.914***	Valid
H6	Accelerated cluster—>industrial cultivation	0.775***	Valid
H7	Industrial cultivation—>process reengineering	0.793***	Valid
H8	Process reengineering—>users	0.822***	Valid

Note: * represents $p<0.05$; ** represents $p<0.01$; *** represents $p<0.001$.

4. SYSTEM REALIZATION

Based on the results of data analysis, this section realizes the PIS for mobile geriatric medical services, with the aim to digitalize, informatize and standardize the mobile geriatric medical industry.

4.1 System modelling

The PIS for mobile geriatric medical services was modelled as Figure 6. The model boasts high openness and interactivity, which are conductive to the resource sharing, profit making and service quality of mobile geriatric medical industry.
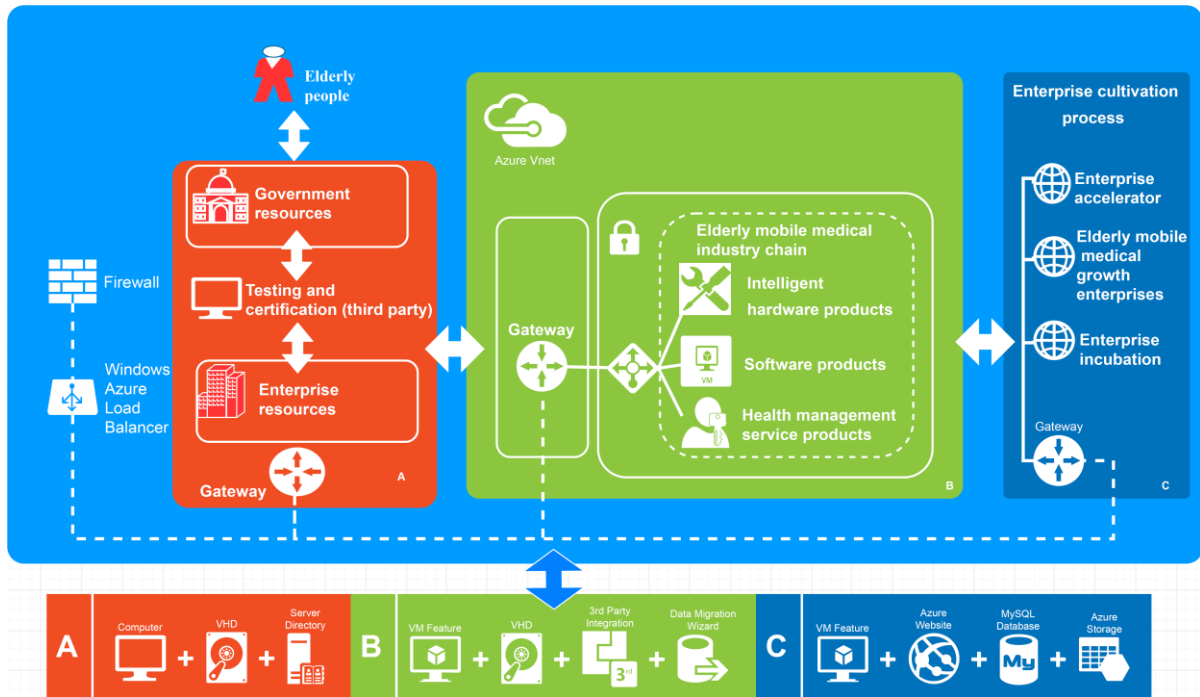

Figure 6. The model of PIS for mobile geriatric medical services

Figure 7. Structure of our PIS for mobile geriatric medical services

4.2 Algorithm design

The intelligent calculation of knowledge similarity was selected to assess the output of the PIS for mobile geriatric medical services. The supply and demand of mobile geriatric medical services were represented by the XML. Then, similarity between the supply text (Kx) and demand text (Ky) can be computed by:

$$\text{Osc}_{\text{text}}(Kx, Ky) = \cos(Kx, Ky) = \frac{\sum_i Kx_i Ky_i}{\sqrt{\sum_j Kx_j^2 \sum_i Ky_i^2}}.$$

Based on the knowledge similarity, the PIS for mobile

geriatric medical services automatically evaluates the similarity between supply and demand, and then output the services that best match the needs of the elderly.

Application is the ultimate goal of the PIS for mobile geriatric medical services. If two pieces of information are often queried by the same user, then the two pieces of information should have a small distance and a close relation. The following matrix was designed to record the use of information:

$$\begin{array}{c} \\ k_1 \\ k_2 \\ k_3 \\ k_4 \end{array} \begin{array}{cccc} U_1 & U_2 & U_3 & U_4 \\ \begin{bmatrix} sum_{use11} & sum_{use12} & sum_{use13} & sum_{use14} \\ sum_{use21} & sum_{use22} & sum_{use23} & sum_{use24} \\ sum_{use31} & sum_{use32} & sum_{use33} & sum_{use34} \\ sum_{use41} & sum_{use42} & sum_{use43} & sum_{use44} \end{bmatrix} \end{array},$$

where, $sum_{use\ ij}$ is an int, representing the frequency of information K_i queried by user U_i. From the perspective of information use, the closeness between demand and supply information can be calculated by:

$$OSC_{use}(K_i, K_j) = \frac{\sum_{t=1}^{n} |sum_{use\ it} - sum_{use\ jt}|}{n_M},$$

where, n_M is the of number of information contributors.

4.3 System structure

Figure 7 above shows the structure of our PIS for mobile geriatric medical services. The main users of this system include enterprises of intelligent hardware, health software and health management in mobile medical industry and the government. The system facilitates the information exchange between these parties. With the aid of this system, the said enterprises can respond quickly to government policies on the industry, and complement each other's advantages, leading to an improved industrial structure. Moreover, the system promotes the incubation and cultivation of emerging enterprises, and provides an opportunity for the process reengineering of mobile medical industry. All these promises better performance of the entire industry.

5. CONCLUSIONS

This paper demonstrates the chain of positive impacts between different dimensions of mobile medical industry for the elderly, and then sets up a PIS for mobile geriatric medical services. The proposed system facilitates the information exchange between the enterprises involved in mobile geriatric medical industry, and solves common technical barriers in the industry, namely, the lack of a standardized PIS, the unclear service orientations, and the unknown attribute of the mobile Internet. In addition, the system helps to optimize the industrial structure, incubate start-ups, and improve the overall competitiveness of the industry. The research findings provide reference for the optimization and upgrading of mobile geriatric medical industry in other places and of other industries.

ACKNOWLEDGEMENT

REFRENCES

[1] You, L.J. (2016). The practice of the health service system for the aged at home based on information technology. China Medical Devices, 31(3): 161-162, 151. https://doi.org/10.3969/j.issn.1674-1633.2016.03.047

[2] Li, K., Yang, H., Zhang, Y.L., Yang, Z.H., Zhu, Y., Xin, Y., Meng, Q. (2015). Improving public health multidimensional services through the use of smart cloud model. International Journal of Smart Home, 9(8): 205-218. http://dx.doi.org/10.14257/ijsh.2015.9.8.22

[3] Barteit, S., Neuhann, F., Barnighausen, T., Bowa, A., Wolter, S., Siabwanta, H., Jahn, A. (2019). Technology acceptance and information system success of a mobile electronic platform for nonphysician clinical students in Zambia: Prospective, nonrandomized intervention study. Journal of Medical Internet Research, 21(10): e14748 http://dx.doi.org/10.2196/14748

[4] Barken, T.L., Thygesen, E., Soderhamn, U. (2017). Advancing beyond the system: telemedicine nurses' clinical reasoning using a computerised decision support system for patients with COPD - an ethnographic study. BMC Medical Informatics and Decision Making, 17: 181-191. http://dx.doi.org/10.1186/s12911-017-0573-7

[5] Cruz, F., Vilela, R.A., Ferreira, E.B., Melo, N.S., Dos Reism P.E.D. (2019). Evidence on the use of mobile apps during the treatment of breast cancer: Systematic review. JMIR Mhealth and Uhealth, 7(8): e13245. http://dx.doi.org/10.2196/13245

[6] Ertugrul, D.C., Ulusoy, A.H. (2019). Development of a knowledge-based medical expert system to infer supportive treatment suggestions for pediatric patients. ETRI Journal, 41(4): 515-527. http://dx.doi.org/10.4218/etrij.2018-0428

[7] Ji, W., Kwon, H., Lee, S., Kim, S., Hong, J.S., Park, Y.R., Kim, H.R., Lee, J.C., Jung, E.J., Kim, D., Choi, C.M. (2019). Mobile health management platform-based pulmonary rehabilitation for patients with non-small cell lung cancer: prospective clinical trial. JMIR Mhealth and Uhealth, 7(6): e12645. http://dx.doi.org/10.2196/12645

[8] Awad, A., Mohamed, A., Chiasserini, C.F. (2017). Distributed in-network processing and resource optimization over mobile-health systems. Journal of Network and Computer Applications, 82: 65-76. http://dx.doi.org/10.1016/j.jnca.2017.01.014

[9] Bervell, B., Al-Samarraie, H. (2019). A comparative review of mobile health and electronic health utilization in sub-Saharan African countries. Social Science & Medicine, 232: 1-16. http://dx.doi.org/10.1016/j.socscimed.2019.04.024

[10] Robinson, S.C. (2019). No exchange, same pain, no gain: Risk-reward of wearable healthcare disclosure of health personally identifiable information for enhanced pain treatment. Health Informatics Journal, 25(4): 1675-1691. http://dx.doi.org/10.1177/1460458218796634

[11] Kumar, A.A., De Costa, A., Das, A., Srinivasa, G.A., D'Souza, G., Rodrigues, R. (2019). Mobile health for

tuberculosis management in south India: Is video-based directly observed treatment an acceptable alternative? JMIR MHealth and UHealth, 7(4): e11687. https://doi.org/10.2196/11687

[12] Kumar, P.M., Lokesh, S., Varatharajan, R., Gokulnath, C., Parthasarathy, P. (2018). Cloud and IOT based disease prediction and diagnosis system for healthcare using fuzzy neural classifier. Future Generation Computer Systems, 86: 527-534 http://dx.doi.org/10.1016/j.future.2018.04.036

[13] Alpay, L., Doms, R., Bijwaard, H. (2019). Embedding persuasive design for self-health management systems in Dutch healthcare informatics education: Application of a theory-based method. Health Informatics Journal, 25(4): 1631-1646.
http://dx.doi.org/10.1177/1460458218796642

[14] Walker, R.L. (2005). Hierarchical task topology for retrieving information from within a simulated information ecosystem. Journal of Network & Computer Applications, 28(2): 77-96. http://dx.doi.org/10.1016/j.jnca.2004.01.007

[15] Elhissi, Y., Haqiq, A. (2016). Information system at the Moroccan University: A business intelligence tool for management and communication of scientific research. 2016 International Conference on Information Technology for Organizations Development (IT4OD). http://dx.doi.org/10.1109/IT4OD.2016.7479286

[16] Shim, S., Lee, B. (2006). Evolution of portals and stability of information ecology on the web. Social Service Review, 1(2): 584-588. https://doi.org/10.1145/1151454.1151465

[17] Javalgi, R.F.G., Todd, P.R., Scherer, R.F. (2005). The dynamics of global ecommerce: An organizational ecology perspective. International Marketing Review, 22(4): 420-435.

[18] Galvin, H.K., Petersen, C., Subbian, V., Solomonides, A. (2019). Patients as agents in behavioral health research

and service provision: Recommendations to support the learning health system. Applied Clinical Informatics, 10(5): 841-848. https://doi.org/10.1055/s-0039-1700536

[19] Heiden, S., Buus, A.A., Jensen, M.H., Hejlesen, O.K. (2013). A diet management information and communication system to help chronic kidney patients cope with diet restrictions. Studies in health technology and informatics, 192(1): 543-547. https://doi.org/10.3233/978-1-61499-289-9-543

[20] Nordfalk, J.M., Gulbrandsen, P., Gerwing, J., Nylenna, M., Menichetti, J. (2019). Development of a measurement system for complex oral information transfer in medical consultations. BMC Medical Research Methodology, 19(1): 139-147. https://doi.org/10.1186/s12874-019-0788-7

[21] Borja, M.P., Isabel, T.D., Miguel, L.C. (2013). Mobile health applications for the most prevalent conditions by the world health organization: Review and analysis. Journal of Medical Internet Research, 15(6): e120. https://doi.org/10.2196/jmir.2600

[22] Zapata, B.C., Fernández-Alemán, J.L., Idri, A. (2015). Empirical studies on usability of mhealth Apps: A systematic literature review. Journal of Medical Systems, 39(2): 1-19. https://doi.org/10.1007/s10916-014-0182-2

[23] Hu, W.B., Zhang, Y.L., Niu, F. (2009). The relationship among entrepreneurial orientation, dynamic capabilities and firm growth of new ventures in China. Chinese Soft Science, (4): 107-118. https://doi.org/10.3969/j.issn.1002-9753.2009.04.014

[24] Dekrita, Y.A., Yunus, R., Citta, A.B., Yamin, M. (2019). Integration of balanced scorecard and analytical hierarchy process as a tool for determining the priority of the program strategy: Case study in Dr.Tc.hillers maumere hospital. Advances in Economics, Business and Management Research (AEBMR), 92: 71-84. https://doi.org/10.2991/icame-18.2019.8