Identifying Radiological Needs of Referring Clinicians

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Published online: 18 November 2012
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Abstract To provide prospective information about quality- and satisfaction-related product features in radiology, a customer-centered approach for acquiring clinicians' requirements and their prioritizations is essential. We introduced the Kano model for the first time in radiology to obtain such information. A Kano questionnaire, consisting of pairs of questions regarding 13 clinician requirements related to computed tomography (CT), magnetic resonance imaging (MRI) access and report turnaround time (RTT), was developed and administered. Each requirement was assigned a Kano category, and its satisfaction and dissatisfaction coefficients were calculated and presented in a Kano diagram. The data were stratified based on different clinics and on staff and resident clinicians. The time interval was evaluated between the completion of an examination and the first attempt to access the report by a clinician. Consultation for modality selection and scheduling and access to CT within 24 h and RTT within 8 to 24 h were considered as must-be requirements. Access to CT within 4 h and within 8 h, access to MRI within 8 h and within 24 h, and access to RTT within 4 h were one-dimensional requirements. The extension of operation time for CT or MRI, as well as MRI access within 4 h, was considered attractive. Eight out of nine clinics considered RTT within 8 h as a must-be requirement. There were differences in responses both among different clinics and between staff and resident clinicians. Access attempts to reports by clinicians in the first 4 h after the examination completion accounted for 65 % of CTs and 49 % of MRIs.

Keywords Kano model · Consumer satisfaction · Performance measurement · Quality · Radiology workflow

Introduction

The introduction of diagnosis-related groups requires a significant reduction in the lengths of stays for healthcare providers to survive financially without sacrificing quality. Imaging departments can contribute to this goal by streamlining radiological processes and improving quality. Lean Six Sigma (LSS) is one of the customer-centered methods for achieving healthcare quality at affordable cost that is safe, effective, patient-centered, timely, efficient, and equitable [1] by increasing efficiency and productivity [2, 3]. Because the value of healthcare has been suggested to arise from its design, its execution, and its cost over time [4], knowledge about quality and performance in radiology, as well as customer requirements, is the basics to a system or process design. To enable the right treatment for the right patient at the right time [4], a clear definition of the role of the stakeholder as service provider or as customer is needed. The knowledge of their needs and performance is indispensable. Studies have shown, however, that these quantitative data are often unavailable [5]. Despite many efforts demonstrating the feasibility of various approaches in process improvement [6, 7], the following questions about requirements of clinicians and their prioritization remain unanswered: What are the current product features in radiology? Do the product features comply with requirements? What are the quality and financial impacts of missing such requirements? Without answers to these questions, any improvement effort will either neglect customer value or lead to wasteful processes, such as overproduction [8].

The Kano model is a dynamic approach for acquiring, classifying, and prioritizing the customer's requirements in customer-centered product development or improvement projects [9]. It prospectively establishes the relationship between product features and customer satisfaction and is distinct from retrospective measurements of service qualities [10]. The Kano model is one of the most important tools in LSS methodology and is widely used in manufacturing and in other service industries [11, 12]. It enables managers to better understand the relationship between the needs of the

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customer and the level of quality necessary to achieve better resource allocation and to maximize customer satisfaction. In healthcare, the Kano model can address the necessary requirements to serve patients best.

In this study, we introduce the Kano model and present its application in acquiring and understanding clinician requirements regarding access time to computed tomography (CT) and magnetic resonance imaging (MRI), as well as report turnaround times (RTTs), for both inpatients and outpatients.

Methodology

The study was performed in a university hospital with approximately 1,200 beds that delivers multidisciplinary care services. CT and MRI scanners are run in the radiology department from 8 am to 4 pm. CT and MRI services for emergency needs are additionally provided at any times. The annual throughputs were 4,919 examinations for MRI and 12,069 for CT in 2009, with two MRI scanners (1.5 T) and two CT scanners (4 and 64 slices). Imaging requests from neurology were not included in this study because they were not processed in this department.

The perceived clinician requirements that have an impact on the turnaround time of a CT or MRI examination, from order entries to signed reports, were formulated. A Kano questionnaire was developed with pairs of clinician requirement questions. Each question pair consisted of a functional and a dysfunctional question. The former referred to a situation in which the clinician's requirement was met, while the latter referred to a situation in which it was not (Table 1). Because access to both imaging and reports was immediate for emergency patients, their requirements were not used as subjects of this study.

A test run of the questionnaire among selected radiologists was undertaken, with subsequent refinement (Table 2).

Table 1 A pair of customer requirement questions in a Kano questionnaire

	Customer requirement questions	Choice of customer response
Functional form of the question	CT access within 4 h is provided	I like it
		I expect it
		I am neutral
		I can tolerate it
		I dislike it
Dysfunctional form of the question	CT access within 4 h is not provided	I like it
		I expect it
		I am neutral
		I can tolerate it
		I dislike it

Because CT and MRI examinations were requested by virtually all in-house referring clinicians, the questionnaire was conducted in nine major clinics requesting CT or MRI procedures: general surgery, trauma surgery, urology, orthopedics, hematology, nephrology, pediatrics, radiotherapy, and gastroenterology. These clinics requested approximately 60 % of the total CT and MRI examinations performed in 2009. Anonymous questionnaires were filled out by referring clinicians and were subsequently collected during same clinical conferences. The number of participants is thus about equal to the number of questionnaires collected.

The first and the second questions addressed services provided by radiology before or during order entry. The third and fourth questions dealt with the operation times of the scanners. The fifth to tenth questions concerned timely access to CT or MRI. The last three questions addressed the timeliness of the radiology reports. Optional questions were asked regarding access to scanners and report finalization. The participants of the questionnaire provided additional demographic data like their functions, such as resident, staff, senior, or chief clinicians, as well as their associated clinics.

According to the highest tally, the response to each question on a single questionnaire was assigned a category as follows, based on the Kano evaluation table (Table 3): attractive (A), one-dimensional (O), must-be (M), indifferent (I), reversal (R), and questionable (Q). If counted numbers in two or more categories were equal or close to equal [9], then the next category in the sequence of A, O, M, I, R, and Q was chosen for that requirement. For example, if one requirement was tied between A and O, then the category O was chosen for it. Additionally, a requirement was regarded as questionable in this study if it was not chosen by a respondent. The attractiveness category indicated that the customer was disproportionately satisfied with the increasing degree of fulfillment of requirements but was not dissatisfied if the requirement was not fulfilled. The must-be category indicated that the customer was disproportionately dissatisfied if the service was less functional, but satisfaction never rose above neutral no matter how functional the service became. The one-dimensional category indicated that satisfaction changed linearly with the degree of service fulfillment. The indifferent category indicated that satisfaction was independent of the requirement being fulfilled. The reversal category indicated that the perceived functional and dysfunctional questions were the opposite of what the customer felt. The questionable category indicated that the responses of the customer to functional and dysfunctional questions were contradictory.

For each customer requirement, coefficients of satisfaction and dissatisfaction were calculated, respectively, according to the following formulas:

$$\text{Satisfaction coefficient} = (A + O) / (A + O + M + I);$$

$$\text{and Dissatisfaction coefficient} = (O + M) / (A + O + M + I).$$

Table 2 Customer requirements included in the Kano questionnaire

		No.	Customer requirements
Order entry		1	Consultation for modality selection provided by radiologist
		2	Coordination of procedure scheduling
Scanner operation time		3	Extension of CT scanner operation time to 8 pm
		4	Extension of MRI scanner operation time to 8 pm
Access to scanner	CT	5	Access to CT within 4 h
		6	Access to CT within 8 h
		7	Access to CT within 24 h
		Optional	Access to CT within___ (please fill in) hours
	MRI	8	Access to MRI within 4 h
		9	Access to MRI within 8 h
		10	Access to MRI within 24 h
		Optional	Access to MRI within___ (please fill in) hours
	Report finalization	11	Within 4 h
		12	Within 8 h
		13	Within 24 h
		Optional	Within___ (please fill in) hours

Satisfaction and dissatisfaction coefficients varied from 0 to 1, with 1 indicating maximum influence on satisfaction or dissatisfaction, depending on whether a product feature was provided or not, respectively. For instance, a value of the dissatisfaction coefficient close to 0 signified that the product feature had hardly any influence on dissatisfaction if it was not available. Alternatively, if the dissatisfaction coefficient approached 1, then dissatisfaction would have been strong if the product feature were not provided. A two-dimensional Kano diagram was constructed using these two coefficients. It was divided into four quadrants at the value of 0.5 on the horizontal and vertical axes. The four quadrants represented the must-be, one-dimensional, attractive, and indifferent categories. A pair of satisfaction and dissatisfaction coefficients for each requirement was then plotted on the Kano diagram.

To prove the validity of the answers to the questions about report finalization, the time interval between the completion in radiology information system by technicians after the end of examination and the first attempt to access the

report by referring clinicians was evaluated for CT and MRI. The data from January 2011 were used because no previous data were available.

Results

Seventy-three questionnaires in total were collected, of which nine questionnaires were disqualified because the questions were not consistently answered in a pairwise manner. In the same time period, there were 142 individual clinicians who actively requested MRI procedures. The total number of clinicians in these nine clinics is estimated to be about 180. According to this, an estimated response rate of about 41 % can be derived. The responses to 13 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 were derived. The 832 choices from 64 respondents to 13 clinician requirements were relatively

Table 3 Kano evaluation table

Customer requirements			Dysfunctional				
			1. I like it	2. I expect it	3. I am neutral	4. I can tolerate it	5. I dislike it
Functional	1.	I like it	Q	A	A	A	O
	2.	I expect it	R	I	I	I	M
	3.	I am neutral	R	I	I	I	M
	4.	I can tolerate it	R	I	I	I	M
	5.	I dislike it	R	R	R	R	Q

A attractive, *O* one-dimensional, *M* must-be, *Q* questionable, *I* indifferent, *R* reverse

Table 4 Responses of customer requirements

No.	Customer requirement	A	O	M	I	R	Q		Grade	Grade ^c
							<i>C</i> ^a	<i>U</i> ^b		
1	Consultation for modality selection provided by radiologist	9	15	28	9	0	1	2	M	M
2	Coordination of procedure scheduling	8	18	28	6	1	2	1	M	M
3	Extension of CT scanner operation time to 8 pm	24	25	2	9	0	3	1	O	O
4	Extension of MRI scanner operation time to 8 pm	22	27	2	11	0	1	1	O	O
5	Access to CT within 4 h	23	25	5	2	0	3	6	O	O
6	Access to CT within 8 h	16	11	16	7	0	3	11	M	M
7	Access to CT within 24 h	4	11	18	8	2	7	14	Q	M
8	Access to MRI within 4 h	24	24	3	6	0	0	7	O	O
9	Access to MRI within 8 h	18	15	11	8	0	2	10	A	A
10	Access to MRI within 24 h	8	17	17	6	2	6	8	M	M
11	Report finalization within 4 h	15	15	19	7	0	2	6	M	M
12	Report finalization within 8 h	5	7	22	6	0	9	15	Q	M
13	Report finalization within 24 h	0	6	23	3	1	13	18	Q	M
	Sum	176	216	194	88	6	152			
	Sum (%)	21	26	23	11	1	18			

^a Counted as defined in Table 3^b Counted if a question is left unanswered^c Grade corrected

evenly distributed over the categories of attractive (21 %), one-dimensional (26 %), must-be (23 %), and questionable (18 %), whereas the categories of indifferent and reversal together accounted for only 12 %. Optional questions regarding report finalization were answered by 13 respondents (20 %), of whom ten respondents required report finalization within 0.5–2 h, one within 6 h, one within 24 h, and one within 48 h. The 13 respondents were distributed in hematology, gastroenterology, pediatrics, trauma surgery, and radiotherapy clinics in respective numbers of 2, 2, 6, 2, and 1. All of the three respondents requiring RTT more than 6 h later were from the pediatrics clinic. No respondents answered other optional questions. Sixty-seven unanswered question pairs were counted from all of the questionnaires, which accounted for approximately 44 % of the questionable category (Table 4). Only six answers were categorized as reversal, indicating that the functional and dysfunctional questions formulated for the questionnaire were consistent with the perception of the clinicians.

It was observed that respondents often chose to answer only those questions that interested them. The questions left unanswered seemed to find their solutions self-evidently from the answers of preceding questions. For example, if question 11 (Table 4) was answered as must-be, then questions 12 and 13 were deemed redundant and were often left unanswered. In this case, it was obvious that questions 12 and 13 should be also treated as must-be requirement. This conclusion was especially true for questions 7, 12, and 13,

for which the assignment of unanswered questions to the questionable category would have biased correct category assignment. It was therefore appropriate to add the number of unanswered questions to that of the must-be category, thereby obtaining a corrected grade (Table 4).

The customer requirements are plotted in Fig. 1 as a Kano diagram. Requirements 1 and 2 related to order entry lie in the must-be area. This result applies to requirements of CT access within 24 h and report finalization within 8 h and within 24 h (requirements 7, 12, and 13). The data points of CT access within 4 h or within 8 h and MRI access within 24 h, as well as report finalization within 4 h (requirements 5, 6, 10, and 11), are located in the one-dimensional area. MRI access within 8 h (requirement 9) lies exactly at the border between the one-dimensional and attractive areas, whereas the data points for operation time extension for CT or MRI and for MRI access within 4 h (requirements 3, 4, and 8) are considered attractive. There are no data in the indifferent area.

As described previously, the classification of customer requirements could be carried out by using tabulation (Table 3) or graphical representation (Fig. 1). The former incorporates all six categories as defined by the Kano evaluation table, while the latter includes only the four statements of attractive, one-dimensional, must-be, and indifferent. A comparison of these two methods of classification shows their differences (Table 4 and Fig. 1). Classification according to tabulation generally shows higher

Fig. 1 Kano diagram of customer requirements adapted from [11, 16]. The dots are numbered according to Table 4

expectations from customers than classification according to graphical representation. This difference lies in the method itself because the former classifies discretely using a simple majority of responses. In the case that no statistically significant majority exists, as with requirements 3, 4, 5, 6, 8, 9, 10, and 11 (Table 4), an exact classification is of a more subjective nature. Conversely, graphical representation provides continuous mapping of customer requirements, with a satisfaction coefficient and a dissatisfaction coefficient. It depicts the evolution of customer requirement prioritizations, and it facilitates comparisons among customer groups in particular. Nevertheless, it is important to notice that the differences among data points that lie close together should not be over-interpreted. For example, it is difficult to discern a difference between data points 3 and 4.

By stratifying the data from nine clinics and plotting them separately (Fig. 2), it was possible to reveal the specific needs of each clinic. First of all, eight of the nine clinics designated report finalization within 8 h (requirement 12) as a must-be requirement.

For the general surgery, pediatrics, hematology, and nephrology clinics, nearly all of the requirements lay in the must-be or one-dimensional areas. Access within 8 h (requirements 6 and 9) was treated as a must-be requirement by the general surgery, pediatrics, and nephrology clinics. Only hematology treated this subject as a one-dimensional requirement. All four of these clinics treated access within 4 h (requirements 5 and 8) as a one-dimensional requirement.

The radiotherapy clinic designated all other requirements as attractive or indifferent, except for requirements 12 and

Fig. 2 Kano diagram of customer requirements from nine different clinics. The numbers in the figure represent different customer requirements from Table 4

13, while the gastroenterology clinic treated only requirements 1, 2, 12, and 13 as one-dimensional and must-be requirements, respectively. The rest of requirements lay in the attractive or indifferent areas.

The urology clinic treated access within 8 h or within 24 h (requirements 6, 7, 9, and 10) as one-dimensional and access within 4 h (requirements 5 and 8) as attractive. The trauma surgery clinic differentiated access requirements between CT and MRI. While access within 8 or 24 h for CT (requirements 6 and 7) was treated as must-be, access within 4 h for CT and access within 24 h for MRI (requirements 5 and 10) were treated as one-dimensional. Access within 4 or 8 h to MRI (requirements 8 and 9) was considered attractive. Similarly, the orthopedics clinic treated access within 24 h (requirements 7 and 10) as must-be and MRI access within 4 h and within 8 h (requirements 8 and 9) as attractive. CT access within 4 h (requirement 5) lay on the border between attractive and one-dimensional.

The nephrology, orthopedics, pediatrics, trauma surgery, and general surgery clinics treated extension of operation times (requirement 3 and 4) as one-dimensional, whereas the gastroenterology, hematology, radiotherapy, and urology clinics treated this factor as attractive. There was no distinction between internal and operative medical disciplines.

As shown in Fig. 3, the distribution of different categories for each customer requirement is illustrated. The majority of the requirements are distributed over the four categories. More than 50 % of the respondents consider the requirements numbered 13, 12, 2, 1, 7, 10, 11, and 6 as one-dimensional or must-be. While about 40 % of respondents take requirements numbered 5, 3, 4, and 8 as attractive, there is the same amount of respondents which

consider them as one-dimensional. For each requirement, there are up to about 20 % of respondents who regard the requirement as indifferent.

The response behaviors of staff and resident clinicians were examined. While the classifications of most of the requirements from both staff and resident radiologists were similar, differences could be observed in requirements 7, 8, and 10. The staff radiologists treated access within 24 h (requirements 7 and 10) as either one-dimensional or must-be. Approximately 20 % of residents, however, considered this factor as attractive. By contrast, while staff radiologists considered requirement 8 as attractive or one-dimensional, roughly 31 % of resident radiologists treated this requirement as must-be.

First Attempt of Report Access Time

There were 1,468 examinations performed in January of 2011. In total, 1,356 (92 %) reports were accessed by referring clinicians after examination completion, of which there were 409 MRI and 947 CT examinations. There were 112 (8 %) reports that remained unaccessed. The proportions of first attempts to access CT or MRI reports within 24 h amounted to 81 and 68 %, respectively. The major part of the attempts was initialized within 4 h after examination completion: 65 and 49 % for CT and MRI, respectively. Eighty and 72 % of CT or MRI reports were accessed in the first 4 h, respectively, of all reports accessed within 24 h after examination. The proportion of access after 4 h increased significantly more slowly with increasing time. After 8 h, there was almost no additional access for CT, while the number of signed reports increased continually. For MRIs, there was renewed access only after 16 h (Fig. 4)

Fig. 3 Distribution of categories—attractive, one-dimensional, must-be, and indifferent—for different requirements. Note: the *number* in the parentheses corresponds to the question number in Table 2

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

Discussion

The Kano model enables well-directed improvements in customer satisfaction, while avoiding the improvement of must-be requirements that have no effect on satisfaction level. The prioritization of improvements, based on their greatest influence on customer satisfaction or on stratified solutions among different customer groups, is made possible by the Kano model. It enables managers having a non-biased judgment in improving customer satisfaction at different levels based on the fulfillment of one-dimensional requirements. At the same time, it provides information about how to outperform a peer group by satisfying attractive requirements. An appropriate service level can be actively and prospectively managed. These reasons are why the Kano model is essential for process-oriented product development activities [13].

Lean Six Sigma, into which the Kano model has been incorporated, aims to realize customer value. Exact knowledge of customer value is a prerequisite for any successful LSS effort. Consequently, process improvement, the use of new technology, and appropriate resource allocation all aim to maximize the degree of fulfillment of customer demands [2, 14, 15]. The advantages of the Kano model were well evidenced in this study. First, it was realized that improvements should be directed to enable access to CT within 4 or 8 h, access to MRI within 24 h, and access to RTT shorter than 4 h. These perceived qualities scale linearly with their fulfillment. With RTT, for example, perceived quality of CT by clinicians was clearly higher than that of MRI (Fig. 4). Nevertheless, not even a 65 % fulfillment of the clinicians' requirements for RTT timeliness in the case of CT could be regarded as good quality in the sense of Six Sigma [16]. This fact shows that a significant discrepancy exists in perceived quality between radiologists and clinicians. If

such a discrepancy is not taken into consideration because the exact needs of clinicians are unknown, then it may be difficult to anticipate any effect on satisfaction level by any improvements introduced by radiologists. That a large number of attempts to access reports take place within 4 h after examination completion underlines the real needs of referring clinicians in two ways: first, radiology reports are valuable to them; and second, the reports are needed on a timely basis. Although it is reasonable to assume that this requirement is not specific only to our hospital, there are, however, to our knowledge, no published data on performance that have met this requirement [6, 7, 17, 18]. In other words, despite the methods used for improvement in the literature having been proved feasible, the results were largely irrelevant to satisfaction level, implying no change in perceived quality. This finding emphasizes that any change in product features through staffing level [14], introduction of new technology [15], and process improvement [7] should be based on the understanding of the relationship between product features and satisfaction level.

Given that clinicians' requirements are closely related to their care processes, there is no reason for healthcare managers and radiologists not to meet these needs. In particular, a delay in access to examinations, as well as delays in reporting, will diminish care quality and will increase costs. From the LSS point of view, such needs can be easily met if processes are streamlined, procedural waste is eliminated, resources are allocated according to process needs, and a staffing model is implemented based on task time and cycle time [2].

The extension of scanner operation time to 8 pm was regarded as attractive. It is obvious that the majority of activities in clinics lie in the baseline period. This finding shows that service times in radiology are basically compatible with current processes in the clinics. Because the absence of this requirement did not negatively impact overall

care quality, it is up to radiologists to decide whether it is worth pleasing the referring clinicians by providing this service at an increased cost.

That no optional questions on access time were chosen by respondents implies the proper formulation of the Kano questions. Only a small number of respondents answered the optional questions for RTT which indicates the overall appropriateness of the time interval of 4, 8, and 24 h. Most of these respondents required a more expedited RTT.

Compared to service quality or to performance questionnaires usually used [10], the Kano questionnaire is rather time-intensive, and the wording and form of the questions are unfamiliar to most respondents. It has been suggested that oral interviews are more suitable for Kano surveying. Because of the limited resources of the project team and the general unwillingness of the clinicians to take such a survey, the questionnaire was administered at clinical conferences. This decision was a compromise between oral interviewing and e-mail surveying, with the result of a high return rate. The survey quality suffered somewhat, as is evidenced by the relatively high percentage of questionable category answers.

The overall results of this study show that the knowledge of radiologists is highly valued. The consultations provided were regarded as crucial. The strong need for the coordination of procedure scheduling can be interpreted as an expression of continuing scheduling congestion because referring clinicians cannot independently determine a procedure time in such situations. Although such coordination is indeed occasionally necessary, it becomes unnecessary if timely services can be provided. The overuse of such coordination because of scheduling congestion increases costs by lowering the productivity of both the referring clinicians and radiologists. More timely access to CT than to MRI was required, which is obviously related to their diagnostic features. Considering the access times to CT or MRI having been reported as often being several weeks [19], it is challenging for radiology to meet the demands expressed via the Kano questionnaire. Essentially, there exists a real gap between the high expectations of clinicians and the actual performance of radiology due presumably to the lack of exact knowledge about clinicians' requirements, and this gap could be bridged by using LSS [2, 20].

The Kano model reveals clear differences in the prioritization of requirements among different clinics and even between residents and staff clinicians. Such differences are largely dependent on the patient groups treated by the different clinics and on their internal processes. In the case of capacity shortage, such analysis enables the providing of performance tailored to various groups. For example, access time greater than 24 h will not cause dissatisfaction for radiotherapy and gastroenterology clinics. Despite such a justifiable response to capacity shortage being possible, this practice should not be encouraged because it would introduce the carving-out of scheduling slots, as well as longer

processing time, based on the clinics and on patient groups, such as inpatients and outpatients. From a queuing theory point of view, it would increase the number of queues and decrease the utilization of resources.

It is important to note that customer requirements and their prioritization behave dynamically in terms of time. A regular reexamination of customer requirements and their classification is necessary to sustain high-quality service and customer satisfaction.

Conclusion

The usefulness of Kano model is demonstrated in this study. The product features critical to quality and satisfaction in view of referring clinicians could be derived: They are the access to CT within 4–8 h, access to MRI within 8–24 h, and RTT within 4 h. This enabled identifying the gap between current product features and customer requirements and facilitates potential organizational adjustments. Especially, Kano model made it possible to identify and satisfy, if needed, specific requirements of individual clinic or occupation group. By making use of attractive product features, it is possible to outperform a peer group.

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