Author's response to reviews

Title: User needs elicitation via analytic hierarchy process (AHP). A case study on a CT scanner.

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USER NEEDS ELICITATION VIA ANALYTIC HIERARCHY PROCESS (AHP).

A CASE STUDY ON A CT SCANNER

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Abstract: elicitation of user needs is a crucial step before medical device design and purchasing. Nonetheless, user needs elicitation is often based on qualitative methods, whose findings are difficult to integrate into medical information in decision making. This paper describes an application of AHP to support user need elicitation in a public hospital. The case study is the acquisition and use of a new CT scanner.

Methods: AHP was used to design a hierarchy of 12 needs, grouped into 4 homogenous categories, and to prepare a paper questionnaire, which was submitted to 5 clinicians, each with more than 20 years of experience, different specializations, and working in different scenarios in the same public hospital.

Results: although safety and performance were considered the most important issues, user needs changed according to different scenario. In elective surgery, the top five most important needs were: spatial resolution, processing software, radiation dose, patient monitoring, and contrast medium. In emergency, the top five most important needs were: patient monitoring, radiation dose, contrast medium control, speed run, spatial resolution.

Conclusions: AHP effectively supported user need elicitation, helping to develop an analytic and intelligible framework of decision making. User needs varied according to working scenario (elective versus emergency) more than clinical specialization. This should be considered before choosing whether to allocate budgets for medical devices according to clinical functions or according to hospital units.

Key words: user needs elicitation, analytic hierarchy process, AHP, medical decision making.


INTRODUCTION

To provide high quality care for patients, the healthcare industry is dependent upon the provision of a large number of complex and expensive medical devices. It is widely accepted that if devices are to be used effectively they must respect the requirements of their users [1], however, user requirements in relation to healthcare technology is a complex concept. Although clinical effectiveness and safety are the primary concerns in medicine, other aspects must also be considered including training needs, storage, labelling, servicing and cleaning [2]. Moreover, for the same medical device, the concepts of effectiveness and safety may relatively change according to the clinical problem, medical specialization, patient conditions.

The topic of user requirements of medical devices is of interest to a wide variety of individuals and organisations, particularly those that are required to make decisions about the development, purchasing and prescription of these products. However, research has shown that collecting and considering this information is a challenging undertaking. A lack of time and resources may preclude rigorous work into requirements [3], as can a lack of knowledge of appropriate research methods of data collection and analysis [4]. The result of these factors can include the collection of data that are incomplete, difficult to interpret or that fail to address the questions of interest [5].

The final and most fundamental difficulty is the complex nature of user requirements of medical devices. For any one medical device there are likely to be a large number of potential users, potentially including both professional and lay users, all with differing specialties, skills and abilities. Even within homogeneous user groups, individuals will have
received different training and vary in their working patterns, attitudes and preferences. In addition, the use of devices will vary considerably, depending upon the particular clinical procedure being performed and the physical and organisational context in which it is used [2]. This information must not only be collected and considered, but differences and conflicts between users must also be balanced. In addition, for publically funded healthcare industries it is important that purchasing decisions about high-cost equipment are transparent and can be shown to be based on the best possible evidence available at the time.

Despite the hierarchy of evidence, the complexities of medical decision making require a spectrum of qualitative and quantitative information [6]. At the start of a user need elicitation problem, a wide-ranging and open-ended study should be conducted to collect data about the needs and priorities of healthcare professionals [7]. This type of information is critical to developing a broad understanding of the range of requirements of users. In medical decision-making, qualitative methods have a crucial role in examining evidence from previous studies [6, 8] and as mediation between evidence and the context of its use. Improving the methods used in qualitative studies will increase the range of admissible evidence in healthcare decision-making [9] and help to legitimise evidence derived from qualitative studies, as advocated by Kaplan [10], who concluded: “a plea is made for incorporating qualitative/interpretive/subjectivist methods, without prejudice to other approaches”.

Furthermore, evidence-based care advocates that medical decisions are made with reference to the best available research evidence [11].

However, the nature of qualitative research can limit its use in scientific decision making and specifically in user needs requirements elicitation for medical decision making. The influence
that the researcher plays in designing and interpreting studies has resulted in qualitative methods being viewed with scepticism by the medical community [12]. In addition, researchers have encountered problems when attempting to use qualitative data in the analytic and scientific decision-making processes that are a fundamental part of healthcare research [13]. For example, how can open-ended interview data collected from a number of caregivers with a range of opinions be used to make decisions on the design of a new medical device in a transparent and rigorous way [5]. There is need therefore for approaches to healthcare decision making that can address the breadth and depth of the topics under investigation, yet also allow these to be analysed in a transparent way and then quantified and prioritised. This is not only important for the decision makers but also for the healthcare staff; research has shown that successful adoption of new healthcare technology is dependent upon joint ownership of the decisions made during the development process [14]. Moreover, the outcome and the model provided by the decision making process should be easy to understand, as intelligibility is strongly appreciated in medical domain decision-making [15, 16], especially in the public sector.

The Analytic Hierarchy Process (AHP) is a multi-dimensional, multi-level and multifactorial decision-making method based on the idea that it is possible to prioritize elements by: grouping them into meaningful categories and sub-categories; performing pairwise comparisons; defining a coherent framework of quantitative and qualitative knowledge, measuring intangible domains. This hierarchical approach allows the construction of a consistent framework for step-by-step of decision-making, breaking a complex problem into many small less-complex ones, with whom decision makers may easily deal. This paradigm, known as divide et impera [17] (divide and rule) and widely investigated in medicine [18, 19], demonstrated to be effective in healthcare decision making[20].
AHP is particularly effective in quantifying qualitative knowledge by also measuring intangible dimensions (e.g. subjective preferences, comfort). This is important in medical decision making because such intangible dimensions [21], which are normally examined with qualitative research, cannot be measured directly using an absolute scale [22]. The AHP is particularly effective in quantifying experts’ opinions [23], which are based on personal experience and knowledge, to design a consistent decision framework. This is a crucial point in medical decision making processes [10], where not all the relevant information is objective or quantitative. A number of articles have highlighted the benefits of the use of AHP in healthcare [24], especially to include patient point of view in health technology assessment [25], in choosing treatments [26], or to improve patient centred healthcare [27]. Other methods have been proposed to elicit user preferences, nonetheless, AHP has proven to be more suitable in the case of complex decisions involving many factors [28].

In this study, the AHP method was applied to elicit user needs of clinicians using a complex medical device. We describe how the AHP method was adapted to improve its effectiveness for medical [29] decision-making [30, 31] and for the elicitation of user needs. This is an important issue since, as far as author knowledge, no studies proposed a quantitative method, easily enterable with a purchasing process, to consider user needs into a coherent framework of decision method. Contrarily, the same method here proposed to elicit user needs, was previously applied to assess and purchase medical devices, prioritizing their features. Therefore, the adoption of a common method to prioritize devices and to elicit user needs could improve the assessment of a new device. A more general description of the AHP can be find elsewhere [32].
As a case study, we focused on clinical user needs related to the use of a multi-slice Computer Tomography (CT) scanner in a middle size city hospital. The multi-slice CT scanner refers to a special CT system equipped with a multiple-row detector array to simultaneously collect data at different slice locations. The multi-slice CT scanner has the capability of rapidly scanning a large longitudinal volume with high resolution. There are two modes for a CT scan: step-and-shoot CT or helical (or spiral) CT [33]. In recent years, developments in CT technology have provided increasing temporal and better spatial resolution. Scan times are much shorter and slice thickness much thinner with increasing rotation speed and increasing number of active detector-rows, from 4 and 16 detector rows to 64-detector CT scanners [34].

The different features of this device may significantly affect its costs. For instance, to equip this device with a system for continuous patient monitoring during the examination may be expensive. In addition, the technical performance of the device may strongly vary, affecting the final cost. It is therefore of paramount importance to elicit user needs before the purchasing decision is made to ensure that the right device is chosen and not one with unnecessary features that hospital management is not willing to pay for. This is also important when negotiating for support for hospital investment and purchasing [35]. Finally, medical device companies have also demonstrated an interest in scientific methods to elicit user needs, to enable them to respond to clinical demand and to enter new markets by adapting their products to the requirements of different medical specializations [31].

In this paper we present the application of AHP to elicit clinical user needs related to the acquisition and use of a new CT scanner. Particularly we focused on the differences between
user needs, stratifying clinicians according to specialization and intervention (elective versus emergency).

**METHODS**

**ETHICAL CONSIDERATIONS**

Ethical approval was discussed with members of hospital ethical commission. Nonetheless, as this was an interview study with clinical staff and without patient involvement, no formal approval by an ethics committee was required. An participant information sheets was presented and discussed with participants before their involvement.

**HIERARCHY DEFINITION**

Through a focus group involving medical doctors in charge of complex units at the university hospital of University Federico II of Naples, 12 clinical needs that must be satisfied by a CT-scanner were identified. These needs were then organized into four categories and a tree designed in which each node represented a category, and each leaf represented a need (figure 1). The tree was then shown to members of the focus group to check its accuracy.

![Figure 1. Tree of needs](image)

**QUESTIONNAIRES**

Questionnaires were designed to ask each respondent to compare the relative importance of each need with all of the other needs within the same category (Figure 2). For each pair of needs $(i,j)$, responders were asked the following question: “in the selection of a new CT scanner, according with your experience, how important do you consider the element $i$ compared to the element $j$?”. Responders answered choosing one of the following
judgments: much less, less, equally, more, or much more important. In accordance with the Saaty natural scale [36], an integer numerical value was given to each judgment as follows: 1 if equally, 3 if more important, and 5 if much more important. The reciprocal values were given to the remaining judgments: 1/3 if less important, 1/5 if much less important.

Although several scales have been proposed [37-39], in this study the Saaty natural scale was used as it is easier to understand for responders that are not skilled in complex mathematics or with the AHP method. The process was then repeated, designing similar questionnaires to elicit the relative importance of each category of needs.

[Figure 2: questionnaire.]

The questionnaire was designed to minimize possible responder bias. For instance, each element was presented the same number of times on the top left and the right, at the top and at the bottom of the questionnaire as responders writing from left to right and top-down can be more likely to judge the elements on top-left as more important than those bottom right. Moreover, the sequence of comparisons (A with B, B with C and C with A) was adapted to minimize intransitive judgments[40].

**JUDGMENT MATRIX**

For each category of needs, a judgment matrix $A_{nxn}$ was designed, where “n” is the number of needs in this category. According to Saaty theory [36], each matrix had the following properties:

1. the generic element $(a_{ij})$ referred to the ratio between the relative importance of the need “i” ($N_i$) and “j” ($N_j$);
2. the element \( a_{ji} \) was the reciprocal of \( a_{ij} \), assuming the reciprocity of judgment (if \( N_i \) was 3 times more important than \( N_j \), then \( N_j \) should be 1/3 of \( N_i \));

3. the element \( a_{ii} \) was equal to 1 (\( N_i \) is equal in importance to itself);

4. the matrix \( A \) was assumed to be a transitive matrix, which means that

\[
\forall i, j, k \in (1; n), a_{ij} = a_{ik} \ast a_{kj} \quad \text{by definition of} \quad a_{ij} \quad \text{(see eq. 1)}.
\]

\[
eq 1
\]

This last property is called the transitivity property and reflects the idea that if “i” was considered twice as important than \( j \) (\( N_i = a_{ij} \ast N_j \)), and “j” was considered three times more important than “k” (\( N_j = a_{jk} \ast N_k \)), then “i” should be judged six times (two times three) more important than “k” (\( N_i = a_{ik} \ast N_k \), with \( a_{ik} = a_{ij} \ast a_{jk} \)).

**Relative importance of needs into each category**

It has been proved [36] that, if a matrix \( A \) respects these properties then each column is proportional to the other and only one real eigenvalue (\( \lambda \)) exists, which is equal to “n”. The corresponding eigenvector is again proportional to each column and its normalized components, and represents the relative importance of each need compared to the other in the same category. The relative importance (weight) of a need \( i \) within the category \( m \) will be further recalled as \( LW_{i}^{m} \) or local weight.

In cases where the judgments are not fully consistent, the columns of the matrix are not proportional. In this case, the matrix has more eigenvectors and none proportional to all the columns. In this case, the main eigenvector, which is the one corresponding to the eigenvalue (\( \lambda_{\text{max}} \)) bigger in magnitude, is chosen. Its normalized components represent the relative importance of each need.
**CONSISTENCY ESTIMATION**

If the transitivity property is not respected, an inconsistency will be generated. This inconsistency was estimated by posing some redundant questions. Considering three needs \((i, j, \text{ and } k)\) the respondent was asked to perform the pair comparisons \(i-j\) and \(j-k\), and then the redundant comparison \(i-k\). The answer to the redundant question was compared with the one deduced from the first two, assuming the transitivity of judgment. The difference between the real answer and the transitive one represents the degree of inconsistency. The global effect of this inconsistency was estimated measuring the difference of the major eigenvalue \(\lambda_{\text{max}}\) from “n”. The error was zero when the framework was completely consistent. This inconsistency is, in the majority of cases, due to loss of interest or to distraction. For that reason, the responders were required to answer again the questionnaire in case of inconsistency. Some inconsistency between responses is expected; using a scale of natural numbers will cause some systemic inconsistency because not all the ratios can be represented and because of the limited upper value (e.g. 3*2 gives 6, but the maximum value in the scale is 5). For this reason, an error less than a certain threshold was accepted in accordance to literature [41]. An error over this threshold should be considered too high for reliable decisions.

**CATEGORY IMPORTANCE PER EACH RESPONDER**

By applying the same algorithm to the categories, it was possible to evaluate their relative importance. The relative importance of a category \(m\) will be further recalled as category importance (weight) or Categorical Weight (\(\text{CW}^m\)).
GLOBAL-IMPORTANCE OF EACH NEED PER EACH RESPONDER

Finally, the relative importance of a need \( i \) compared to all the others (not only those in the same category) is defined as global-importance (Global-Weight) of the need \( i \) (GW\(_i\)). GWs are calculated by multiplying the local (within category) importance of the need by the importance of the root element (category) into the Hierarchy. For instance the global-weight of the need \( i \), which is in the category \( m \), was calculated as the product of the local importance of the need \( (LW^k_i) \) per the importance of its category \( (CW^m) \) (Eq2).

\[
GW_i = LW^k_i \times CW^k
\]

CORRELATION AMONG RESPONDERS’ PREFERENCES

To assess the correlations among responders prioritization, the Spearman rank correlation \( (\rho, \rho) \) was calculated. This correlation measured the strength of coherency between two rankings, setting the empirical covariance in proportion to the standard deviation of both rankings [28]. Large values show well-matched rankings (1, identical ranking). To verify the significance of \( \rho \), the p-value was used to test the hypothesis that two responders’ prioritizations are strongly correlated. A value of p less than 0.05 was considered significant [40].

USER NEEDS ELICITATION

In order to fully understand the reasons behind the needs prioritization, the results obtained were finally discussed with the responders, other domain experts (clinicians working in similar scenarios to responders) and the Medical Director of the Trust. In this step some open questions were also posed to assess the method.
**RESPONDERS**

Five clinicians, each with more than 20 years of experience, working in a public hospital of medium dimension, were involved as final responders in the study. Each one had experience of different clinical theatres, but each was asked to answer in relation to the personal responsibility and experience of the unit they were working in at the time of the study, which were: radiology unit, emergency unit, minimally invasive ear surgery unit, neurology unit. The surgeon from the ear surgery unit was mainly responsible for child ear cochlear implants, which is an elective surgery. Two surgeons answered from neurology units: one was in charge of emergency neurological surgeries and the other of the elective neurologic surgeries.

**RESULTS**

All responders achieved the required threshold for coherence. The relative importances for each category of needs are reported in Table 1.

[Table 1 categorical local weight]

Global and local weights of each need are reported in Table 2.

[Table 2: local and global weight of needs]

Table 3 and 4 shows the correspondence among responders’ prioritization via Spearman rank correlation, respectively per category weight and per needs’ global weight.

[Table 3: Spearman correlation and p-value among responders per categories]

[Table 4: Spearman correlation and p-value among responders per needs’ GW]


**DISCUSSION**

In this paper, we presented the results of a study on the application of AHP to elicit clinical user needs. As a case study, we focused on user need related to the use of a CT scanner in a middle size hospital.

In elective surgery (ear and neurology), technical performance was considered the most important category of needs, while in emergency the safety of the patient was dominant. Patient safety was considered at least the second most important category by all the clinicians. All the responders considered technical issues the least important category. The results presented in Tables 1 and 3, show that the relative importance of each category of needs changed according to the type of intervention more than for the clinical specialization. This is illustrated by the strong and statistically significant correlation between the priorities of the neurologist performing elective surgery and the surgeon in charge of ear cochlear implants in children. Discussion of the results with the responders confirmed that their needs were the same: first scanner performance (in both cases anatomical details and processing capability were crucial), then patient safety (referred as generally important in medicine), usability and finally technical issues (considered important but not as much as the other needs). No significant rank correlation was observed between the neurologists performing elective or emergency surgeries. Finally, the rankings between surgeons working in emergency were strongly and significantly correlated. Discussion of results with responders confirmed that their needs were the same: first patient safety (due to the usually unstable condition of their patients), then performance (execution time was crucial, once again due to patient instability), then usability and finally technical issues. The clinician in charge of the radiology unit ranked categories similarly to emergency surgeons,
but with different motivations: first patient safety (as a general medical approach, but also because of legal responsibility), then performance (also in consideration of working organization, unit competitiveness and radiologist scientific interest), usability and technical issues.

Regarding local weights within the category of performance, in elective surgeries, spatial resolution was considered the most important need. This reflected the fact that both in neuro-surgeries as in cochlear implants, it was important to investigate small anatomical details. For this type of case, the neurologist considered the processing software almost as important as the spatial resolution. This reflected the fact that the images for neurology surgery required more complex pre- and post-processing than those for ear implants. Speed was not considered crucial mainly because of the usually stable condition of the patients. Again regarding the performance, in emergency surgeries, speed run was considered of paramount importance, especially because of the unstable condition of the patients, which placed them at risk of death or serious impairments. The neurologist reported that spatial resolution was as important as speed run, due to the importance of anatomical details in neurosurgery. Processing software was reported as the least important issue, this was mainly because in emergency situations real-time information is crucial, whereas software require time to process images. Radiologist prioritization was more similar to the rankings of emergency surgeries than elective. Once again, by discussing this result with the Trust Medical Director, it emerged that the majority of radiologist activities are requested from the emergency unit. This shaped the radiologist priority according to his daily activities.
Regarding the local weights in the category of safety, in elective surgeries as in radiology, all the issues were considered equally important. This is because patient safety is considered as important as general issues in all the branch of medicine. Contrarily, in emergency, patient safety is of paramount importance and the differences in importance between needs in this category were evident. Patient monitoring was scored as maximally important, as patient are constantly in unstable conditions during these kinds of surgeries. The neurologist also considered contrast medium control as important as the brain is particularly sensitive to these drugs. Radiation dose was considered less important during emergencies as the short-term benefits to patient justify some risk from radiation exposure.

Regarding local weights in the category of usability, tables 2 shows the highest heterogeneity among responders’ judgments. This reflects different needs; the radiologist, the surgeon responsible for cochlear implants and the neurologist in emergency scored application support as the most important need. The neurologists considered interoperability important, in emergency and in elective surgeries. This reflected the fact that they often needed to integrate information from images obtained with different technologies (ultrasound, magnetic resonance and CT).

Regarding local weight in category of technical issues, no significant information emerged from the radiologist and the ear surgeon. The neurologist considered data storing for elective surgery important. In emergency, technical assistance was considered of paramount importance. Discussing this result with the emergency surgeons revealed that time to first intervention, up-time and mean time to repair were considered important to guarantee service continuity. These were not considered crucial for elective surgery, where
the number of interventions in the year and the condition of the patients allowed small delays.

Regarding global weights, Table 2 shows that in elective surgery the top five most important needs are the same: spatial resolution, processing software, radiation dose, patient monitoring, and contrast medium. Similarly, in emergency surgery, the first five needs were the same: patient monitoring, radiation dose, contrast medium control, speed run, spatial resolution. Table 4 shows that there was again a higher rank correlation per surgery, election-election or emergency-emergency, respectively of 86% (p<0.01) and 90% (p<0.01), more than per specialization, neurologist-neurologist (p<50% and p>0.05). Also in this case, radiologist prioritization is significantly and strongly correlated to emergency (82% and 77% with p<0.01) more than to elective surgery. In this case, a valuable correlation between radiologist and ear surgeon (73%, p<0.1) was observed. This result was unexpected considering that the number of CT scans required for ear-surgery represent less than the 5% of the total activity of radiology. From the methodological point of view, this result was mainly due to the fact that both the radiologist and the clinician responsible for ear-surgery, scored equally important all the needs in safety and technical categories. This could be a weakness of this method. Nonetheless, after discussing this result with the radiologists and with the Medical Director of the Trust, it emerged that this correlation was likely to be due to the fact that radiologist and ear surgeons strongly collaborated in designing surgery for cochlear implants: in fact, in this kind of intervention, computer assisted design in pre-surgery planning is crucial to select the cochlear device and to plan the implant. This may illustrate the strength of the AHP method in mapping specific needs of specific trusts.
Regarding the method, all the responders reported that they encountered no difficulties in completing the questionnaires and that the results accurately reflected their needs. Moreover, all declared that they would not have been able to spontaneously quantify their preference in such a detailed manner. Furthermore, all five responders declared that the method helped them to elicit their needs. The other domain experts involved in this study found the method clear and useful to speed up the user needs elicitation process. The limitation of element number to three per each category facilitated the responders, who were not experienced with this method, especially in avoiding inconsistence and speeding up the process. The scale used, from 1 to 5 and not to 9 as proposed by Saaty [36], resulted in more significance to responders, as already stated in previous research [21]. This was possible because of few elements in each node. The questionnaire design facilitated responders’ coherence.

**CONCLUSION**

User need elicitation is a fundamental step before considering acquisition of a new medical device. The method described in this paper facilitated decision making in eliciting user needs according to different working scenarios and medical specializations. Moreover, AHP provided a fully intelligible and traceable framework for decision process, which is essential in the public sector, where decision makers are required to respond about their choice to different stakeholders, also after many years. The results discussed in this paper demonstrated that, in the case study presented, user requirements varied more according to medical scenario (elective surgery versus emergency) than to clinical specialization. This should be considered before choosing between allocating budgets for medical devices per clinical functions or per hospital units.
ACKNOWLEDGEMENTS

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REFERENCES

5. Martin JB, J: Integrating the results of user research into medical device development: insights from a case study. *BMC medical informatics and decision making* 2012, in press.


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