Hemşire Perspektifinden Sağlık Bilgi Sistemi Kullanıcı Beklentileri

Literatür Makalesi/Review Article

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Özet— Tüm sağlık çalışanları kaliteli bir şekilde bilgisayar desteğine ihtiyaç duyarlar, ancak hekimler ve hemşirelerin bu desteğe daha çok ihtiyaçları vardır. Hekimler teşhis koyma esnasında inanılmaz sayıda karar verirler. Doğru kararları zamanında verebilmek için hastanın geçmişten itibaren tüm kayıtlarına ihtiyaç duyarlar. Hemşireler de hasta bilgisinin doğru ve tutarlı olmasına ihtiyaç duyarlar. Kullanıcı beklentilerinin karşılanmasının kullanıcı tatmini üzerinde büyük etkisi oluğuna dair literatürde bir görüş birliği mevcuttur. Beklentileri karşılayabilmek için en başta bu beklentilerin neler olduğunu ve bunların önem derecesini bilmeliyiz. Literatürde beklentilerin önceliklendirmesi konusunda bir eksiklik mevcuttur. Bu çalışma ile Literatürde bu beklentilerin önceliğinin belirlenmesi konusunda bir dikkat çekme amaçlanmıştır. Bu çalışmada, hemşirelerin sağlık bilgi sistemlerinden beklentilerinin önemi incelenmiştir. Tanımlı 17 kullanıcı beklentisi Fuzzy Conjoint Analysis metodu ile önem derecesine göre sıralanmıştır. Hız ve erişebilirlik ilk iki sırayı alırken, raporlama olanakları ve araştırma olanakları son iki sırayı almıştır. Fuzzy Conjoint Analysis metodunun sonuçları, ağırlıklı ortalama metodunun sonuçları ile karşılaştırıldığında sıralamanın tamamen değiştiğin görülmüştür. Bu farklılığın, karmaşık, bulanık, sübjektif ve kesin olmayan veride bulanık mantık metodolojileri kullanılmadığı zaman ortaya çıkan hassasiyet kaybından kaynaklandığı değerlendirilmiştir.

Anahtar Kelimeler— değerlendirme, kullanıcı beklentisi, sıralama, bulanık mantık, fuzzy conjoint analysis

User Expectations from Healthcare Information Systems: Nurses' perspective

Abstract— Although all healthcare staff needs qualified computer support, physicians and nurses need more. The physician makes enormous number of decisions. To make true and just-in-time decisions, he needs the longitudinal past record of the patient. Nurses have to ensure that patient information is consistent and correct for nursing practice. There is consensus that meeting user expectations has great influence on user satisfaction. To meet the expectations, first of all, we have to know what are these "expectations", and then their importance. Literature lacks about the priority of the expectations from the Healthcare Information Systems. With this study, an attention is invoked on the importance of the priority of these expectations, in the literature. In this study, perceived importance of nurses' expectations from Healthcare Information Systems is examined. 17 predefined user expectations are rank ordered using Fuzzy Conjoint Analysis. Fuzzy Conjoint Analysis is used for determining consumer preferences in marketing. In this study, Fuzzy Conjoint Analysis is applied to healthcare. Speed and Availability are the top ranks in perceived importance, whereas Report Facilities and Research Facilities are the least. When compared the results of the Fuzzy Conjoint Analysis with the weighted average formula, we see that ranking is totally different. That stems from the loss of precision when fuzzy methodologies are not used in vague, uncertain, subjective, and imprecise data.

Keywords— evaluation, user expectation, ranking, fuzzy logic, fuzzy conjoint analysis

1. INTRODUCTION

Healthcare is a technology-intensive industry. In the digital era, all healthcare organizations use an information system (IS). The ISs used in healthcare organizations are called as Healthcare Information System (HCIS). HCIS helps doing routine works of a healthcare institution by the capability of processing and computing huge amounts of data, quicker and more accurate than a human being. In addition, it has research facilities and advanced analyzing

capabilities. A HCIS can be defined as the system composed of data, workflows, users, and technology; used to collect, store, process, and provide the needed information to support healthcare professionals and institutions [1]. The physician makes enormous number of decisions. To make true and just-in-time decisions, he needs the longitudinal past record of the patient. Nurses have to ensure that patient information is consistent and correct for nursing practice. The physicians and nurses need qualified computer system support to give qualified healthcare service.

1.1. Importance of User Expectations

Healthcare staff is the user of HCISs. They are named as "user groups". Office workers, laboratory staff, biologists, nurses, physicians, technicians and administrative staff constitute these user groups. All these groups contribute to the HCIS, especially by entering the right, complete and consistent data. Although nurses and physicians are the core staff of a healthcare organization and the core user groups of HCISs, nurses interact more with electronic records in HCISs than other user groups, due to the nature of their work [2].

Literature also tells us that healthcare professionals differ from other users in innovative adoption process [3]. There are studies proving that nurses' attitudes toward HCISs differs [4-7]. Nursing Informatics emerged because of this difference. Nursing Informatics is a growing and blossoming field. In 2002 Staggers and Thompson [8] gave many definitions while investigating the evolution of these definitions. Today the most used and accepted definition belongs to American Nurses Association: "A specialty that integrates nursing science, computer science, and information science to manage and communicate data, information, knowledge, and wisdom in nursing practice." [9].

Patient privacy and Security, integrating informatics with evidence-based practice, electronic documentation, standardizing nursing language (Code Systems such as North American Nursing Diagnosis Association(NANDA), International Classification of Nursing Practice(ICNP)), are some examples to the important areas of research in nursing informatics [10].

Having defined the nursing informatics and stated that the nurses are the main and crucial users of HCIS together with physicians, it is time we examined nurses' expectations from HCIS. User expectations are stated as one of the success factors as well as the failure reasons of IS in the literature [11-14]. In the implementation of a new HCIS; involving the end-users, keeping the end-users with positive and realistic expectations helps reaching high acceptance [15]. To design and deploy successful HCIS with high user acceptance, the expectations of users from HCIS must be discreetly examined; their priorities and importance to the users must be well understood. Understanding the expectations, priorities of these expectations, and their importance to the users becomes vitally important, when the high failure rates in IS projects including healthcare are considered [16-18].

However, in the literature, there is no study investigating the priorities or relative importance of the nurses' expectations from the HCISs. There are some studies, although reported to be not adequate, examining the correlation of the HCIS attributes with user satisfaction and productivity of the nurses [19]. There is a recent study that prioritizes the HCIS attributes influencing nurses' satisfaction [20] which is reported to have small sized sample and missing criterion variable [21]. In Cohen et.al' s research [19], the most important attributes of a hospital information system (HIS), for the satisfaction and productivity of nurses and their priorities for managerial aspect is tried to be determined.

1.2. Background

This study is an extension of series of studies about user expectations from HCIS. The study began with the proposal of a new evaluation framework in the user expectations context; purpose was to evaluate HCISs in measuring the extent that it meets users' expectations [22]. In that framework, 17 user expectations in four dimensions (Figure1) were examined. Evaluation variables took part in evaluation result according to the importance degree to the healthcare users. The information about the framework and the case study in two hospitals about expectation meeting ratio (ETRs) results were given in the previous work (Author).

In the next study, determinants of user expectations from HCIS, user assets that may affect HCIS user expectations, were examined [23], with multivariate analysis using forward stepwise binary logistic regression.

The next study was about perceived importance of user expectations from HCIS, to understand the priorities of users [24]. In the study, some unexpected results occurred. These unexpected results are further examined in another study [25].

In this study the part of the above studies' data (related to nurses) are used to further examine and analyse the HCIS user expectations from the nurses' perspective.

In Figure 2, the summary of the user expectation studies [22-25] is given.

1.3. Purpose of the Study

The objective of the study is therefore to analyze the HCIS user expectations from the nurse's perspective. It is objected to understand the expectations of the nurses as HCIS users, to understand their priorities to develop better systems. To accomplish this purpose, nurses' expectations from HCIS are ranked to obtain the perceived importance of expectations. To capture the perceived importance,

Fuzzy Conjoint Analysis (FCA) is used. FCA is used for determining consumer preferences in marketing, both in literature and industry. In this study, FCA is applied to healthcare.

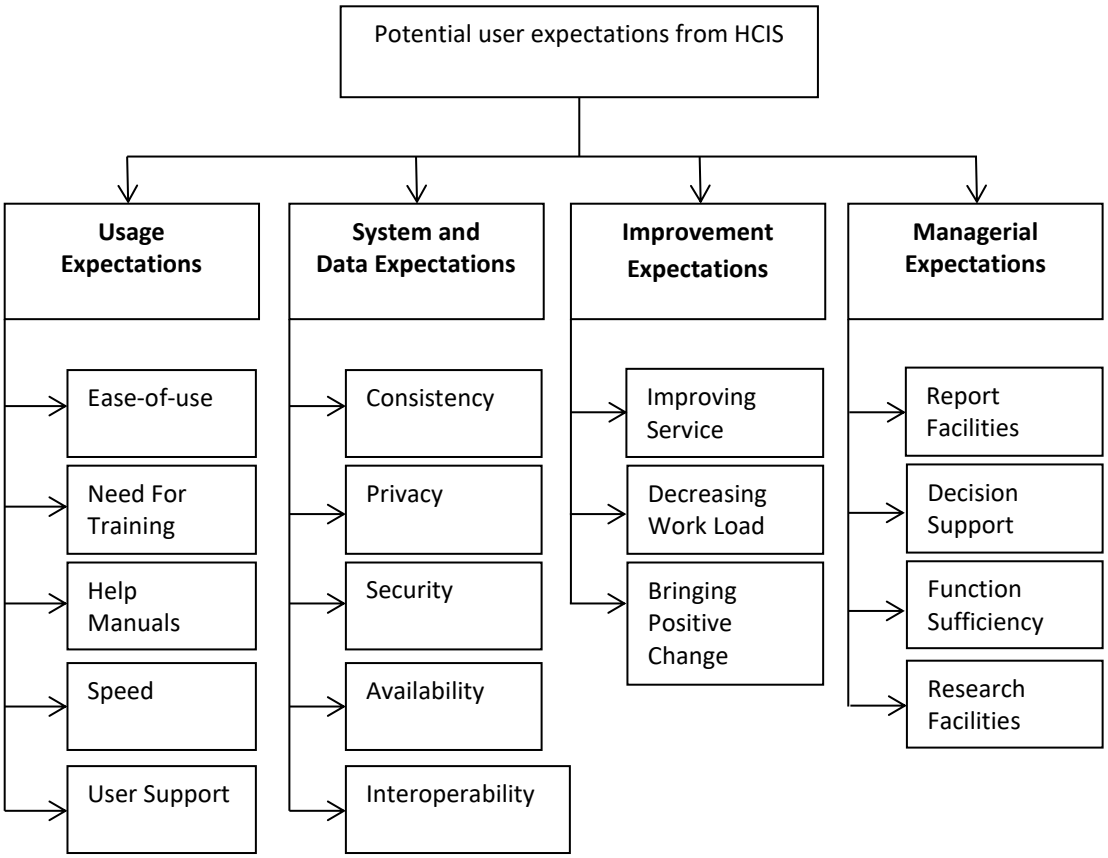


Figure 1. Potential user expectations from HIS

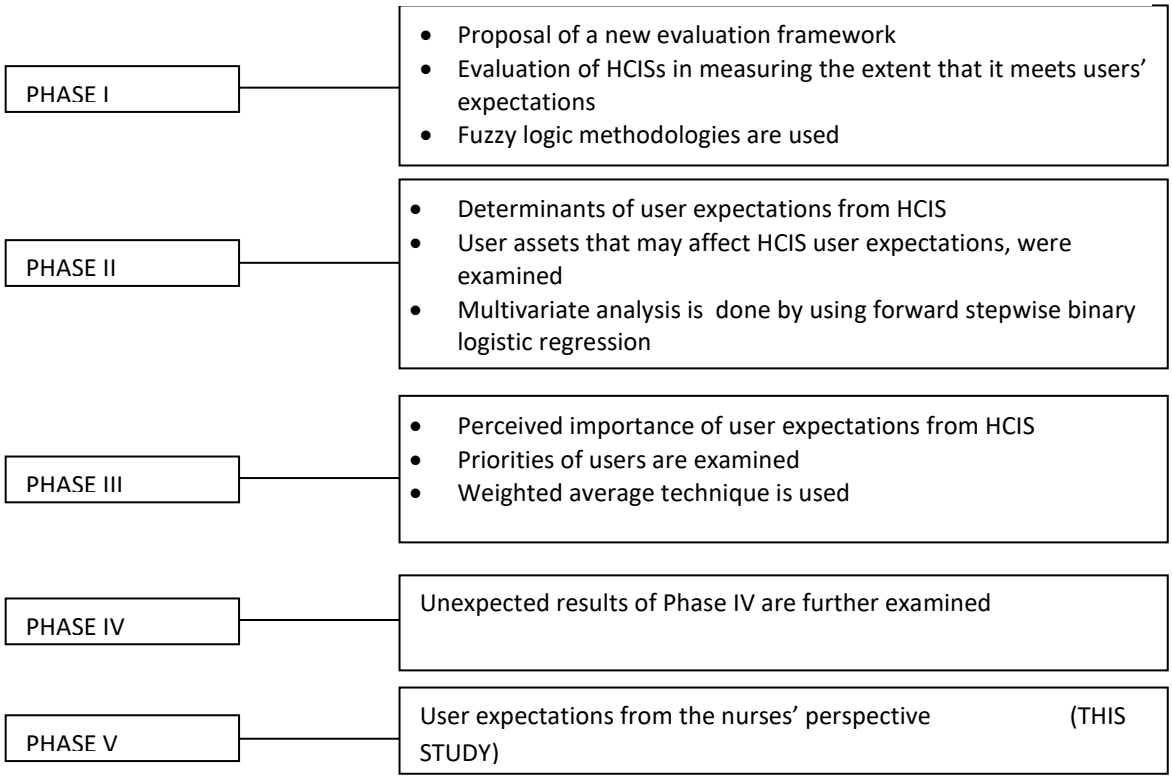
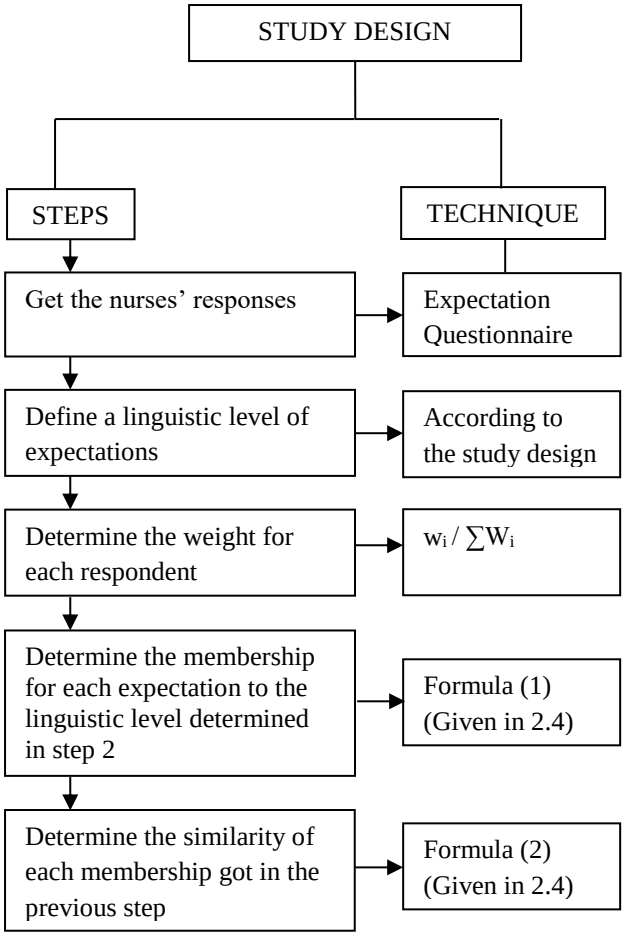


Figure 2. User expectation study series

2. METHODS

In Figure 3, the study design is given.



The responses of the nurse are captured using questionnaire and details are given in section 2.1. Then according to the Table1, linguistic levels are defined. Weights for the respondents are determined again according to the Table1. By using the formulas (1) and (2), final similarities are calculated. Details are given in the subsections.

2.1. Expectation Questionnaire

In the previous work [22], "Expectation Questionnaire" was formed. In the questionnaire, users participating in the study are supposed to answer a question for each expectation variable (Figure 1). These answers are used to capture the perceived importance weight of each user for that variable. In the importance questions 5-point Likert scale is used for answers. The weights assigned to the Likert scales are 5 (very important), 4 (important), 3 (Average important), 2 (Not so important) and 1 (not important). In addition to the importance question, some questions for each variable, for expectation rating, were asked; the answers were another 5-point Likert scale (strongly agree, moderately agree, not sure, moderately disagree, strongly disagree).

2.2. Data

In this study, part of the data (the part related to the nurses) captured in the previous study [22] by the Expectation Questionnaire is used. The Questionnaire was applied to two hospitals; a big hospital with 5 months deployed HCIS, called as Hospital A in the study and a small hospital with routine use HCIS, called as Hospital B. In hospital A, 504 questionnaires were completely filled out, 140 (27.77%) of which belonging to the nurses. In hospital B, 96 questionnaires were completely filled out, 26(27.08%) of which belonging to the nurses.

2.2. Fuzzy Logic

Fuzzy Logic uses linguistic variables, to represent vagueness. In this study, the Likert values are our linguistic variables (Table 1). Fuzzy triangular numbers are commonly used in fuzzy problem-solving researches because of simplicity and convenience. In this study, to use this advantage of simplicity and convenience, fuzzy triangular numbers are used. In fuzzification process, importance weights and expectation ratings linguistic variables are converted into fuzzy triangular numbers. Fuzzy triangular numbers assigned to our linguistic variables are given in Table 1. For the perceived importance of expectations FCA is used

Table 1. Triangular fuzzy numbers assigned to Likert scales (Linguistic variables)

Importance Weights	Fuzzy Number	Expectation Ratings	Fuzzy Number
Very Important	0.75,1,1	Strongly Agree	0.5,1,1
Important	0.5,0.75,1	Moderately Agree	0,0.5,1
Average Important	0.25,0.5,0.75	Not Sure	-0.5,0,0.5
Not So Important	0,0.25,0.5	Moderately Disagree	-1,0.5,0
Not Important	0,0,0.25	Strongly Disagree	-1, -1, -0.5

2.4. Analysis

To examine the perceived importance of nurses' expectations from HCIS, expectations are rank ordered. This ranking gives the idea about the nurses'' priorities of the expectations. As ranking method; FCA is used. Conjoint analysis is a suitable method to estimate the relative importance of the target features. Because the preferences of respondents are basically vague, uncertain and subjective, fuzzy set theory was combined with conjoint analysis [26].

$$\mu_R(X_j, F_j) = \sum_{i=1}^{n} \left[w_i \Big/ \sum w_i \right] . X_i \qquad (1)$$

Where;

- wi is the answer given by i-th participant
- ∑Wi is the sum of the answers given to jth expectation

wi / ∑Wi is the weight of the i-th participant

- Xi is the linguistic correspondent of the i-th respondents (if the answer is "Not So Important" then Xi is (0,0.25,0.5))
- Fj is the jth expectation
- n is the total number of answers.

This membership gives us the fuzzy set of each expectation. Now it is time for comparison of these sets with the defined fuzzy sets, to determine to which linguistic variable the given response is closer. Here, the aim is to capture which linguistic variable is the closest to the final fuzzy set. Similarity is measured by;

$$Sim(R_i(y_j, A), F(x_j, l)) = \frac{1}{\left[1 + \sqrt{\sum_{j=1}^{n} (\mu_{Ri}(y_j, A) - \mu_F(x_j, l))^2} \right]} \qquad (2)$$

Where;

- Ri (yj, A) is the fuzzy set determined by 1 (above formula)
- F (xj, l) is the standard fuzzy sets defined (Table 1)

The linguistic variable with the maximum similarity value will be our resulting value of the criterion. To ease the comprehensibility, a toy example is given in Table 2 and Table 3, where 5 criteria exist.

Table 2. Example similarity results

Likert	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Very Strong	**0.84830**	**0.78954**	0.73949	0.73301	0.74809
Strong	0.67447	0.71680	**0.75893**	**0.76791**	0.50870
Average	0.47507	0.49155	0.51311	0.51478	**0.75280**
Weak	0.40177	0.41059	0.42474	0.42366	0.42035
Very Weak	0.40649	0.40632	0.41197	0.40899	0.40860

In Table2, for each criterion, the highest value, in another means the closest value to 1, is our most similar value, which are highlighted as dark. Its corresponding fuzzy linguistic variable the we are looking for. These values are given in Table 3 as rounded to two digits.

Table 3. Example similarity results

Criteria	Results
Criterion1	Very Strong (85%)
Criterion2	Very Strong (79%)
Criterion3	Strong (76%)
Criterion4	Strong (77%)
Criterion5	Average (75%)

3. RESULTS

HCIS expectations ranking of nurses, and their similarities to the linguistic variables are given in Table 4. The topmost five ranked expectations are; Speed, Availability, Ease of Use, Need for Training and Decreasing Work Load. The five least ranked expectations appeared to be; Decision Support, Research Facilities, Report Facilities, Help Manuals, and Privacy. Dimensions' ranking is, respectively, Usage Expectations, System and Data Expectations, Improvement Expectations, and Managerial Expectations.

Table 4. Nurses' expectations ranking and similarities

Rank	**Expectation**	**Similarity**	**Linguistic Variable**
1	Speed	0.899320093	Very Important
2	Availability	0.891744456	Very Important
3	Ease of Use	0.863642972	Very Important
4	Need for Training	0.861884407	Very Important
5	Decreasing Work Load	0.848306364	Very Important
6	User Support	0.845635955	Very Important
7	Function Sufficiency	0.825309747	Very Important
8	Improve Service Quality	0.816247622	Very Important
9	Consistency	0.810898545	Very Important
10	Security	0.794077318	Very Important
11	Bringing Positive Change	0.789547110	Very Important
12	Interoperability	0.785644549	Very Important
13	Privacy	0.760631941	Very Important
14	Help Manuals	0.752811548	Very Important
15	Report Facilities	0.767910657	Important
16	Research Facilities	0.758934509	Important
17	Decision Support	0.752800579	Important

4. DISCUSSION

It is seen that Speed is the topmost important expectation for the nurses. Then comes the Availability. To perform the nursing practice in a healthcare environment uninterruptedly, nurses think that a HCIS should be very

fast and avail when it is needed. It can also be said that Ease of Use also serves this "uninterrupted nursing practice" by decreasing the things to be done by nurses.

The four of the topmost six rated expectations are the Usage Expectations. The topmost ranked dimension, Usage Expectations, also support this finding. That means; nurses want easy to use, easy to learn, fast and well supported HCIS, to perform nursing practice.

The surprising finding is; nurses think Managerial expectations as the least important. Decision support, Report Facilities and Research Facilities are ranked as the least. This result is surprising, because for nursing informatics, these concepts are expected to be higher. This result shows that nurses should be encouraged to deal with nursing informatics more and take part in managerial activities, and then their expectations from a HCIS develop in these expectations.

The second topmost ranked dimension is System and Data Expectations. The nurses have priority in data quality over improvement. This finding is interesting and can be further investigated.

To rank the nurses' expectations and determine their perceived importance, Fuzzy Conjoint Analysis (FCA) is used. Because the preferences of users are basically vague, uncertain, subjective, and imprecise, fuzzy set theory was combined with conjoint analysis. In the previous study (Author), fuzzy logic was not employed, and the ranking was done by weighted average formula. The comparison of FCA and weighted average is given in Table 5.

Table 5. Comparison of FCA ranking with the weighted average

Weighted Average	**FCA**
Speed	Speed
Availability	Availability
Decreasing Work Load	Ease of Use
User Support	Need for Training
Ease of Use	Decreasing Work Load
Need for Training	User Support
Function Sufficiency	Function Sufficiency
Consistency	Improve Service Quality
Improve Service Quality	Consistency
Interoperability	Security
Security	Bringing Positive Change
Bringing Positive Change	Interoperability
Help Manuals	Privacy
Privacy	Help Manuals
Decision Support	Report Facilities
Report Facilities	Research Facilities
Research Facilities	Decision Support

As seen in the table, ranking is totally different, close, but different. When the two rankings are compared, the expectations differ one or two steps. That stems from the loss of precision when fuzzy methodologies are not used in vague, uncertain, subjective, and imprecise data. When it comes to scientific studies, we have bias and misleading deductions.

Success stories of implementing IS, propose to constitute an interdisciplinary committee, consisting of nurses, physicians, clerical staff, information technologists, finance officers and departmental administrators, for developing the system and managing the change [27]. To involve nurses in the HCIS development proved to be an effective strategy, to deploy successful systems based on the users' needs [28]. Because the nurses constitute the largest group of users and they are the core healthcare staff together with physicians, nurses frequently interact with HCIS (19). Understanding their preferences, priorities, needs is very important. Studying these features are of crucial importance. To develop usable, user-accepted, useful HCISs, the literature should concentrate on these kind of studies, and the HCIS industry should demand and use the findings of these studies.

5. CONCLUSION

In this study, user expectations from HCISs are examined from the nurses' perspective. A new analysis is performed; to understand the perceived importance of nurses' expectations from HCIS. In this analysis, instead of crisp computing, fuzzy logic methodologies are used, to invoke the attention of the literature, to the loss of precision in crisp computing.

In the literature, healthcare information systems from nursing perspective are widely studied. Some investigated only nursing information systems' satisfaction [29], some investigated priorities of the system attributes [30], some explored the critical factors affecting the acceptance of HISs [31], some examined the effect of nursing information system on clinical performance [32], without expectations. Some examined expectations, but do not prioritize them [33]. But the priority of these expectations, with a similarity based Fuzzy applications, is missing. With this study, such contribution to the literature is tried to be made.

In the results, it is seen that, although the ranking is close, it is different. It stems from the loss of precision mentioned above. The one we are looking for must be the more precise one, FCA ranking, is clearer and enlightening. The other method is also right, and widely used in the literature. But it is prone to bias, because of the loss of precision.

As future work, it can be proposed that the be done for the different user groups such as physicians, technicians, laboratory workers etc.

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