Understanding the need of referring clinician

ABSTRACT

**Purpose:** Application of Kano model to acquire clinician requirements and develop product features of radiology accordingly.

**Materials and methods:**

Kano model was described that classifies customer requirements as categories must-be, one-dimensional, attractive and indifferent. A Kano questionnaire, consisted of question pairs of 13 clinician requirements related to the access to Computer tomography (CT) and Magnetic resonance imaging (MRI), and report turnaround time (RTT), is developed and administered among referring clinicians in nine clinics. Each clinician requirement was assigned a category and its satisfaction and dissatisfaction coefficients were calculated that were presented in the Kano diagram. The data are stratified according to different clinics, staff and resident clinicians. The time interval between completion in radiology information system (RIS) after finalizing examination and the first attempt to access a report by referring clinician was evaluated for CT and MRI.

**Results**

Seventy three qualified questionnaires were totally collected. Consultation for modality selection and scheduling, access to CT within 24 hours, RTT within 8 and 24 hours are considered as must-be requirements. Access to CT within 4 or 8 hours, access to MRI within 8 and 24 hours, and RTT within 4 hours are one-dimensional requirements. The extension of operation time for CT or MRI as well as MRI access within 4 hours were considered as attractive. Eight out of nine clinics considered RTT within 8 hours as must-be. There exist differences both among different clinics and between staff and resident clinicians. The majority of attempts to access report by clinicians were initialized within 4 hours after examination: 65% for CT and 49% for MRI.

**Conclusion**
The Kano model provides information about quality and satisfaction related product features. This is the basis for any quality improvement effort.

INTRODUCTION

The introduction of Diagnosis Related Groups (DRG) requires a significant reduction in the length-of-stay for healthcare provider to financially survive without sacrificing quality. Imaging department can contribute to this goal by streamlining radiological processes and improving quality. Lean Six Sigma (LSS) is one of the customer centered methods to achieve healthcare quality that is safe, effective, patient centered, timely, efficient and equitable (1) at affordable cost by increasing efficiency and productivity (2-4). Since the value of healthcare was suggested to be its design, its execution and its cost over time (5), the knowledge about quality and performance in radiology as well as customer requirements is thus fundamental in a process design. To enable the right treatment for the right patient at the right time (5), a clear role definition of the stakeholder as provider and customer is needed and the knowledge of their needs and performance is indispensable. Study showed, however, that these quantitative data often were unavailable (6, 7). Despite that many efforts demonstrated the feasibility of different approaches in process improvement (8-10), following questions often remain open. What are the customer requirements and their prioritization? What are the current product features in radiology? Do the product features comply with customer requirements? What are the quality and financial impact by missing customer requirements? Without answering these questions, any improvement effort can either miss customer values or lead to process wastes such as over production.

The Kano model is a dynamic approach for acquiring, classifying and prioritizing the customer’s requirements in a customer-centred product development or in an improvement project (11). It establishes the relationship between product features and customer satisfaction and is one of the important tools in the LSS methodology. Kano model is widely used in manufacturing and other service industries (12-14) to capture customer’s expectations and preferences. It further enables managers to better understand the relationship between needs of customer and quality level for making better resource allocation to maximize the satisfaction of customer. In healthcare, it means to address the right requirements to best serve patients.
In this study we introduce the Kano model and present its application in acquiring clinician requirements about access time to computer tomography (CT), magnetic resonance tomography (MRI) as well as report turnaround times (RTT) for both inpatient as well as outpatient.

**MATERIALS AND METHODS**

The university hospital with about 1200 beds delivers multidisciplinary care services. The radiology department provides full range of radiological examinations including CT and MRI from 8 am to 4 pm. CT services are additionally provided between 4 pm and 8 am or during holidays. Annual throughputs are 4919 for MRI and 12069 examinations for CT in 2009, respectively, with two MRI scanners (1.5-Tesla, Sonata and Espree, Siemens) and two CT scanners (Definition, Volume zoom, Siemens).

Perceived customer requirements were formulated that have impact on the turnaround time of a CT or MRI exam from order entry to signed report. A Kano questionnaire was developed with pairs of customer requirement questions. One question pair consists of a functional and a dysfunctional question. The former refers to the situation in which the customer requirement is met, while the later refers to the case where the requirement is not met (Table 1).

A test run of the questionnaire among selected radiologists was undertaken and subsequent refinement was made. Since CT and MRI examinations were virtually requested by in-house referring clinicians, the questionnaire was conducted in nine major clinics requesting CT or MRI procedures. They are clinics for general surgery (VTG), trauma surgery (Uch), urology (Uro), orthopedics (Ort), hematology (Hae), nephrology (Nep), pediatrics (Pae), radiotherapy (Stt) and gastroenterology (Gas). They have requested about 60% of the total CT and MRI examinations performed in 2009. The anonymous questionnaires were filled out by referring clinicians in clinical conferences. Customer requirements included in the Kano questionnaire to build functional and dysfunctional question pairs are listed in Table 2.

The first and the second questions address services provided by radiology prior to or during an order entry. The third and fourth ones deal with operation times of scanners. The fifth to tenth questions concern the timely access to CT or MRI. The last three questions are related to the timeliness of radiology reports. Optional questions were provided for access to scanner and report finalization.
According to customer responses to each pair of questions, a requirement can be classified according to the highest tally into one of the following categories: A = attractive, O = one-dimensional, M = must-be, I = indifferent, R = reversal and Q = questionable. If two or more categories are tied or close to tied (11), then the lower category in the sequence of A, O, M, I, R, Q for that requirement is chosen. For example, if one requirement are tied at A and O, then the category O is chosen for it. The category attractive indicates that the customer is more satisfied when the requirement is more fulfilled, but is not dissatisfied if the requirement is not fulfilled. The category must-be means that the customer is dissatisfied if the service is less functional, but the satisfaction never rises above neutral no matter how functional the service becomes. The category one-dimensional indicates that the satisfaction changes linearly with the degree of service fulfillment. The category indifferent indicates that the satisfaction is independent of the requirement fulfillment. The category reversal indicates that the perceived functional and dysfunctional question were the reverse of what the customer feels. The category questionable indicates that the responses of a customer to functional and dysfunctional questions are contradictory.

The response to each question in one questionnaire was assigned a category based on the Kano evaluation table (Table 3). Additionally, a requirement was assigned Q in this study if it was not filled out by a respondent. For each customer requirement, coefficients of satisfaction and dissatisfaction were calculated respectively according to the following formulas:

Satisfaction coefficient (SC) = \( \frac{A + O}{A + O + M + I} \)

Dissatisfaction coefficient (DC) = \( \frac{O + M}{A + O + M + I} \).

Satisfaction and dissatisfaction coefficients vary from zero to one, with one indicating maximum influence on satisfaction or dissatisfaction if a product feature is or not provided, respectively. For instance, a value of DC near zero signifies that the product feature has hardly influence on dissatisfaction if it is not available. Alternatively, if DC approaches one, dissatisfaction will be strong if the product feature is not provided. A two dimensional Kano diagram can be constructed by using these two coefficients. It is divided into four quadrants at the value of 0.5 on horizontal and vertical axis. The four quadrants represent: must-be, one-dimensional, attractive and indifferent area. A pair of
satisfaction and dissatisfaction coefficients for each requirement can be then plotted in the Kano diagram.

To prove the validity of the answers to the questions about report finalization, the time interval between completion in radiology information system (RIS) after finalizing examination and the first attempt to access report by referring clinician was evaluated for CT and MRI. Since data from 2009 were not available, the data from January 2011 were used.

**RESULTS**

Seventy three questionnaires were totally collected, of which nine questionnaires were disqualified because questions were not answered pairwise. The responses to thirteen customer requirements are summarized in Table 4. According to the classification method described before, one attractive, four one-dimensional, five must-be and three questionable requirements are derived. The 832 choices from 64 respondents to 13 customer requirements are more or less evenly distributed over categories attractive (21%), one-dimensional (26%), must-be (23%) and questionable (18%), whereas the categories indifferent and reversal together account for 12 percent. Optional question regarding to report finalization were answered by 13 respondents (20%), of whom 10 respondents require report finalization within 0.5 – 2 hours, one within 6 hours, one within the same day and one within 48 hours. The thirteen respondents are distributed in clinics Hae (2), Gas (2), Pae (6), Uch (2) and Stt (1). All the three respondents requiring RTT more than 6 hours were from clinic Pae. No respondent answered other optional questions. Sixty-seven unanswered questions was counted, which accounts to about 44% of the category questionable (Table 4). Only 6 answers were categorized as reversal, indicating that the functional and dysfunctional questions formulated in the questionnaire were consistent with the perception of the customers.

The number of questions unanswered accounts for a significant part of the category questionable (Table 4). It is observed that respondents often answered questions of their interest alone. The questions left unanswered seem to find their solutions self-evidently in the answers of preceding questions. For example, if question number 11 (Table 4) was answered as must-be, then the question number 12 and 13 were often left unanswered. In this case it is reasonable to assume that question 12 and 13 should be treated as must-be as well. This is especially true for question 7, 12 and 13 where unanswered...
questions would bias a correct category assignment. It is therefore appropriate to add the number of unanswered questions to that of the must-be category, obtaining a corrected grade (Table 4).

The customer requirements are plotted in Figure 1 as Kano diagram. The both requirements related to an order entry, i.e. consultation about modality selection and scheduling lie in the must-be area. This applies to requirements of CT access within 24 hours and report availability within 8 and 24 hours. The data points of CT access within 4 or 8 hours, MRI access within 24 hours as well as report availability within 4 hours locate in one-dimensional area. MRI access within 8 hours lies exactly at the transition between one-dimensional and attractive areas, whereas data point of operation time extension for CT or MRI and MRI access within 4 hours were considered attractive. There is no data in the indifferent area.

As described previously, the classification of customer requirements is possible by using tabulation (Table 3) and graphic representation (Figure 1). The former incorporates all six categories as defined by Kano evaluation table, while the later includes only the four statements of attractive, one-dimensional, must-be and indifferent. Comparison of the two classifications shows their differences (Table 4, Figure 1). The classification according to tabulation generally shows higher expectation from customer than that according to graphic representation. This lies in the method itself because the former classifies discretely by simple majority of responses. In the case that no statistically significant majority exists like the requirements 3, 4, 5, 6, 8, 9, 10 and 11 (Table 4), an exact classification is of more subjective nature. On the other hand, the graphic representation gives a continuous mapping of customer requirements with SC and DC. It shows the evolution of customer requirements and especially facilitates comparison between customer groups (Figure 2). It is nevertheless to notice that the difference among data points which lie close together should not be over interpreted. For example, it is hard to interpret a difference between data point 3 and 4.

The distribution of different categories for each customer requirement is presented in Figure 3. It shows that except the requirements in must-be area (Figure 1), all other requirements are less dominated by one single category.
By stratifying the data from nine clinics and plotting them together in one Kano diagram (Figure 2), it is possible to reveal specific needs of each clinic. First of all, eight of nine clinics assigned report finalization within 8 hours to a must-be requirement.

For clinics VTG, Pae, Hae and Nep, nearly all customer requirements lie in the must-be or one-dimensional areas. VTG expected requirement 10 as must-be, whereas Pae, Hae and Nep treated this requirement as a one-dimensional requirement. The access within 8 hours is treated as a must-be requirement by clinics VTG, PAE and Nep. Only Hae treated this as a one-dimensional requirement. All these four clinics treat ‘Access within 4 hours’ as one-dimensional requirement.

The clinic Stt has designated all other requirements as attractive or indifferent except number 12 and 13, while the clinic Gas treated only first and second requirements as one-dimensional and must-be requirement, respectively. The rest of requirements lie in attractive or indifferent areas.

The clinic Uro treated access within 8 or 24 hours as one-dimensional and access within 4 hours as attractive. The clinic Uch differentiates the access requirement between CT and MRI. While the access within 8 or 24 hours for CT were treated as must-be, the access within 4 hours for CT, access within 24 hours for MRI were treated as one-dimensional. Access within 4 or 8 hours for MRI was considered as attractive. Similarly, the clinic Ort treated access within 24 hours as must-be, whereas CT access within 4 hours as one-dimensional and MRI access within 4 hours and access within 8 hours as attractive.

The clinics Neph, Ort, Pae, Uch, VTG treat the extensions of operation times as one-dimensional, whereas the clinics Gas, Hae, STT and Uro treat these as attractive. There is no distinction between internal and operative discipline.

The response behaviours of staff and resident clinicians were examined. While the classification for most of the requirements from both staff and resident radiologists are similar, the difference can be observed in requirement 7, 8, 10. The staff radiologists treat the access within 24 hours as either one-dimensional or must-be. About 20% of residents considered this as attractive. On the other side, while staff radiologists considered the requirement 8 as attractive or one-dimensional, about 31% of resident radiologists treat this requirement as must-be.
First attempt of report access time

There are 1468 examinations performed in January of 2011. Totally, 1356 (92%) reports were accessed by referring clinicians after examination completion, of which there are 409 MRI and 947 CT examinations. There were 112 (8%) reports remained unaccessed. The fraction of first attempt to access CT or MRI report within 24 hours accounts to 81 or 68 percent, respectively. The major part of attempts was initialized within 4 hours after examination completion, 65 and 49 percent for CT and MRI respectively. Eighty or seventy two percent of CT or MRI reports were accessed in the first 4 hours in all the reports accessed within 24 hours after examination. The proportion of access after 4 hours increases significant slowly with advancing times. After 8 hours, there is nearly no more access for CT while the reports signed increases continuously. For MRI there was renewed access only after 16 hours.

Discussion

Kano model enables well-directed improvements targeting at increasing perceived quality expressed by customer satisfaction, while avoiding improvement of must-be requirements that have no effect on satisfactory level. This is based on the understanding that the relationship between fulfilments of product features and customer satisfaction is not always only a linear one. Prioritization of improvements based on the greatest influence on customer satisfaction or stratified solutions among different customer groups is made possible by Kano model. It enables managers to have an objective judgement of customer satisfaction based on the fulfilment of one-dimensional requirements. On the other side, it gives information about how to outperform the peer group by providing attractive requirements. An appropriate service level can be tuned from the beginning. That is why Kano model is fundamental for a process oriented product development activities (15).

Lean Six Sigma, in which the Kano model is incorporated, aims to realize customer values. The knowledge of exact customer values is the prerequisite of any successful LSS effort. Process improvement, use of new technology and appropriate resource allocation all aim at maximizing the degree of the fulfilment of customer demands (2, 16-19). The advantages of the Kano model are well evidenced in this study. First, it was realized that improvements should be directed to enable the access
to CT within 4 or 8 hours, access to MRI within 24 hours and RTT shorter than 4 hours. These perceived qualities scale linearly with the fulfilment of above requirements. Take RTT for example, the perceived quality for CT is clearly higher than that for MRI (Figure 4). Nevertheless, it shows that there is still potential for improvement to suffice customer need. If customer requirements were not known, it is difficult to anticipate any effect on satisfactory level by improvements initialized by radiologists. This is demonstrated in different improvement efforts towards reduction of RTT (9, 10, 20, 21). The fact that the majority attempts accessing reports are within 4 hours after examination completion underlines the real need of referring clinicians in two ways: first, the radiology reports are important for them (22) and secondly, the reports are needed timely. The later is clearly expressed in the results of the Kano questionnaire. It is reasonable to assume that this requirement is not just localized in our hospital. Astonishingly, there is to our knowledge until now no published performance that meets this requirement. In other words, despite that the methods used for improvement themselves are proven to be feasible, the results are however largely irrelevant to the satisfactory level, implying no change in perceived qualities. It emphasizes that any change in product features through staffing level (16), introduction of new technology (19) and process improvement (10) should be based on the understanding of the relationship between product features and satisfactory level. Only product features that lead to more perceived satisfaction by customer are relevant to quality and worth providing or improving.

Given that the customer requirements are closely related to care processes in different clinics, there is no reason for healthcare manager and radiologists not to meet these needs. Especially, a delay in the access to examination as well as delay in reporting will diminish care qualities and increase cost. From the LSS point of view, such needs can be easily covered if processes are streamlined, process wastes eliminated, resources allocated according to process need, and staffing model implemented based on takt time and cycle time (2, 23).

The even distribution of all answers over different categories shows the reasonable differentiation made by referring clinicians. The widespread perception that referring clinicians always require the maximum performance and radiology can never suffice their demands can not be verified in current study.
The extension of scanner operation time to 8 pm was regarded as attractive. It is obvious that predominant activities in clinics are distributed in the baseline period. This shows that service times in radiology are compatible with processes in clinics. Since the absence of this requirement does not negatively impact overall care quality, it is up to radiologists if it is worth to delight the referring clinicians by providing this service with increased cost.

That no optional question to access time was chosen by respondents implies proper formulation of the Kano questions. Only a small part of respondents answered the optional questions for RTT. It indicates the overall appropriateness of the time interval 4, 8 and 24 hours used for RTT. Most of these respondents required a more expedited RTT. Considering that the requirement is widely spread even in one clinic like Pae, requiring RTT from 1 to 48 hours, it is difficult at this stage to take such inhomogeneity into account. Besides, these respondents represent only about 16 percent of all sample population.

Compared to the usually used service quality or performance questionnaire (24), Kano questionnaire is rather time intensive, the wording and the form of questions are unfamiliar to most respondents. It was suggested that oral interviews are most suitable for Kano survey. Because of limited resources of the project team and general unwillingness of clinicians for such survey, the questionnaire was administered in clinical conferences. This is a compromise between oral interview and email survey with the result of a high return rate. The quality is somewhat suffered that is evidenced by the relative high percentage of the category questionable.

The overall results of this study indicate that the knowledge of radiologist is highly valued. The consultation provided was regarded as crucial. The strong need for coordination of procedure scheduling can be interpreted as an expression of continuing scheduling congestion because the referring clinicians can not independently determine a procedure time in this situation. Although such coordination is indeed necessary occasionally, it becomes obsolete if timely services can be provided. The overuse of such coordination because of scheduling congestion increases cost by lowering productivity of both referring clinicians and radiologists. More timely access to CT than that to MRI was required that is obviously related to their diagnostic features. Considering the access times to CT or MRI published being often several weeks (25), it is challenging for radiology to meet the demands expressed in the Kano questionnaire. Essentially, there exists a real gap between high expectations of
customers and actual performance of radiology due to presumably the lack of the knowledge about customer requirements and it can be bridged by using LSS (2, 8).

Kano model reveals clear differences in the prioritization of requirements among different clinics or even between resident and staff clinicians. Such differences are largely dependent on patient groups treated by the different clinics and on internal processes within these clinics. In the case of capacity shortage, such analysis helps to enable providing performances tailored for various groups. For example, access time more than 24 hours will not cause dissatisfaction for clinics STT and Gas. Despite the fact that such justifiable response to capacity shortage is possible, this practice should not be encouraged because it would introduce carving-out of scheduling slots as well as processing time based on clinics and patient groups like inpatient and outpatient. From queueing theory point of view, it increases the number of queues and decreases the utilization of resources.

It is to note that customer requirements and their prioritization behave dynamically. A regular re-examination of customer requirements and their classification is necessary to a sustained high service quality and customer satisfaction.

Conclusion

As a whole, the Kano model demonstrates that the perceived quality and customer satisfaction is linearly related to the degree of the fulfilment in the customer requirements of access to CT within 4 - 8 hours, access to MRI within 8 - 24 hours, and RTT within 4 hours. It is clear that the product features in radiology should comply with them. Alternatively, any improvement project should aim at maximizing their fulfilment to reach measurable perceived quality or change in satisfaction. An implementation of the product features like extension of operation time and access to MRI within 4 hours will increase satisfaction over proportionally.
References


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<th>Functional form of the question</th>
<th>Customer requirement questions</th>
<th>Customer response</th>
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</table>
| CT access within 4 hours is provided | 1. I like it.  
   2. I expect it.  
   3. I am neutral.  
   4. I can tolerate it.  
   5. I dislike it. |
| Dysfunctional form of the question | CT access within 4 hours is not provided | 1. I like it.  
   2. I expect it.  
   3. I am neutral.  
   4. I can tolerate it.  
   5. I dislike it. |
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<td>3</td>
<td>Extension of CT scanner operation time to 8 pm</td>
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<td>Extension of MRI scanner operation time to 8 pm</td>
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<td>Access to CT within 8 hours</td>
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<td>Access to CT within 24 hours</td>
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<td>Optional</td>
<td>Access to CT within___(please fill in ) hours</td>
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<tr>
<td>8</td>
<td>Access to MRI within 4 hours</td>
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</tr>
<tr>
<td>11</td>
<td>within 4 hours</td>
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<td>12</td>
<td>within 8 hours</td>
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<td>13</td>
<td>within 24 hours</td>
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<td>Optional</td>
<td>Within___(please fill in ) hours</td>
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<td>4. I can tolerate it</td>
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<td>5. I dislike it</td>
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Table 4 Responses of customer requirements

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* Counted as defined in Table 3
** Counted if a question is left unanswered
§ Grade corrected
Figure caption

Figure 1 Kano diagram of customer requirements adapted from (11). The dots numbered are according to Table 2.

Figure 2 Kano diagram of customer requirements from nine different clinics. The numbers in the Figure are different customer requirements from Table 4.

Figure 3 Distribution of categories attractive, one-dimensional, must-be and indifferent for different requirements.

Figure 4 Time for first attempt to access report and RTT for CT and MRI.
Figure 1

![Graph showing customer satisfaction and dissatisfaction coefficients with points labeled as Attractive, Surprises, One-dimensional, Performance, expectations not fulfilled, and expectations exceeded. The graph also includes indicators for Basic requirement, implied, self-evident, not mentioned, and taken for granted.]
Figure 2
Figure 3

- MRI access within 4 h (8)
- MRI operation extension (4)
- CT operation extension (3)
- CT access within 4 h (5)
- MRI access within 8 h (9)
- CT access within 8 h (6)
- Report available within 4 h (11)
- MRI access within 24 h (10)
- CT access within 24 h (7)
- Modality selection (1)
- Scheduling consultation (2)
- Report available within 8 h (12)
- Report available within 24 h (13)

Legend:
- Attractive
- One-dimensional
- Must-be
- Indifferent
Figure 4

![Graph showing the percentage of time for different tasks over time](image)

- **First attempt accessing CT report**
- **First attempt accessing MRI report**
- **RTT CT**
- **RTT MRI**

**Axes:**
- **Y-axis:** Percent
- **X-axis:** Time (Hour)

The graph illustrates the percentage of time spent on different tasks over a 24-hour period, with specific tasks being more time-intensive than others.