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Investigation of RIS/PACS Information Systems' Incorporation in Greek Public Hospitals

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Abstract

Purpose: The objective of this study is to assess the current level of Radiological Information Systems (RIS) and Picture Archiving and Communication Systems (PACS) incorporation in Greek public hospitals through a national web-based survey. Since there are no previous studies on this field of medical imaging management in Greece, we look forward to export useful conclusions about RIS/PACS incorporation and set the foundation for further investigation.

Methods: A comprehensive measurement instrument that integrates the existing theoretical and empirical literature knowledge on Information Systems (IS) evaluation was properly modified and used for the purpose of this study. A web-based survey was conducted via Google Form questionnaire, which was distributed to the entire population of radiologists and radiologic technologists (potential users) of all Greek public hospitals (urban and rural), in order to identify the availability of RIS/PACS Information Systems, the level of incorporation through system's impact on users satisfaction and their operating capacities (i.e. computerized activities and processes).

Results: A total of 49 valid responses out of 77 collected questionnaires were received from all 124 Greek public hospitals. Our very first findings indicate that the establishment of RIS/PACS has not been fulfilled so far for the vast majority of Greek public hospitals. Almost half of the participants (51%) responded that they use only the capabilities of PACS as a repository for medical images, instead of implementing all capabilities of RIS. Also, although 85.7% of the participants responded that they use disc publisher for medical imaging exams copies, only 6.1% responded that has gone totally filmless or paperless. 59.2% of the respondents have access to 5 or more workstations and 100% of the respondents agree that ER and clinics should connect on hospital's RIS/PACS for viewing medical images, receiving electronic reports, and updating patients' electronic files. Overall findings from statistical techniques demonstrate a statistically significant difference in perceived information (p-value=0.021) and service quality (p-value=0.036) with the age of respondents. Finally, open feedback answers indicate that Greek public hospitals have still many to set to successfully

incorporate and exploit the wide range of RIS/PACS capabilities to improve quality, effectiveness, and efficiency of patient care services.

Conclusion: Although, most of the respondents have an adequate level in the operation of information systems, lack of RIS/PACS usage training is noted, as well as users' support from their own organization IT staff. Also, structural deficiencies worry the system's users, making them intolerant of adopting the system in daily practice. The recommendations of this study include RIS/PACS incorporation in every medical imaging department of Greek hospitals, user training and support, as well as updating infrastructures where needed.

Introduction

Information Systems (IS) are one of the most significant categories of information and communication technology that have been developed over the last decade. Even in business sectors such as banks and insurance companies, administrators must constantly invest in new IT infrastructure, in order to keep up with the growing demand, competition and new demands of services offered.

Healthcare services as the cornerstone of the health system, could not stay on the sidelines of this development. The ever-increasing demand for health services, with the consequent increase in the volume of medical data produced on the one hand, and the development of medical devices, which make new methods and techniques for daily practice available to health professionals on the other hand, require the administration of medical information in such a way that it is readily available and easily accessible by healthcare professionals where necessary.

Also, the need for medical confidentiality, demographic and sensitive personal data protection and the compliance of all organizations, which handle personal data, with the new European General Data Protection Regulation (GDPR), dictate training of health professionals involved in medical information management procedures, so that all this information can be readily available and easily accessible, but at the same time the fundamental right of individuals for keeping their personal data safe and their freedom is being protected.

Radiology, as a medical specialty, is on the one hand a link among other medical specialties when it comes to assessing the severity of the disease or staging a patient's illness, on the other hand it is a specialty, which uses constantly evolving medical imaging technologies, which in turn produce huge amounts of digital data, such as x-rays, mammograms, computed (CAT scans) or magnetic resonance (MRI scans) tomography, digital angiography, ultrasound (U/S) studies of organs and vessels of the body and nuclear medicine images.

From the beginning of radiology to the present day, the imaging result of radiographic examinations has been imprinted on a radiographic film. Radiographic film is the most reliable material of imprinting medical information, however it's costly, time-consuming

because of storage conditions and may be lost. Also, for some tests, such as CTs and MRIs, the amount of films printed and their dimensions make carriage difficult due to volume and weight. In addition, up to a decade ago, before the first digitization and storage systems for radiographic imaging appeared, printing of medical images using a manual chemical imager on the one hand and the computers of most sophisticated imaging methods, such as tomographs on the other hand, allowed the storage of radiographic images for a few days or not at all, depending on the method, as a result imaging tests were not available after this time.

The RIS/PACS which enters the Greek digital medical imaging and administration market at 2010, begins to be installed in public and private sector healthcare providers, originally intended to manage and archive patients' personal data, store and archive the radiographic images, in order to make them available to physicians, radiologists and radiologic technologists in the future, and also to evaluate the impact of health service organizations in the health system and in the insurance organizations.

This survey aims to investigate the implementation of RIS/PACS in Greek public hospitals, the impact of the IS integration in daily practice, the level of medical imaging staff interaction with IS and the staff satisfaction from its usage, focusing on the psychosocial aspect of IS, rather than its technical aspect. Also, this study seeks to find the correlation between the user's characteristics, behavior and background towards the RIS/PACS. In detail, the individual objectives of the research are the following:

- The identification of the characteristics (cognitive and empirical background) of the users, which are related to their satisfaction from the RIS/PACS.
- Assessment of perceived user satisfaction from RIS/PACS technical aspects (system quality).
- Assessment of perceived user satisfaction from RIS/PACS output (information quality).
- Assessment of perceived user satisfaction from RIS/PACS technical support (service quality).
- Assessment of perceived overall user satisfaction from RIS/PACS usage and its parameters.
- RIS/PACS interconnectivity and possible future upgrade.

Methods

Selection and Description of Participants

The psychometric orientation of the survey required basic usage knowledge of RIS/PACS. For the purpose of this survey, the questionnaire was distributed among radiologists and radiologic technologists in all 124 Greek public hospitals nationwide, which constitute the Greek National Health System. Those are the healthcare professionals that are supposed to use the RIS/PACS and consist of the target population. An email invitation to participate in the survey was sent to potential participants, along with a link to the web-based questionnaire in google form. The list of the radiologists and radiologic technologists

recipients nationwide was created from researcher's personal and LinkedIn contacts. The data from the respondents was collected over a period of three months (October 2019 to January 2020). In order to increase the response rate, two reminders via email and LinkedIn were sent two weeks after the beginning of the survey and one month before the end of it.

Technical information

The development of the survey instrument (questionnaire) is based on DeLone & McLean (2003) revised IS success model [1], Mahmood et al. (2000) research model of factors affecting IT EUS (end-user satisfaction), Chin and Le (2000), Doll and Torkzadeh (1988) end-user computing satisfaction (EUCS) models, Ives et al. (1983), Bailey and Pearson (1983) computer user satisfaction models [2][3]. The questionnaire is obtained after permission from the dissertation of Mrs. Doumpa Triantafyllia, entitled "Hospital Information System Evaluation" [2].
The questionnaire was translated into Greek, according to the ethics of the translation methodology of a questionnaire [4]. The translated questionnaire had small verbal rewordings compared to the original, in order to be used for the research needs of the RIS/PACS. After translation, the questionnaire was given to five colleagues for face validation [5][6]. Simulation test of the questionnaire indicated that statements were easily understood and sections, which investigated each dimension, were clearly distinct. Also, there was no need to reweight the data of the Greek population, since the original questionnaire is addressed to the Greek population, while the question groups and scales were kept the same as in the original.

The final survey instrument that was used to evaluate the incorporation of RIS/PACS IS in Greek public hospitals consisted of the following 3 domains:

1. Demographic data,
2. RIS/PACS evaluation statements (theoretical model)
3. RIS/PACS interconnectivity capabilities questions (multiple choice, open feedback)

The second domain (theoretical model) had 5 sets of statements, that investigated the following dimensions of RIS/PACS:

1. Statements (10 variables) investigating the dimension of user background, that involve the concepts of user experience, user training and user skills on operating IS.
2. Statements (16 variables) investigating the dimension of RIS/PACS quality, that involve the concepts of ease of use, system speed, screen interface and error recovery.
3. Statements (22 variables) investigating the dimension of information quality, that involve the concepts of content, accuracy, format, timeliness and data security.
4. Statements (6 variables) investigating the dimension of service quality, that involve the concepts of internal and external support for the IS.
5. Statements (3) investigating the user overall satisfaction, that result from the previous four dimensions and rate the satisfaction with the usage and parameters of the system.

All statements were measured on a 1-5 Likert agreement scale, where -1- represented "Strongly Disagreement" and -5- "Strongly Agreement".

Ethics

In compliance with General Data Protection Regulation (GDPR)[7] participants were informed that participation in the survey is voluntary and the provided information will stay anonymous and confidential. Participants read all terms of confidentiality and consent statements and chose to agree or disagree with their participation in this survey. In case a participant does not consent, the survey is stopped.

Statistics

Statistical analysis of the collected data was performed, using IBM SPSS Statistics v24.0 package. The individual variables (54 statements) of the questionnaire were converted into 14 concepts, which in turn were grouped into the 4 dimensions of RIS/PACS evaluation[5]. The internal consistency of each dimension assessed, was validated using Cronbach's Alpha[5]. Shapiro-Wilk normality test to theoretical model dimensions was performed, to decide whether to continue in analysis with parametric or nonparametric techniques. Analysis of Variance (ANOVA) or Kruskal-Wallis technique was used to test the variance between users demographic characteristics and theoretical model dimensions, where applicable. Independent Samples T-test or Mann-Whitney U techniques between theoretical model dimensions and gender and profession variables was performed, where applicable. Finally, Spearman Correlation between theoretical model dimensions was also performed.[6][8][9]

Results

User Profile and Response Rate

We received 49 valid questionnaires out of 77 collected. The rest 28 questionnaires provided no-existence of RIS/PACS, so we did not include them in the study. Also, the reason for low correspondence to our survey is that the majority of Greek public hospitals don't have RIS/PACS installed yet in their radiology departments, so we assume that many recipients intentionally did not provide at least RIS/PACS no-existence feedback. Table 1 provides the respondents demographic characteristics by gender, age group, job title, educational level, experience, system usage and health region.

The following conclusions are drawn from the demographic data of the respondents. Most of the respondents were males (65%). Also, most of them belong at the age group of 25-44 years old (57%). The highest educational level was bachelor for the majority of the respondents (71%) . Most respondents were radiologic technologists (79%) and the majority of all respondents' experience is 11-20 years (53%) in radiology departments. Regarding the use of the IS, half of the respondents (49%) answered they use all features of it, in contrast with the rest (51%), who use only the archiving and communications features of the IS.

Finally, most of the responses came from the 1st Health Region (32%), as it refers to Athens, which is the capital of Greece and has many hospitals close to each other.

Table 1. Demographic characteristics of respondents

		Freq. (N=49)	Percent
Gender	Female	17	34.7%
	Male	32	65.3%
Age group (yrs)	<25	1	2.1%
	25-44	28	57.1%
	45-60	18	36.7%
	>60	2	4.1%
Educational level	BSc degree	35	71.4%
	MSc degree	11	22.4%
	PhD degree	3	6.2%
Job title	Radiologist	10	20.4%
	Radiologic technologist	39	79.6%
Experience	<3	2	4.1%
	3-10	8	16.3%
	11-20	26	53.1%
	>20	13	26.5%
RIS/PACS usage	PACS only	25	51.0%
	RIS+PACS	24	49.0%
Health authority (region)	1st- Attica	16	32.7%
	2nd -Piraeus & Aegean Isl.	8	16.3%
	3rd -Macedonia	9	18.4%
	4th -Macedonia & Thace	4	8.2%
	5th -Thessaly & Central Greece	0	0%
	6th - Peloponnese, Epirus, Ionian Isl. & Western Greece	9	18.4%
	7th - Crete	3	6%

Variables Descriptive Statistics

The internal consistency coefficients (Cronbach's alpha) of the measuring dimensions proved satisfactory (Appendix I) . The Cronbach's alpha coefficients vary between 0.852 and 0.942, which is considered beyond acceptable, with a minimum threshold of 0.700 according to literature[5]. "Training" and "timeliness" fell below this threshold, with a coefficient of 0.623 and 0.539 respectively. We nevertheless maintained these factors, since the Cronbach's alpha coefficients of the corresponding dimensions range above the minimum threshold.

Table 2 captures the descriptive statistics of the individual concepts, as well as for the dimensions. From the column with means the following main conclusions can be drawn. The mean of concept "training" demonstrates a moderate level of users training (mean=3.556), affected by low degree in RIS/PACS training, despite the adequate level of users cognitive and empirical background (mean=3.954). The mean of concept "error recovery" demonstrates low level of user satisfaction from RIS/PACS error recovery capabilities (mean=2.925). Finally, the means of internal (mean=3.006) and external support (mean=3.210) for RIS/PACS both demonstrate somewhat moderate user satisfaction of perceived service quality.

Table 2. Descriptive statistics of concepts and dimensions used to evaluate RIS/PACS

Variables		# Statements	Mean	SD
User Background	Experience	3	4.170	0.819
	Training	4	3.556	0.733
	Skills	3	4.136	0.748
	Dimension score	**10**	**3.954**	**0.676**
System Quality	Easy of Use	5	3.987	0.061
	System Speed	4	3.404	0.954
	Screen Interface	4	3.280	1.065
	Error Recovery	3	2.925	1.052
	Dimension score	**16**	**3.400**	**0.724**
Information Quality	Content	5	3.498	0.920
	Accuracy	4	3.755	0.948
	Format	5	3.779	0.934
	Timeliness	5	3.318	0.710
	Data Security	3	3.503	1.025
	Dimension score	**22**	**3.570**	**0.733**
Service Quality	Internal Support	3	3.006	0.973
	External Support	3	3.210	1.064
	Dimension score	**6**	**3.108**	**0.866**
Overall satisfaction		**3**	**3.670**	**0.651**

Survey Dimensions Level of Impact

Shapiro-Wilk normality test indicated normal distribution for system, information and service quality dimensions and non-normal distribution for user background and overall satisfaction. The Analysis of Variance (ANOVA) parametric technique was used to test the level of impact of the user characteristics on system, information and service quality and Kruskal-Wallis nonparametric technique to test the level of impact of the user characteristics to user background and overall satisfaction. The results of these tests, as well as results (p-values) from T-test and Mann-Whitney U test for the level of impact of gender and profession to RIS/PACS dimensions, where applicable, can be found in Appendix II.

Also, Appendix II indicates the significant correlation between the age group of users and the dimensions of perceived service quality (p-value=0.036<0.05) and perceived information quality (p-value=0.021<0.05) for RIS/PACS. We conclude that perceived qualities for information output and support of the system show differentiation with age.

Correlation Between RIS/PACS Dimensions

Spearman Correlation analysis demonstrates the following relationships between survey's dimensions (Appendix III). The correlation coefficient is being pointed as "r" and level of significance (p-value) as "p", where level of significance was set at 0.05.

User background showed moderate positive and statistically significant correlation with perceived system quality (r=0.492<0.5, p=0.000<0.05) and perceived information quality (r=0.414<0.5, p=0.003<0.05). Also, user background showed somewhat moderate positive and statistically significant correlation with perceived service quality (r=0.383<0.5, p=0.007<0.05) and perceived overall satisfaction (p=0.383<0.5, p=0.007<0.05). System quality showed very strong positive and statistically significant correlation with perceived

information quality (r=0.790>0.5, p=0.000<0.05), perceived service quality (r=0.650>0.5, p=0.000<0.05) and perceived overall satisfaction (r=0.757>0.5, p=0.000<0.05). Information quality also showed strong positive and statistically significant correlation with perceived service quality (r=0.569>0.5, p=0.000<0.05) and perceived overall satisfaction (r=0.608>0.5, p=0.000<0.05). Finally, service quality also showed strong positive and statistically significant correlation with perceived overall satisfaction (r=0.503>0.5, p=0.000<0.05).

All five dimensions have positive correlation with each other, which reflects that overall satisfaction is proportional to user background and qualities of system, information and service.

RIS/PACS Interconnectivity and Possible Future Upgrades

Table 3 shows interconnectivity results of installed RIS/PACS. Also, there was a question whether users agree with the prospect of a hospital Local Area Network (LAN), which will connect RIS/PACS with clinics and the Emergency Room (ER), for direct electronic patient record (EPR) updating from the radiology department and access of physicians to medical images and reports. Finally, there was an open feedback question, where users were being asked to point out issues, problems or weaknesses in the operation of RIS/PACS for further improvement or upgrade. Users denoted the need for speed improvement in images and exams retrieval and availability, indicated equipment (powerful workstations with medical monitors), RIS/PACS administrator, network upgrading, 24-hour online support, the need to simplify procedures for error correction, search/sort patient entries with criteria and incorporating changes in entries (interface), department's statistical analysis, mandatory original incorporation of RIS with PACS and increasement of PACS capacity.

Table 3. RIS/PACS Additional Features

		Freq. (N=49)	Percentage
Number of Workstations for RIS/PACS access	1-2	6	12.2%
	3-4	14	28.6%
	5+	29	59.2 %
Copy of medical images given	CD/DVD (DICOM) only (filmless)	3	6.1%
	Radiographic film only	19	38.8%
	CD/DVD (DICOM) or/and radiographic film	22	44.9%
	CD/DVD (DICOM) and paper printout	5	10.2%
Use of disc publisher for medical images distribution	yes	42	85.7%
	no	7	14.3%
Interconnection of RIS/PACS with clinics and ER	agree	49	100%
	disagree	0	0%

Discussion

The main purpose of this study was to explore the level of impact of RIS/PACS on its users in Greek hospitals, based on their interaction with the system. This study is important, as it occurs for the first time in Greek public healthcare sector and highlights the lack of

interaction between potential users and computer systems. As information systems become crucial for the healthcare sector, it becomes necessary to learn how the users perceive these systems and how these affect their work routine.

The level of impact was measured in four different dimensions, covering the user's overall satisfaction on RIS/PACS. User background, system quality, information quality and service quality were measured, as preconditions of perceived users overall satisfaction. The statistical analysis showed that the implementation of this new technology has not been fronted with reserve, although our very first finding is the inexistence of RIS/PACS from several hospital workplaces, which arises from the fact that 28 of 77 respondents declared that. All specialties of all age groups already have cognitive and empirical background from interaction with software packages and other information systems. Users claim that they are somewhat satisfied with their work with RIS/PACS, as they have the right tools at their disposal, which directly expedite them and when they attempt to configure their preferences, image processing and access to older examination files, in order to perform comparative tests.

The study of correlation showed positive correlations among RIS/PACS variables. Particularly, the strongest correlation of user's overall satisfaction with RIS/PACS variables is with system's quality, following information quality and service quality and user background. This fact shows that the user's overall satisfaction is proportionate to all four RIS/PACS dimensions. However, the results of this research show that the implementation of RIS/PACS system into medical imaging departments happened or is happening without certain conditions being met. These conditions are training and support of the staff in the use of the system, the interconnection of the system with the Hospital Information System (HIS) and the upgrading of the network infrastructures used for the interconnection of the system and the transfer of the data. The absence of all 3 of these conditions is the cause of 3 key problems, which are (i) inadequate training in configuration and use of system tools, (ii) difficulty in finding patients or examinations when there is not correct and central data entry, using a unique patient registration number (multiple registries), due to non-use of RIS and (iii) outdated network infrastructures, which may not support large amount of transferring data and result to delay in data recovery.

The international literature review has to show many examples of research around RIS/PACS, either with psychosocial or technical orientation. Aldosari, Saddik and Al Kadi (2018)[10] conducted a survey for the impact of PACS system on radiology staff in a hospital facility of Saudi Arabia. Psychosocial variables such as external communication, service outcome, personal intentions, personal hassles, and increased blame were used in this study to conduct the examination of PACS impact on its users and the study showed that PACS users gave a positive perception toward the PACS and its impact on them and their work routine was also positive. Alalawi, Eid and Albarrak (2016)[11] conducted another survey for the assessment of PACS systems at three hospitals, also in Saudi Arabia, investigating the perceived benefits of PACS among physicians and radiologists, secondly,

the perceived challenges of PACS implementation and adoption inside and outside the radiology department, and thirdly, comparing between physicians' and radiologists' perceptions toward PACS. The results of this study concluded that PACS was well perceived among physicians and radiologists but also indicated the main disadvantages of PACS, which were difficulty in finding images, recurrent downtime and insufficient staff training.

Other surveys from RezaeiHachesu, Pesianian and Mohammadian (2016)[12], Pare, Aubry, Lepanto and Sicotte (2005)[13], Mešanović et al. (2010)[14] and Buccoliero, Calciolari, Marsilio and Mattavelli (2008)[15] have been conducted during the last 15 years, aiming to evaluate the degree of incorporation of RIS, PACS or both as one system in radiology departments and hospital facilities, to demonstrate the challenges of this incorporation, highlighting the clinical and financial or administration benefits (net benefits) at the same time. As perceived clinical benefits, improved efficiency in doctor's patient evaluation and patient's follow-up process, improved ability in decision making regarding patient care, easy consultation among different medical departments are mentioned. As perceived administration benefits, the availability of telemedicine (remote access), reduction in patient's length of hospitalization, elimination of errors and lost studies, decrease in radiation dose, reduction in used and wasted films (filmless examinations), reduction in required examination time for radiologic technologist and data entry time and finally increased productivity, due to easy accessibility and availability of medical images and reports in multi locations are mentioned. As challenges from RIS/PACS incorporation, insufficient staff training, difficulties with interface in retrieving images or correcting errors in patient registry and difficulties due to duplicate patient registries and multiple patient IDs are mentioned.

There was no previous list of radiologists and radiologic technologists working in public hospitals nationwide, so this was created from researcher's personal and LinkedIn contacts. This approach constitutes limitation for the study, containing the bias of selection, but it should be noted that we received responses from professionals (radiologists and radiologic technologists) working in hospitals in all health regions, nationwide.

Conclusion

This paper, which is based on the IS revised success model by DeLone and McLean (2003), proposed a multidimensional model for evaluating RIS/PACS incorporations success. The results in this research conclude that benefits of RIS/PACS system are partially satisfactory perceived among users.

The main disadvantages or deficiencies are insufficient users training and support, use of the system only as images repository (no-use of RIS) and complex interface, that results in difficulty in error correction. Also, the degree of coverage of Greek hospitals is still small, a fact that demonstrates that there is much to be done toward the direction of RIS/PACS incorporation in hospitals' daily routine. Specifically, digital transformation of radiologic

departments and Greek hospitals must move forward, by installing RIS/PACS, upgrading hospitals' local network infrastructures and interconnecting RIS/PACS systems with each hospital's HIS (Hospital Information System) and consequently in a single national network. Each radiologic department must have a highly qualified RIS/PACS administrator, who will also be in charge of data administration, as Data Protection Officer (DPO).

By extension of digital transformation, financial resources for radiographic film supply and conventional display equipment maintenance can be channeled to upgrade x-ray departments with fully digital equipment. In that case, the route of x-ray image digitization and distribution does not use conventional and expendable means of display, a fact that will also lead to depreciation of the new digital equipment cost quickly, but will bring further financial resources saving.

However, it is necessary all this digital transformation to be accompanied by staff training to be efficient and effective.

So, taking into account all above as mentioned, it is concluded that Greek users have to face challenges, which are not unprecedented, however they have to do with digital transformation of radiologic departments and healthcare organizations, as well.

This research signifies a first step toward a comprehensive understanding of RIS/PACS system success in the field of Greek public hospitals setting. Continued research will be needed periodically, involving physicians' factor and investigating "net benefits" for staff, patients and financial management.

Conflict of Interest

The authors declare that they have no competing interests.

References

[1] Ojo, A. (2017). Validation of the DeLone and McLean Information Systems Success Model. Healthcare Informatics Research, 23(1), 60. https://doi.org/10.4258/hir.2017.23.1.60

[2] Doumpa, T. (2009). Hospital Information System Evaluation (MSc). University of Greenwich.

[3] Chatzoglou, P., Fragidis, L., Doumpa, T. and Aggelidis, V., 2012. Hospital Information System Evaluation. In: 10th International Conference on Information Communication Technologies in Health.

[4] Galanis, P. (2012). Using the appropriate questionnaire in epidemiological studies [Ebook] (pp. 744-755). Athens Medical Society. Retrieved 17 September 2020, from http://www.mednet.gr/archives/2012-6/pdf/744.pdf (in Greek)

[5] Galanis, P. (2012). Validity and reliability of questionnaires in epidemiological studies [Ebook] (pp. 97-110). Athens Medical Society. Retrieved 17 September 2020, from http://www.mednet.gr/archives/2013-1/pdf/97.pdf (in Greek)

[6] Apostolakis, I., & Stamouli, M. (2007). Computational Statistic Exercises in Health A'. Papazisi. (In Greek)

[7] Personal Data | General Data Protection Regulation (GDPR). General Data Protection Regulation (GDPR). (2020). Retrieved 17 September 2020, from https://gdpr-info.eu/issues/personal-data/

[8] Apostolakis, I., Daras, T., & Stamouli, M. (2009). Computational Statistic Exercises in Health B'. Papazisi. (in Greek)

[9] Apostolakis, I., Kastania, A., & Pierrakou, C. (2003). Statistical Health Data Processing. Papazisi. (in Greek)

[10] Aldosari, H., Saddik, B., & Al Kadi, K. (2018). Impact of picture archiving and communication system (PACS) on radiology staff. Informatics In Medicine Unlocked, 10, 1-16. https://doi.org/10.1016/j.imu.2017.11.001

[11] Alalawi, Z., Eid, M., & Albarrak, A. (2016). Assessment of picture archiving and communication system (PACS) at three of ministry of health hospitals in Riyadh region – Content analysis. Journal Of Infection And Public Health, 9(6), 713-724. https://doi.org/10.1016/j.jiph.2016.09.004

[12] RezaeiHachesu, P., Pesianian, E., & Mohammadian, M. (2016). Evaluating Usability of Radiology Information Systems in Hospitals of Tabriz University of Medical Sciences. Acta Informatica Medica, 24(1), 42. https://doi.org/10.5455/aim.2016.24.42-46

[13] Pare, G., Aubry, D., Lepanto L., and Sicotte C. Evaluating PACS Success: A Multidimensional Model, Proceedings of the 38th Annual Hawaii International Conference on System Sciences, Big Island, HI, USA, 2005, pp. 147c-147c, doi: 10.1109/HICSS.2005.249

[14] Mesanovic, N., Huseinagic, H., & Avdagic, H. (2010). Filmless Hospital: Integration and Data Workflow in Hospital. Acta Medica Saliniana, 39(1), 31-35. https://doi.org/10.5457/ams.99.10

[15] Buccoliero, L., Calciolari, S., Marsilio, M., & Mattavelli, E. (2008). Picture, Archiving and Communication System in the Italian NHS: A Primer on Diffusion and Evaluation Analysis. Journal Of Digital Imaging, 22(1), 34-47. https://doi.org/10.1007/s10278-007-9101-0

[16] Lingamallu, K., & Nayakvadi, S. (2017). Role of HIS and RIS in Improving Quality of PatientCare. Internalmedicine.imedpub.com. Retrieved 17 September 2020, from https://internalmedicine.imedpub.com/role-of-his-and-ris-in-improving-quality-of-patientcare.php?aid=22295

[17] Cox B, Dawe N. (2002). Evaluation of the impact of a PACS system on an intensive care unit | Emerald Insight. Emerald.com. Retrieved 17 September 2020, from https://www.emerald.com/insight/content/doi/10.1108/02689230210434934/full/html

[18] Pilling J. (2003). Picture archiving and communication systems: the users' view | The British Journal of Radiology | Vol 76, No 908. Birpublications.org. Retrieved 17 September 2020, from https://www.birpublications.org/doi/10.1259/bjr/67551353

Appendix

(I) *Cronbach's Alpha Coefficients of Factors and Dimensions Used to Evaluate RIS/PACS*

	Variables	# Statements	Cronbach's alpha
User Background	Experience	3	0.924
	Training	4	**0.623**
	Skills	3	0.825
	Dimension Score	**10**	**0.887**
System Quality	Easy of Use	5	0.890
	System Speed	4	0.931
	Screen Interface	4	0.892
	Error Recovery	3	0.872
	Dimension Score	**16**	**0.918**
Information Quality	Content	5	0.930
	Accuracy	4	0.961
	Format	5	0.958
	Timeliness	5	0.539
	Data Security	3	0.804
	Dimension Score	**22**	**0.942**
Service Quality	Internal Support	3	0.765
	External Support	3	0.944
	Dimension Score	**6**	**0.852**
Overall Satisfaction		**3**	**0.913**

(II) *P-values between RIS/PACS dimensions and user characteristics*

User Characteristic	User Background	System Quality	Information Quality	Service Quality	Overall Satisfaction
Gender	0.199	0.417	0.078	0.362	0.164
Age Group	0.105	0.246	**0.021**	**0.036**	0.125
Education	0.314	0.618	0.572	0.655	0.971
Profession	0.179	0.105	0.250	0.573	0.448
Experience	0.457	0.178	0.119	0.099	0.758

(III) *Correlation between RIS/PACS dimensions*

User Background	**User Background**				
System Quality	*r=0.492 p=0.000*	**System Quality**			
Information Quality	*r=0.414 p=0.003*	*r=0.790 p=0.000*	**Information Quality**		
Service Quality	*r=0.383 p=0.007*	*r=0.650 p=0.000*	*r=0.569 p=0.000*	**Service Quality**	
Overall Satisfaction	*r=0.383 p=0.007*	*r=0.757 p=0.000*	*r=0.608 p=0.000*	*r=0.503 p=0.000*	**Overall Satisfaction**