Customers satisfaction in pediatric inpatient services: A multiple criteria satisfaction analysis

Diogo Cunha Ferreira [a,*], Rui Cunha Marques [a], Alexandre Morais Nunes [b], José Rui Figueira [c]

[a] *CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001, Lisbon, Portugal*
[b] *CAPP, Instituto Superior de Ciências Sociais e Políticas, Universidade de Lisboa, R. Almerindo Lessa, 1300-663, Lisbon, Portugal*
[c] *CEG-IST, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001, Lisbon, Portugal*

A B S T R A C T

Objective: To assess customer satisfaction determinants in a public pediatric inpatient service and propose some strategies to enhance the consumer and customer experience.
Methods: We applied a Multiple Criteria Customer Satisfaction Analysis to estimate the value functions associated with each satisfaction (sub)criterion and determine the corresponding weights. We characterized satisfaction criteria (according to the Kano's model), estimated the customers' demanding nature and the potential improvements, and proposed strategic priorities and opportunities to enhance customer satisfaction.
Main findings: Strategies for satisfaction enhancement do not depend solely on the criteria with the lowest satisfaction levels and the estimated weights, each criterion's nature, the customers' demanding nature, and the technical margin for improvements.
Conclusions: Areas deserving attention include clinical staff's communication skills, the non-clinical professionals' efficiency, availability, and kindness; food quality; visits' scheduling and quantity; and facilities' comfort.

1. Introduction

The definition of proper strategies to improve customers' experience in any health care service is on the agenda of policymakers and hospital managers worldwide [1]. It requires the knowledge of what is going "*wrong*" in the service ("*wrong*" in this case, refers to the dimensions of care that contributed to customer dissatisfaction, see Ref. [2]). Because the customer takes the purchase decision in the face of multiple alternatives [3], getting satisfied with the service and its outcomes is compulsory [4]. Otherwise, the probability of using it in the future (loyalty) is low [5]. Note that the term "*customer*" is frequently misconstrued with "*consumer*," which refers to the person who effectively uses the service [6]. In some empirical cases, the consumer and the customer are the same person. Even in healthcare, marketing strategies are usually directed towards customers (not necessarily consumers) to influence their behavior as they make the purchasing decision [7,8].

Despite being recognized as a crucial indicator of process quality and its importance to both the customers and the service managers, satisfaction is a problematic term to define [9]. The most widely accepted

definition of satisfaction is the fulfillment of customer expectations and needs, leaving no room for complaints [10]. Likewise, satisfaction is the difference between the overall assessment of the experience and the initial prospects [11,12]. A positive (negative) difference identifies a satisfied (dissatisfied) customer [13–17]. Although simple, these definitions give rise to some relevant aspects embodying the complexity of this matter. These aspects are particularly relevant in the case of healthcare services. According to Donabedian [2], satisfaction is a result of healthcare. Still, satisfaction assumes a relative (or subjective) rather than an objective nature. Nonetheless, it plays a pivotal role in achieving other healthcare outcomes like full health status recovery and the absence of readmissions within a short time-lapse [18]. It happens because satisfied customers are more likely to follow the treatment guide [19].

On the one hand, as customers, patients are usually incapable of evaluating the technical quality due to the usual information asymmetry between clinical staff and the patient [20]. Instead, they can only have a perception of quality. On the other hand, some non-discretionary criteria may affect satisfaction without changing healthcare quality: *e.*

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g., some amenities, including wi-fi, are unlikely to be directly relevant for improving the health condition, but they may be necessary for satisfaction. Another example is the working environment (managerial control *vs.* emphasis on cohesion and workers' morale) that may affect customers' judgments and satisfaction [21]. Healthcare services customers may bias their satisfaction assessment because of the process of care misjudgments: *e.g.*, the clinical staff may have been displeasing, although professionally competent [22–24]. Besides, two customers are unlikely to equally rate the same practitioner for the same medical act [25]. Therefore, although complementary, satisfaction and quality are not synonyms [26]. In the words of Izumi et al. [27], "*[i]t may be more critical, therefore, to know what patients consider essential to quality […] care and what their expectations are than whether or not they are satisfied.*"

Managers should always account for customer preferences in performance assessment. Their preferences volatility can result, for instance, from the increase of knowledge, which in turn may have a perverse effect because of the expectations rise [28]. It puts pressure on healthcare managers to formulate appropriate and timely strategies to enhance the customers' experience. Given that preferences are individual, it is impossible to frame a tactic good enough for all customers. Nonetheless, a central tendency of preferences should be estimated (Greco et al., 2014).

The most recurrently employed method to study and understand customer satisfaction and its determinants is the survey [29]. A random sample of customers who have experienced the service under scrutiny should typically rate its quality in a few criteria. Assigned rates should reflect the judgments of those customers per criterion [30]. In a few cases, criteria are disaggregated into additional subcriteria. It refines the search for better strategies to enhance customer satisfaction [28]. However, merely looking at the surveys' answers provides no useful insights for managers as data on their own mean nothing with no proper analysis. Indeed, Mobley and Locke [31], Blood [32], and Oliver [13] argue that the crucial aspects of satisfaction are not directly provided by customers and are only uncovered after using analytical methods.

The primary goal of satisfaction analyses is to define the (most) crucial criteria for customers to act upon the former in detecting deficiencies. However, we believe that it is just the *tip of the iceberg*. To design effective strategies, one should also assess other relevant dimensions, including the demanding nature of customers regarding each criterion and the expected change of their satisfaction when the performance level changes. Indeed, the former does not necessarily increase when the latter improve, nor does it decrease when the opposite happens. The latter dimension is what we name as *customers' behavior in the face of performance enhancement* and can be scrutinized through the Kano's model [33,34]. Strategies and opportunities to improve customer satisfaction largely depend on these last satisfaction-related dimensions [28,35].

Some studies have been conducted to understand the critical factors or criteria underlying satisfaction in pediatrics [36–44]; Lee at al., 2018; [45]. However, there is some lack of consistency over conclusions; a brief overview of these studies follows in the next section. Also, little is known about the satisfaction of parents of the children admitted to pediatric inpatient services [46,47]. There is a gap in the literature in terms of (*i*) what those parents value the most in the pediatric ward service for acute inpatients; (*ii*) what is their demanding nature (more or less demanding) regarding quality criteria; and (*iii*) how their satisfaction is likely to change when the hospital improves its performance in those criteria. A note is worth pointing out: in the present paper, we study the satisfaction in a pediatric inpatient service, in line with previous research (see next section). Here, the consumer is the youngster, aged less than eighteen. In contrast, the customer is her/his parent or any other representative if she/he has decided to admit the child to the (pediatric) inpatient service. Therefore, as mentioned earlier, any result of this paper is from the parents' perspective.

To conduct our analysis and complement the literature in the gap mentioned above, we use a robust alternative based on optimization and linear programming that attributes value to each level of the ordinal scales used to characterize satisfaction (*e.g.*, Likert scales). It is the so-called Multicriteria Satisfaction Analysis (MUSA) method, proposed by Grigoroudis and Siskos [35,48]. Instead of using ordinal scales in mathematical operations (which is theoretically unseemly), value functions' application to derive opportunities and strategic movements has been reported as more robust [49].

Following the previous arguments, this study's primary objective is to contribute to the discussion around the satisfaction-related critical areas in pediatric inpatient services. To do so, we (*a*) run the MUSA method for a complete set of ordinal levels observed in a hospital located in Portugal mainland; (*b*) obtain the value scales associated with each (sub)criterion; (*c*) study the demanding nature of customers as well as the customers' behavior in the face of performance enhancement through the integration of MUSA and the Kano's model as suggested by Grigoroudis and Siskos [35]; and, accordingly, (*d*) detect leverage opportunities and propose empirically-driven strategies to improve the satisfaction of customers in a specific pediatrics service. It is the first time that one applies MUSA to a pediatrics service. Regarding this service, the number of criteria and subcriteria used in this study is substantially larger (total of 62) than most of the remaining literature; we remark that all fundamental points of view should be present in any multiple criteria decision analysis.

The manuscript is structured as follows. Section 2 gives an overview of previous research on satisfaction analysis and discusses some of its limitations and strengths. In that section, we discuss why MUSA is a more appropriate candidate for the satisfaction analysis method than other alternatives. Section 3 briefly describes MUSA and some of its outputs and outcomes that can be assessed through them. Section 4 details the case study, presenting the sample, data collection, and satisfaction criteria. Section 5 presents and discusses the results of the present case study. Section 6 grants some managerial implications, and section 7 concludes this study.

2. Previous research on satisfaction analysis (and what is going wrong with it) …

2.1. … in pediatrics

Table 1 provides a review of ten studies that evaluated customer satisfaction in pediatric services worldwide. Those studies were published after 2000. We retrieved the following relevant data from them: surveyed population, the country of study, the sample and period of analysis, the service, the items (*e.g.*, criteria, dependent variable), the adopted methods, and the main findings. Some relevant conclusions are as follows:

   i. All studies tried to unveil the determinants of satisfaction with pediatric services. However, determinants were not always criteria. In some cases, they included the way of conducting the survey (mail *vs.* point of care), demographic and socioeconomic variables (*e.g.*, age, gender), and some dimensions related to the service provided (*e.g.*, length of stay, the process of discharge).
   ii. All studies evaluated the satisfaction of the parents or the legal guardians of the children receiving care.
   iii. Five studies (out of ten) were conducted in the USA, and only two in Europe; no study concerning Portugal was found.
   iv. The respondents' quantity ranges from a few hundred to dozens of thousands, with an average of 2416 respondents and a standard deviation of 3,008, meaning that studies are quite heterogeneous in this aspect (coefficient of variation: 124%).
   v. In five reviewed papers, the period comprised more than one year; in opposition, the other five consider one year for the survey only.
   vi. Only the two studies conducted in Europe (Denmark and Norway) evaluated pediatric wards' satisfaction (inpatient service).

Table 1
A review of ten studies that evaluated customer satisfaction in pediatric services worldwide.

Author(s)	Surveyed population	Country	Sample and period	Service	Items ((sub)criteria, dependent dimension(s), questions)	Method(s)	Main findings
King et al. [36]	Parents	Canada	645 respondents	Special needs	*Criteria:* Structure (access, availability, cost, bureaucratic, waiting time at the site, amount/ frequency/length of service, appropriateness of service, facilities); Process (respectful and supportive care, competence, attention to the needs, enabling or partnership, continuity and coordination of care, general information provided); Outcomes	Surveys (56-item); Client Satisfaction Questionnaire; Customers divided into highly satisfied and relatively dissatisfied	Relatively dissatisfied parents most often mentioned structural elements (mainly lack of access to existing services) and process elements (respectful and supportive care, as well as lack of continuity and coordination of care); Measures of satisfaction should contain items tapping elements of both process and structure
Ammentorp et al. [37]	Parents	Denmark	423 respondents; 2002	Pediatric ward (acute inpatients)	*Criteria:* Access to care and treatment (8 subcriteria); Information and communication (10 + 3); Physicians' behavior (5); Nurses' behavior (6); Access to service (4)	Surveys (87-item); 5-point Likert scales; Mean scores; Compare priorities before admission with satisfaction after discharge	The most significant gap between priorities and satisfaction was in the waiting time related to admission, waiting time-related to the fulfillment of the child's needs, and information given about care and treatment.
Solheim and Garratt [40]	Parents	Norway	3308 respondents; 2005	Pediatric ward	*Dependent variables:* Doctor services; Hospital facilities; Information discharge; Information about examination and tests; Nursing services; Organization *Independent variables:* Child's age; respondent's age; child's health status; outcomes (health improved or worsened); unexpected waiting; incorrect treatment; disappointment at staff *Sociodemographic characteristics:* Gender; ethnicity; education; main activity; marital status; information on new medication; staff eased pain; type of treatment; help friends/ family; not alone with the child	Surveys (25-item); 0-100 score per item; Cronbach's alpha; Pearson's correlation; Ordinary least squares	Disappointment with staff exhibited the strongest association with some dependent variables; Socioeconomic characteristics, in general, have no association with parent experience
Segal et al. [41]	Parents	USA	802 respondents (469 mailed; 333 at the point of care); second quarter 2013	Pediatric outpatient service	*Questions:* Courtesy and respect of the medical receptionist, medical receptionist helpful, knew how to call for help after appointment, organization of care, provider talked about the pros and cons of choices, would recommend the provider's office	Mailed surveys *vs.* point of care surveys; 11-point Likert scales, with dichotomization into excellent (9–10) and not-excellent (0–8)	For most of the items, rates in the point of care surveys are consistently higher than rates in mailed surveys
Barsoom et al. [42]	Parents	USA	458 respondents; December 2012 to December 2014	Pediatric neurosurgery	*Independent dimensions:* Access, moving through the visit, nurse/assistant domains, care provider domains, personal issues *Dependent dimension:* Likelihood of recommending the practice to others	Surveys (34-item); 5-point Likert scales	The most vital indicators of satisfactory clinical experience are cheerfulness of practice and ability to get the desired appointment; Patients are not as much affected by the length of appointment or clinic waiting times
Davis et al. [43]		USA	1244 respondents; 2012 to 2014	Pediatric hematology/	*Criteria:* 28 subcriteria clustered into	Surveys (34-item, including five background	The most important predictors of overall

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Table 1 (*continued*)

Author(s)	Surveyed population	Country	Sample and period	Service	Items ((sub)criteria, dependent dimension(s), questions)	Method(s)	Main findings
	Caregivers of patients (children)			oncology (outpatient)	six criteria – access to care, care provider, during the visit, nurse/assistant, personal issues, and overall assessment *Dependent dimension:* Likelihood of recommending practice (as a proxy for overall patient satisfaction)	questions); Top box scores evaluated; Pearson's correlation between rates in criteria and the dependent dimension	satisfaction level were cheerfulness of practice, waiting time, and staff working together; Waiting time at the clinic was among the lowest-rated items; Care provider information about medicines was not correlated to the likelihood of recommending the practice
Peng et al. [44]	Parents or legal guardians	USA	6195 respondents; 2012 to 2014	Pediatric orthopedics	*Criteria:* 28 criteria including patient-physician relationship (*e.g.,* friendliness, courtesy, explanation of the condition and follow-up instructions, concern); staff collaboration; privacy; facilities; waiting time *Dependent dimension:* Likelihood of recommending the practice to others	Surveys (34-item); 5-point Likert scales; Pearson's correlation between rates in criteria and the dependent dimension	Criteria including friendliness, courtesy, cheerfulness of practice, staff collaboration, and provider's information about medicines are the most relevant for the likelihood of recommending a provider to others
Lee et al. [50]	Patients	Korea	1505 respondents; 2010–2012	Emergency department	*Dependent dimension:* Overall satisfaction *Patient characteristics:* Gender, education, presence of chronic disease, disability, medical insurance type, source of payment for medical costs, household income, admission to the pediatric ward within one-year, total emergency department visits *Other variables:* Reason for the visit (injury/disease), transport, travel time, delayed visit, length of stay, services provided, type of discharge (admission, transfer, home discharge), the amount paid, hospital ownership, and level	Surveys; 4-point Likert scales; Multiple logistic regression analysis	The odds of expressing satisfaction are associated with gender and with the type of discharge after the emergency department visit
Patel et al. [45]	Patients	USA	9577 answered surveys related to pediatricians and 85,301 related to non-pediatrician primary care physicians; 2005 to 2016	Primary health care	*Criteria:* Friendliness, thoroughness of the examination, time spent with the patient, communication skills, care instructions, engaging the patient in decision-making, the turnaround time for test results, how well the physician follows up with the patient, and treatment success	Surveys; 11-point Likert scales; Confirmatory factor analysis; Cronbach's alpha; A random coefficient model with a random slope and intercept with patient satisfaction as a function of pediatrician/primary care physicians, covariates, and random physician effects	Shorter waiting times and longer visit times were associated with higher patient satisfaction ratings

Other services include the emergency department and medical appointments (*e.g.*, hematology, oncology, and orthopedics).

vii. In general, studies use several criteria to characterize the satisfaction of the pediatric service. The most frequently used criteria are related to friendliness, courtesy, respectfulness, competence, attention to needs, and communication skills, particularly staff's capacity in providing information about the health status, the follow-up procedure, medicines, and examinations. Interestingly, the authors tend to evaluate the staff satisfaction, not splitting them by professional category (*e.g.*, doctors, nurses). However, we disagree with that approach, as segregation is essential for acceptable management practices.

viii. In some cases, authors do not use satisfaction criteria but evaluate the overall satisfaction (or another dependent variable) in terms of the patients and their parents' sociodemographic characteristics and other dimensions, such as the reason for the visit and the type or quantity of services provided.

Table 2
Pediatric inpatient service attributes that may influence customer satisfaction.

Criteria	Subcriteria	Description, rationale, and some references
1. Capacity of providing useful information	1.1. Children's treatment guidelines	The success of therapeutics largely depends on the clinical staff's capacity to comprehensively explain the child's treatment guide, namely the patient flow through the health system. Customer satisfaction is influenced by such an ability and the outcomes (the health status improvement).
	1.2. Children's rights and their families' duties	In any health care service, the patient has the right to be treated respectfully by professionals, who should listen to the former carefully about her/his concerns and answer transparently and honestly to inform the customer about the illness. Nonetheless, the patient or the customer also has some duties. She/he should give the relevant information about her/his health status and medical history and advise the professionals about any change in health conditions or problems associated with the caring process. Ethically, no process of care should be carried out without the informed consent of the customer. It means that user rights and duties must be well defined and clarified before any medical act.
	1.3. Means of complaint and suggestion	Complaints result from poor care or, at least, from the unfulfillment of the customer expectations. The absence of a straightforward way of complaining or, in opposition, making suggestions to improve the service quality can be seen as the health care provider's carelessness regarding customer opinions. Hence, it can be a determinant of dissatisfaction.
2. Facilities	2.1. Cleanliness and hygiene	Unclean facilities potentiate the dissemination of diseases within health care services. Cleanliness and hygiene are two attributes of Donabedian's model of healthcare quality. On the one hand, the inpatient health status is weakened. Hence, the lack of hygiene may result in the raising of in-hospital infections. It is a fundamental issue, especially in the nursery and in services such as pediatrics. On the other hand, customers (in this case, on behalf of consumers) can quickly evaluate whether a facility is clean or not. It results from the high dissemination of information. They are aware of the need for hygiene and cleanliness within the health care service. In general, this assessment should not primarily depend on the psychographic dimensions characterizing each customer, including age, gender, and education.
	2.2. Comfort and amenities	Being in a nursery can be distressful, especially for children who use to be more active. The existence of amenities such as wireless, TV, and games may enhance the staying experience and reduce stress. Additionally, each inpatient spends much time lying in the nursery bed, which should be as comfortable as possible.
	2.3. Privacy of children and their families	Confidentiality is an essential topic in healthcare because of the so-called human dignity. Any staff working within a health care facility has a legal duty of keeping the patient's information safe. Moreover, most nurseries are shared by at least two inpatients, and privacy must always be ensured as caring situations are mostly intimate [103,104].
	2.4. Adequacy and conservation of furniture and outfit	The adequacy and conservation of furniture and outfit in the nursery, including beds, mattresses, chairs, and TVs, are paramount to ensure comfort to the inpatient and the visitors. We remark that, in the present case, inpatients do not answer the satisfaction surveys. Instead, their legal representatives are responsible for that, and they play the role of visitors, who should be comfortable.
	2.5. Protection against noise	Noise in nurseries is always problematic as it hinders the inpatient recovery, who spend considerable time in bed, sleeping. The existence of white-noise machinery, medical alarms, and unquiet staff and visitors can increase the nursery's noise and potentiate the inpatient's malaise. According to Ref. [105]; "*excessive noise in hospitals reduces the intelligibility of speech and impairs communication, causing annoyance, irritation, and fatigue, and reducing the quality and safety of healthcare.*"
	2.6. Room temperature	Like noise, the room temperature should be regulated to provide a comfortable stay to the inpatient. Too cold or too hot rooms turn the stay unpleasant. As early as 1977, Smith and Rae [106] concluded that 21.5–22° Celsius is the optimum steady-state air temperature for inpatients comfort.
	2.7. Existence of hobbies	Hobbies can be vital for any inpatient because they help them spend time.
3. Visits	3.1. Visiting time	In general, hospitals have scheduled times for visits. These times may conflict with visitors' availability, which is especially relevant in pediatric inpatient services. Smith et al. [107] concluded that the hospital management should consider open visitation to improve the inpatients' satisfaction as liberal visiting hours and increased infection rates are not significantly associated.
	3.2. Maximum allowed length of visits	Just like the scheduling of visits, their duration can be a determinant of (dis)satisfaction. In pediatric inpatient services, customers (the parents) wish to spend a meaningful amount of time with their children. Hence, short visits are likely to promote customer dissatisfaction. Additionally, visits can be used by the parents to clarify doubts with clinicians. As pointed out by Halfon et al. [108], "*longer visits* [are] *associated with more anticipatory guidance,* […]*, and higher family-centered care ratings*".
	3.3. Quantity of allowed visits	There is a maximum number of allowed visits per day associated with the visiting schedules and the maximum duration of visits. This value should be optimized. On the one hand, too many visits may increase infections in the patient and disturb her/his rest. On the other hand, too few allowed visits can be problematic, especially in pediatric inpatient services, as children wish to be close to their parents as long as possible.
	3.4. Assistance to the relatives	A hospitalization is a stressful event not only for the child but also for her/his parents. Any support from the hospital staff to the customer during her/his visit is welcome. In opposition, the carelessness about the situation reveals a lack of empathy, compassion, and poor interpersonal relationships. It can contribute to customer dissatisfaction.
4. Food	4.1. Preparation, temperature, and taste of food 4.2. Diversity of food 4.3. Quantity of food 4.4. Support during meal	Hospital food has been pointed out as a relevant item related to satisfaction [109]. The preparation, temperature, and taste of food are, according to Dubè et al. [110], Wadden et al. [111], and Kuperberg et al. [112], some of the most critical dimensions in explaining the overall satisfaction of customers with meals. Stang et al. [113] found an association between satisfaction with the hospital foodservice, the size of served portions, and food diversity on the menu. In some cases, inpatients require assistance from healthcare assistants or support (auxiliary) staff during meals, especially the elderly, the post-surgical patients, and those with a physical disability [114]. Hence, the support during a meal may also contribute to (dis)satisfaction.
5. Doctors	5.1. Readiness and availability	The low availability of staff at any secondary health care stage can be understood as a barrier to access proper healthcare [115]. The main goal of health services is to enhance the user's health status, and it requires available and ready staff, either clinical or not, to take care of the patient.
	5.2. Concern with the child	Pain management is not the only dimension of care that matters for customer satisfaction. Communication and responses to a request are also important. Care about the patient's health status is paramount to

Table 2 (*continued*)

Criteria	Subcriteria	Description, rationale, and some references
	5.3. Kindness and sympathy	understand what is behind her/his clinical condition. The patient's care includes, for instance, nursing acts like "*documenting patient care, performing vital signs, delivering as-needed medication, ambulating, feeding, and turning patients, responding to call bells, and performing patient education*" [1]. Carelessness is usually easy to detect by customers. It hampers the relationship between the professional and the customer and the ability to treat the latter in the best possible way [116].
		Kindness, sympathy, empathy, and compassion are terms used interchangeably, although their definitions are distinct [117]. Nevertheless, they should be part of the interpersonal relationship among the health care consumer, the customer, and the staff, regardless of whether it is clinical or not [118]. According to Ferreira et al. [28], "*through the interpersonal relationship, the staff induces and motivates the patient following medical advice and actively collaborating in care.*" This dimension of quality (and satisfaction) can be as important as the staff's technical performance. Additionally, Jeffrey refers that "*empathy is critical for diagnosis and effective treatment, doctors need empathy to learn more about the patient's situation. So, empathy supplements objective knowledge and technology. By allowing the patient to participate more fully in decision-making, empathy supports the patient's autonomy*" [119].
	5.4. Child's health condition explanation 5.5. Prescriptions explanation 5.6. Diagnosis explanation 5.7. Further care explanation	Explaining the clinical status, the health professionals' diagnosis, and the care at home (including prescriptions of drugs and treatments) and providing further important information is a duty of all clinical professionals. Communication between the clinical staff and the customer/consumer appears to be associated with overall satisfaction [120]. In general, customers cannot rate these professionals' technical performance because the former may not have enough literacy. Hence, the way to characterize the clinical staff's professionalism is to evaluate their capacity to explain what matters for the patient.
6. Nurses	6.1. Readiness and availability 6.2. Concern with the child 6.3. Kindness and sympathy 6.4. Child's health condition explanation 6.5. Nursing treatments explanation 6.7. Further care explanation	*Vide supra (criterion 5. Doctors)*
7. Auxiliary staff	7.1. Readiness and availability 7.2. Concern with the child 7.3. Kindness and sympathy	*Vide supra (criterion 5. Doctors)*
	7.4. Efficiency	According to Donabedian [121], efficiency is the ability to obtain the most significant health improvement at the lowest cost or, in other words, the capacity of delivering the highest quantity of care services at the minimum waste of resources, including time. Whether clinical or not, efficient staff are associated with efficient and effective healthcare, reducing waiting times, and maximizing the service's productivity and the return on assets.
8. Administrative staff	8.1. Readiness and availability 8.2. Concern with the child and her/his family 8.3. Kindness and sympathy 8.4. Efficiency	*Vide supra (criterion 7. Auxiliary staff)*
9. Volunteering	9.1. Readiness and availability 9.2. Concern with the child 9.3. Kindness and sympathy	
10. Diagnosis and treatments	10.1. Readiness and availability 10.2. Concern with the child 10.3. Kindness and sympathy 10.4. Child's health condition explanation 10.5. Medical treatments explanation 10.6. Diagnosis explanation 10.7. Further care explanation	*Vide supra (criterion 5. Doctors)*
11. Discharge process	11.1. Details regarding care and practices at home	The inadequate post-discharge care and lack of patients' preparedness have been pointed out as two determinants of inpatients' readmission for the same cause [122]. Readmissions within a specific (short) period after discharge reveals a lack of care appropriateness. Therefore, it is an excellent practice to prepare well the discharged patient (or someone responsible for her/him) for good care at home. Missing or confusing information provided by the clinical staff contributes to the lack of preparedness and, consequently, customer dissatisfaction. We remark that surveys were conducted three up to six months after discharge, which is a considerable period in which the inpatient could be readmitted for reasons like the low resolution of the patient's main problem, unstable therapy at discharge, and inadequate preparedness in the period after discharge [115]. Although readmissions could result from factors other than the discharge process, the procedure undertaken here can discard them from the analysis.
	11.2. Waiting time prior to discharge	Waiting time is likely a determinant of dissatisfaction in healthcare, no matter in what stage the inpatient is since she/he enters the facility until the moment she/he leaves it. Waiting time and waiting lists are frequently seen as barriers to access. Meanwhile, efficient hospitals usually have short waiting times [17]. The longer the waiting time, the more dissatisfied the customer is [123]. However, the converse is not necessarily true: if the waiting time is very short or even null, the customer may take it for granted because she/he needs the medical/nursing act. It means that waiting time is usually pointed out as a must-be requirement [28,45].

ix. In a few cases, the likelihood of recommending the provider/practice replaced the overall satisfaction. The authors using such an approach argue that it is a better proxy for loyalty.

x. Regarding the employed methods, surveys were always used in the selected research papers. Six studies clearly stated the number of items used in surveys, being the average 45 (standard deviation: 21; coefficient of variation: 47%). Some of the items of those surveys were background questions. Six studies clearly stated the use of Likert scales for customer judgments. The number of points used ranges from four to eleven, being five the most common

number of levels. Once collected and treated data from surveys responded, the authors adopted several methodologies, including (*a*) cluster customer into *deeply satisfied* and *relatively dissatisfied*; (*b*) Pearson's correlation coefficient between variables measured in ordinal scales; and (*c*) Ordinary least squares (OLS), logistic regression, and random coefficient models, using one dependent variable and several independent variables to explain the dependent one – the dependent variables used in OLS were also measured in ordinal scales. Criticisms of these approaches follow in Subsection 2.2.

2.2. … in operational research and management science

Several literature reviews on patient satisfaction have been found in the literature [51–55]. None of these have investigated which methods are the most frequent in the study of patient satisfaction determinants. However, four are noteworthy for their dissemination: ordered logistic regression (OLR), factor analysis, structural equation modeling (SEM), and ServQual [56]. The combined utilization of those methods is also expected, *e.g.,* factor analysis with SEM [57,58].

Factor analysis is an outspread method in statistics that allows us to study the *hidden* variance within a set of observed variables to find latent variables. In some cases, factor analysis is simply used to narrow down the number of variables and remove redundancy within data [59]. SEM also seeks to model the relationship between some observed variables and latent constructs based on somehow complex mathematical equations [60]. The OLR models the association between a response (*e.g.,* overall satisfaction) and potential explanatory variables (*e.g.,* satisfaction criteria). Like factor analysis, the OLR implementation is easy and straightforward; however, the proportional odds assumption should be satisfied, *i.e.,* the odds ratio is constant across the cutoff point for each of the covariate in the model. Finally, ServQual is a model based on twenty-two questions related to five relevant dimensions of quality (tangibility of assets, reliability of the service providers, responsiveness, assurance, and empathy; see Refs. [61–64]. This model is based on the gap between the expectations and perceptions of customers on the service quality. According to Lucadamo et al. [65], healthcare customers' expectations are challenging to assess, meaning that ServQual is not appropriate and should be replaced by ServPerf [66,67].

Besides some SEM pitfalls related to its mathematical formulation and weak external validity [60], there is a significant problem of using it or factor analysis in satisfaction analysis: data are ordinal. If scales are ordinal, then categories can be represented by any symbol or verbal statement, provided that, for a set of ordered semantic categories, say {*a, b, c, …, z*}, the category *c* is preferred to *b,* and this one is preferred to *a*. Overall, the category *z* is the most preferred one. For the sake of simplicity, researchers very often use numbers to represent these categories. However, basic mathematical operations like addition, subtraction, multiplication, and division are not allowed for data measured in ordinal scales (Stevens, 1946; [68,69]). Also, in the words of García-Lapresta and del Pozo [70]: "*when agents can perceive different proximities between the terms of the scale, this conversion of linguistic terms into numerical values is meaningless and could generate distinct outcomes when individual assessments are aggregated using different codifications of the same ordered qualitative scale.*" It happens because the distance between two consecutive levels in an ordinal scale (like the Likert ones) is not necessarily constant. Thus, the effort spent to go from one level to the next one is not the same effort of switching from the latter to its adjacent level. It means that using SEM and factor analysis requiring data measured in interval scales is, at least, questionable. We remark that this topic is still controversial as authors keep using these methods regardless of the data nature and assuming that the distance between two consecutive levels of ordinal scales remains unchanged. Researchers advocating in favor of using ordinal and interval scales indistinctly base their arguments on controlled simulations [71]; however, we argue that such simulations do not always match real-world conditions.

ServQual (and ServPerf) intends to measure service quality rather than understanding customer satisfaction determinants [72]. Notwithstanding this fact, ServQual estimates a score of service quality based on the (weighted or not) average difference between the performance perception and the excellence expectation [35]. Both expectation and perception in each of the twenty-two items of the ServQual model are expressed in seven-point Likert scales. Likewise, ServPerf also uses this kind of ordinal scales to estimate a score that averages customers' perception into a service quality score. Because of the data's ordinal nature, the criticisms made above still apply if one cannot assume that the ordinal independent variables successive categories are equally spaced [65].

Two alternatives for satisfaction analysis are OLR and MUSA. While the first is widely known and employed, the second is not. Indeed, we may say that MUSA is a nonparametric version of OLR. However, MUSA does not rely on the proportional odds assumption. If this assumption is not truthful, the estimate of the parameters obtained by OLR is not valid. Unfortunately, testing for this assumption using real data nearly always returns rejection [73]. Therefore, an alternative to use in this case study is MUSA, which is not sensitive to the data nature nor to the proportional odds assumption. MUSA and its outputs and outcomes are described and detailed in Section 3.

3. A Multiple Criteria Customer Satisfaction Analysis: the MUSA model

3.1. An overview

The analysis of satisfaction and its determinants requires the customers' judgments explicitly on criteria and their overall satisfaction in terms of the complete service. Usually, such judgments follow an ordinal scale (such as the Likert scale), say 1–7, where one denotes "*deeply dissatisfied*" and 7 "*deeply satisfied.*"

MUSA has been considered a robust alternative to analyze satisfaction and its determinants [35,48]. The model provides a useful set of key performance indicators that help decision-makers design the best strategies to improve customer satisfaction. MUSA has been used in a substantial number of fields, including healthcare [28,74–76], job satisfaction [77], climate change strategies [78], airline services [79], e-services [80], visits to national parks [81], and project management [82].

MUSA constructs value (or utility) functions related to the criteria and the overall judgments of customers. Judgments are assumed to be independent, and no interaction effects should exist. MUSA integrates the robust ordinal regression methodology with the value theory, as the value associated with the overall satisfaction judgment is the sum of the partial value (contribution) of each criterion as well as some "misjudgments" (or "residuals"). Errors model the difference between the expected and the observed satisfaction because customer judgments are sometimes inconsistent [28]. The final mathematical model results in a linear programming problem concatenating the robust ordinal regression (Greco et al., 2014). It contains all customer judgments and some additional constraints related to decision variables' nonnegativity, monotonicity, and normality. The model's objective is to minimize those residuals, thus estimating the value functions' central tendency.

In some cases, criteria are organized in a tree structure, meaning that some subcriteria feature each criterion. One can easily extend the mathematical model to accommodate this structure. Interestingly, the value in the highest satisfaction level of a (sub)criterion is its weight. It can be understood as the relative contribution of the (sub)criterion to their overall judgments and the overall value function. Therefore, it is easy to conclude that the hierarchical MUSA model is nothing but several standard MUSA models running simultaneously with the appropriate adjustment for the values achieved.

Appendix A contains the mathematical details of MUSA. These details are a summary of the works of Grigoroudis and Siskos [35,48]. In

short, we solve Eq. (A.19) (see Appendix A.3), which is an optimization problem that consists of maximizing, in practice, the weight of each satisfaction criterion. We have to consider a set of parameters, including: (*i*) partial and global satisfaction levels, resulting from surveys; (*ii*) the number of satisfaction levels and satisfaction criteria and subcriteria; and (*iii*) some user-defined thresholds that do allow (or not) for the indifference of two consecutive satisfaction levels. We imposed a minimal threshold (0.001) for criteria and subcriteria to impose that value functions were strictly increasing in this empirical case. Thresholds above that value would return an infeasible model.

We developed codes associated with Eq. (A.19) (Appendix A.3) using the software Matlab ® (version R2015a). By default, Matlab's solver is the 'linprog' function available for the users with the optimization package installed. Otherwise, one can install the CPLEX from IBM and integrate it with Matlab, which slightly hastens the linear program solving.

3.2. The outputs and outcomes of MUSA

3.2.1. The value functions

Let us consider that one customer judges the pediatric inpatient service quality using n criteria and Likert scales. Her/his (partial) judgment for the ith criterion is X_i. Suppose that her/his overall judgment (concerning the whole pediatrics service) is Y. There are non-decreasing functions, called value functions (x_i ( ) or y ( )), that transform the ordinal scales related to satisfaction (X_i and Y). If X' is preferable over X'' for one criterion i (represented by $X' \succ X''$), then $x_i (X') \geq x_i (X'')$. Likewise, if $Y' \succ Y''$, then $y (Y') \geq y (Y'')$. MUSA optimizes these value functions through a linear programming model, as specified in Appendix A.3 (see Eqs. (A.21) and (A.22)). In other words, the main output of MUSA consists of the set of value functions for criteria and the overall judgments. These functions represent the central tendency of customers' judgments as MUSA relies on robust ordinal regression. Some properties of these functions are as follows:

(*i*) Value functions are non-decreasing. The original MUSA model allows for some stationary transitions, in which $x_i (X') = x_i (X'')$ or $y (Y') = y (Y'')$ if $X' \succ X''$ or $Y' \succ Y''$. Users can define some thresholds to avoid this issue (details in Appendix A.2).
(*ii*) Both partial and global value functions are non-negative: $x_i \geq 0$ and $y \geq 0$. The least preferred satisfaction level (typically "*deeply dissatisfied*") has a null value. However, if no strict preference is applied, the next level(s) can also have null value(s); see the previous property.
(*iii*) The sum of the n partial value functions is approximately equal to the overall value function – the difference between that sum and the overall value function results from customers' misjudgments. MUSA's objective is to minimize the latter. Therefore, as with ordinary least squares, the overall function is equal to the sum of the n partial value functions and some residuals that correspond to those misjudgments.

Value functions are useful for defining weights, satisfaction indexes, margins for improvement, and studying customers' demanding nature and the change over the value functions when the hospital improves its performance. Because of their usefulness, we detail them below.

3.2.2. Weights associated with criteria (and subcriteria)

Using value functions, one can quickly obtain the weights associated with each criterion. Indeed, Bouyssou et al. (2006) show that the weight of the ith criterion, b_i, is the value in the last (most preferred) satisfaction level, *i.e.*, $b_i = v_i$ (7) in the case of a 7-point Likert scale. Alternatively, one can use Eq. (A.20); see Appendix A.3.

3.2.3. Satisfaction indexes

It is also possible to assess the average satisfaction index, either

global or partial, S, S_i and S_{iq}, $i = 1 \ldots n$, $q = 1 \ldots n_i$, as shown in Eq. (1) below, where P represents the frequency of customers/customers belonging to a particular satisfaction level. Satisfaction indexes range from 0 to 1 (or 100%), and the higher the index, the more satisfied the customers are.

$$\begin{cases} S = \sum_{m=1}^{\alpha} P_m y^{*m} \\ S_i = \sum_{k=1}^{\alpha_i} P_{ki} x_i^{*k}, \ i = 1 \ldots n \\ S_{iq} = \sum_{k_q=1}^{\alpha_{iq}} P_{k_q i} x_i^{*k_q}, \ i = 1 \ldots n, \ q = 1 \ldots n_i \end{cases} \quad (1)$$

These indexes can then be rescaled to a range [–100,100] such that we can easily observe the (sub)criteria where customers are more (dis) satisfied, taking 0 as the cut-off for high/low satisfaction. The smaller the satisfaction index (close to −100), the less satisfied the customers are, resulting from high frequencies in low satisfaction levels.

3.2.4. The Kano's model: how does customer satisfaction evolve when the performance improves?

One relevant aspect of satisfaction analysis is associated with customer satisfaction expected evolution when the provider improves its performance. Indeed, the improvement of a satisfaction criterion does not necessarily point towards a linear enhancement of customer satisfaction. In some cases, customers take some of those criteria for granted. They become very dissatisfied whenever the health care service has a poor performance but is neither satisfied nor dissatisfied otherwise. According to the Kano's model [33], these criteria are named *must-be*. On the opposite side, *attractive* requirements do not result in dissatisfaction when absent, and satisfaction usually improves if the service's attribute exists. Finally, *one-dimensional* criteria exhibit a quasi-linear function, with a positive slope, relating their fulfillment to customer satisfaction [83,84].

MUSA outcomes are useful to classify each satisfaction (sub)criterion into these three Kano's categories [28,35]. Let satisfied (dissatisfied) customers be the ones with an overall satisfaction level above (below) 4, *i.e.*, the neutral level. Then:

- Must-be criteria: the weight estimated for the dissatisfied customers is larger than the one for the satisfied customers;
- Attractive criteria: in opposition to must-be criteria, here the weight estimated for the dissatisfied customers is smaller than the weight for the satisfied ones;
- One-dimensional criteria: weights are similar for both satisfied and dissatisfied customers.

Two weights for both satisfied and dissatisfied customers would hardly match exactly. Hence, we could not find any one-dimensional criterion. Let us consider that b^s and b^d denote the weights estimated by MUSA for those two groups of customers, concerning one criterion. Let $\nabla = \left| b^s - b^d \right|$ be the absolute value of the difference between those two weights. That criterion is one-dimensional if $\nabla \leq 0.1\%$ (assuming that weights are expressed on the scale of 0–100%).

3.2.5. Customers' demanding nature

Using utilities, we may infer how demanding customers are regarding each satisfaction attribute. Given a (sub)criterion, demanding customers are not satisfied unless it is totally fulfilled. In opposition, for non-demanding customers, an increase of satisfaction beyond a certain level (threshold) will not greatly upsurge the value or, in other words, the contribution to the overall satisfaction. Finally, neutral customers are neither demanding nor non-demanding, and their satisfaction grows linearly with the fulfillment of their expectations. We may then

construct a demanding index, D.

Let $m, p \in [1 \dots \alpha]$ be two satisfaction levels, such that $p < m$. Let also $D_{m,p}$ be the demanding global index defined as the difference between two derivatives of the function y^* (the optimal utility function associated with the overall satisfaction), *i.e.*, $D_{m,p} = \partial y^{*m}/\partial m - \partial y^{*p}/\partial p$, $m \neq p$. For discrete functions, it is clear that $\partial y^{*m}/\partial m = y^{*m} - y^{*m-1}$, so:

$$D_{m,p} = y^{*m} - y^{*m-1} - y^{*p} + y^{*p-1} \tag{2}$$

If $m = p+1$, then $D_{m,m-1} = y^{*m} - 2y^{*m-1} + y^{*m-2}$, $m > 2$. For the sake of simplicity, demanding is analyzed near the highest satisfaction level, *i.e.*, $m = \alpha$ and $y^{*\alpha} = 1$. A similar exercise can be done for criteria and subcriteria cases so that demanding customers can be assessed for each satisfaction dimension.

In theory, neutral customers verify $D_{\alpha,\alpha-1} = 0$. Positive demanding indexes $D_{\alpha,\alpha-1} > 0$ identify demanding customers. In opposition, non-demanding customers are identified by $D_{\alpha,\alpha-1} < 0$. However, in practice, hardly a demanding index is precisely zero for neutral customers. Therefore, we assume that neutral customers verify $D_{\alpha,\alpha-1}$ close to 0% (in practice, between −5% and 5%), whilst demanding (non-demanding) customers exhibit $D_{\alpha,\alpha-1}$ larger (smaller) than 5% (−5%).

3.2.6. Margin for improvement

Once the partial satisfaction index and the corresponding weight, b_{i}, and b_{iq}, have been optimized, one may achieve the average improvement index, I_i and I_{iq}, $i = 1 \dots n$, $q = 1 \dots n_i$, as $I_i = b_i(1 - S_i)$ and $I_{iq} = b_{iq}(1 - S_{iq})$. Since both weights and satisfaction indexes range from 0 to 1, the average improvement ranges from 0 to 1 (or 0–100% instead). It is 0 whenever the *i*th criterion (or sub-criterion) has null weight (no impact to the customer), or the customer is delighted with it.

4. Case study

This section presents the case study, which applies MUSA to surveys conducted within a Portuguese public hospital – *Local Health Unit of Castelo Branco*. This hospital is responsible for providing health care services to a population of nearly 200,000 inhabitants (34 inhabitants per km-squared). This population is featured by considerable aging (nearly two ancients per youngster) but an adequate supply of healthcare resources. For instance, there are 395 inhabitants per doctor and 242 inhabitants per nurse in Castelo Branco (2017 data), which compares with the values in the metropolitan area of the Portuguese capital city, Lisbon (373 and 385, respectively). Because of the population aging, one should promote some strategies to allure the younger population to that region. Good health care services with high satisfaction levels are potential engines to reach such a goal.

4.1. Sample and data collection

One hundred and fifty-four satisfaction cross-sectional surveys to the parents (or other legal guardians) of youngsters (aged less than eighteen) admitted to the hospital's pediatric nursery were obtained for this study. All inpatients were admitted in 2018. Customers were randomly selected to be survey participants. Respondents were mostly female (87%) and aged 20–75 (average: 31; standard deviation: 10; coefficient of variation: 32%, *i.e.*, low heterogeneity).[1]

There are two main models for the survey timing. The first conducts the survey immediately after discharge. In contrast, the second considers

the possibility of emotional biasing, thus surveying customers after a specific time lag ranging from two weeks up to three months [85]. Indeed, the survey timing can influence satisfaction. Several studies have analyzed such an impact, although without consistent conclusions about the best moment to conduct a survey [86–88]. In the present case, following the guidelines of both the hospital and the national health entities, surveys were conducted in 2018, through phone calls, three up to six months after the inpatient discharge. After this period, the objective of surveying was to filter possible emotional biasing that could somehow affect the customers' judgments. In some cases, such a period should be sufficient for the surveyed customers to get all the information they need to evaluate the service (including answers to complaints) fairly.

In general, children cannot fully understand what satisfaction is and which quality dimensions had a poor or a good performance. We assumed high parent-child agreement, although there exists some controversy in the literature [89–91]. Nonetheless, most of the studies scrutinized in Subsection 2.1 targeted their surveys towards the parents or legal guardians of the children who did receive health care, supporting our assumption.

4.2. Satisfaction criteria

Surveys were composed of fifty-one subcriteria (satisfaction subdimensions) unevenly distributed by eleven criteria (main satisfaction dimensions). These surveys were built by the Health Ministry itself, in line with the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS), widely employed in the USA [92,93]. Each satisfaction (sub)criterion intends to capture the quality of the delivered service from when the inpatient enters the nursery until she/he is discharged [94]. The main dimensions of quality assessed by the customers on behalf of the consumers were:

(i) Criterion 1 - the capacity of providing useful information in an exact way, including the patients' treatment guidelines, rights and duties, and means of complaint/suggestions;

(ii) Criterion 2 - the facilities, namely their cleanliness and hygiene, comfort and temperature, privacy and protection against noise, conservation status, the existence of amenities and hobbies, and adequacy and conservation of furniture;

(iii) Criterion 3 - visits, in terms of visiting schedules, length, and quantity, and the existence of assistance to the family;

(iv) Criterion 4 - food, considering its preparation, temperature, taste, diversity, and quantity;

(v) Criteria 5 to 10 - staff, considering doctors, nurses, health technicians, ancillary and administrative staff, as well as volunteers – in these criteria, we only considered the staff social skills, namely their concern for the patient, kindness, and sympathy, availability and readiness, and capacity of explaining the health condition, treatments, and further care; and

(vi) Criterion 11 - the leaving or discharge process, which is vital because it has impact on the quality of care at home and, therefore, on the achievement of good health outcomes.

Table 1 identifies and characterizes each of the satisfaction related dimensions and subdimensions considered in the surveys and our analysis.

Customers rated each satisfaction (sub)criterion using a seven-point symmetric Likert-type scale. Level four represents neutral judgments, while one (seven) represents the deeply dissatisfied (satisfied) level. According to the literature, seven levels maximize the reliability, validity, and discriminating power of results [95–98]. According to Miller [99], the human mind can distinguish about seven different items, including the ones in surveys. Perhaps, for these reasons, seven-point Likert scales have been extensively used in the healthcare-related literature [100–102]. However, we note that none of the studies found about

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[1] Parent's age can be determinant of satisfaction. To test that hypothesis, we ran an experiment by clustering the parents in terms of their age (younger than 35 and older than 35) and compared the MUSA outcomes. No meaningful differences were found, suggesting that age (in this case) may not be determinant of MUSA outcomes (criteria weights, demanding nature, …). It happens because the distribution of ages has a positive skew (tail is on the right).

satisfaction in pediatrics (see Subsection 2.1) have used a seven-point Likert scale as we do here. Therefore, some bias might exist in previous research in terms of the reliability of respondents' judgments.

5. Results and discussion

This section presents the main results of the application of MUSA to the Portuguese case study. We remark that Subsections 5.1, 5.2, and 5.3 are some contributions to the literature as the results translate the customers' preferences and behavior in pediatric inpatient services. Meanwhile, Subsection 5.4 presents some directions to improve the quality of the service in the case study; for this reason, results may not be extrapolated to other case studies (but researchers may adopt the same methodology to rank priorities elsewhere).

5.1. What do customers value the most?

Table 3 presents the primary outcomes resulting from MUSA applied to the pediatrics inpatient service. Weights estimated, according to all judgments, are provided in the third column. One may easily prove that the weight's centroid is equal to the reciprocal of the number of criteria (or subcriteria), no matter what cluster of customers has been considered for the analysis (satisfied, dissatisfied, or both). Therefore, the average weight is 9.09%; likewise, it is 1.92% for subcriteria. It means that criteria and subcriteria exhibiting weights above those thresholds are considered the most critical satisfaction dimensions. We may rank those dimensions in the same vein according to the achieved weights; see Table B.1 (see Appendix B).

It is interesting to note that, on behalf of customers' judgments, the model assigned larger weights to food, volunteers, and the capacity of the health care service to provide useful information to the customer on behalf of the inpatient. Accordingly, subcriteria, including the user rights and duties and treatment guide, the diversity, and quality (preparation, temperature, and taste) of food, and the kindness, sympathy, readiness, and availability of volunteers, belong to the top-10 sub-dimensions related to satisfaction. The subcriteria associated with the three most valued criteria exhibit weights above the average, 1.92%.

Surprisingly, the criteria usually associated with the clinical staff (doctors, nurses, and diagnosis/treatment technicians) and facilities achieved low weights. The bottom subcriteria of the ranking in Table B.1 are precisely related to those three criteria, meaning that factors such as the existence of hobbies, the room temperature, noise, the professionalism, and kindness of the clinical staff are the least essential dimensions of satisfaction. Low weights may reveal small margins for potential improvements in those dimensions, which in turn should witness either a strategy of resources transfer elsewhere or no further necessary action, depending upon the satisfaction level of customers in those satisfaction criteria.

5.2. Attributes classification using the Kano's model

According to Table 3, Kano's classification for each criterion is generally consistent with each subcriterion assessment. For example, all subcriteria associated with doctors' quality, including their professional competence and personal skills, are must-be requirements, taken for granted by the customers that do not become satisfied if practitioners are indeed right professionals but dissatisfied otherwise. Likewise, the quality of food, the facilities, the volunteers, and the discharge process are also must-be requirements.

In opposition, the quality of nursing care, the diagnosis technicians, the auxiliary, and the administrative staff, the capacity to deliver useful information, and the visits are all attractive to the customers. Hence, except for five subcriteria, customer satisfaction does not linearly change with the healthcare performance level.

Comparing these results to the previous subsection results, we observe that the criteria that contribute the most to the overall assessment of satisfaction are not necessarily must-be attributes. Indeed, according to the Kruskal-Wallis test for groups, Kano's classification and the nature of the (sub)criterion is not associated with estimated weights ($\chi^2 = 2.13$, $p = 0.34$). Instead, (sub)criteria exhibit different natures as attributes can be crucial to the customers, but their absence or poor performance may not contribute negatively to satisfaction. Consequently, the improvement of satisfaction largely depends on both the nature and the behavior of each criterion and subcriterion.

Weights represent the partial contribution of each (sub)criterion to the overall satisfaction. However, it is interesting to note that weights associated with dissatisfied customers are positively and significantly correlated with the ones of satisfied customers (see Table B.2, Appendix). Hence, we may predict the weight associated with one group of customers based on the other group or overall assessment through a linear regression model and a fair goodness-of-fit. Therefore, it would be tempting to conclude that satisfaction would change linearly with the provider's performance, as it happens with the one-dimensional requirements. Of course, it would not be correct because, as we have noted before, that change has little to do with each attribute's weight.

5.3. Demanding nature of customers

Table 1 characterizes the customers in terms of their demanding nature (seventh column). Customers were classified as non-demanding in nine subcriteria, neutral in seven, and demanding in thirty-five. That is, customers are, in general, demanding regarding the health care attributes.

We can construct a relationship between the demanding nature of customers and the classification of the Kano's model. Recalling the Kruskal-Wallis test to relate the demanding nature (index) of customers and the Kano's category, we get $\chi^2 = 14.90$ and $p = 6 \times 10^{-4}$ (<0.05), which means that demanding is related to the category and, hence, to the displacement of weights associated with each group of customers. Looking at averages, must-be requirements are the ones where demand is more extensive. These are followed by one-dimensional and, finally, by attractive requirements. It is expected because the absence or the poor performance in attractive requirements do not translate into dissatisfaction.

Additionally, provided that there is a negative trend between the weights related to the satisfied customers and the demanding index, we may expect that the larger the weight (regarding satisfied customers), the less demanding the customer is. Nonetheless, overall, no linear relationship between customers and weights' demanding nature can be assessed, which results partially from the nature of the (sub)criterion itself, according to the Kano's model. Demanding is also negatively correlated with the overall satisfaction index – Table B.2 (Appendix) –, meaning that must-be attributes are expected to be the ones with the lowest satisfaction levels.

5.4. Strategies and opportunities to enhance the satisfaction of customers in the case of LHU of Castelo Branco

MUSA allows us to construct two principal diagrams, as illustrated in Fig. 1: opportunities and actions (left side) and priorities (right side). The former relates weights and satisfaction and considers four quadrants: action opportunities, leverage opportunities, *status quo*, and transfer resources elsewhere. Action opportunities are a priority, being followed by leverage opportunities. These classifications are also provided in Table 4.

The two diagrams of Fig. 1 can represent a SWOT analysis. However, the conjoint study of them both may generate conflicting outcomes. Their results rarely let us construct a ranking of strategies reflecting what should be done first. Therefore, we started by looking at criteria classified as a first or top priority. Their subcriteria were ranked according to the strategic priorities and the opportunities, giving precedence to action opportunities, followed by leverage opportunities, and

these by resource transfer. The procedure follows a similar pathway for the remaining criteria with lower priority. Hence, we constructed the ranking of strategies provided in the last column of Table 2 and represented it as a five-level pyramid in Fig. 2.

It is worth commenting on the strong linear relationship between weights and satisfaction indexes of (sub)criteria (see Fig. 1, left side). Recalling Eq. (1) in Subsection 3.2.3., we verify that the satisfaction index is the linear combination of values or utilities associated with each satisfaction level. The frequencies per satisfaction level constitute the coefficients of that combination. We also know, from Subsection 3.2.2. and from Ferreira et al. [28] that the value of the most preferred satisfaction level is equal to the weight. Therefore, it is straightforward to conclude that a linear relationship $b = \alpha S + \beta$ reduces to $b = S$ when all customers are delighted with all service attributes. Deviations from that perfect linear regression (with $\alpha = 1$ and $\beta = 0$) occur when some customers are not entirely satisfied with a few attributes. In the current case study, we verify that customers were consistently delighted with the service provided. The linear regression also exhibits a significant coefficient of determination ($R^2 = 0.9501$). It implies that most attributes should be considered either as *status quo* (satisfaction index below the average) or as *leverage opportunities* (otherwise). Indeed, leverage opportunities or no actions are observed for most of the considered (sub) criteria. Action opportunities or resources transfer were observed only for a few criteria (when there is a broader dispersion of satisfaction rates).

The diagram of priorities (Fig. 1, right side) ranks the precedence of satisfaction requirements, classifying them into three priority levels, depending upon the demanding nature of customers and the potential improvements (expected effectiveness) associated with each (sub)criterion. Because customers are very demanding regarding healthcare (*vide supra*), most satisfaction attributes are positioned above the cut-off; hence, they can only be second or third priorities depending on the potential improvements' expected effectiveness. *Status quo* requirements require no further action; thus, they are mostly third priorities, requiring extraordinary efforts despite their small marginal potential improvement. However, the converse is not necessarily true. Based on the previous results, we verify that:

(i) The auxiliary staff's efficiency and concern with the children demand a very high priority action. In general, these employees support nurses in the (pediatric) ward, helping them regarding inpatients' hygiene, feeding, and comfort. Overall, customers are satisfied with these staff, classifying their efficiency and concern with the admitted youngsters as attractive requirements and leverage opportunities. However, there is substantial room for improvements with a small demanded effort.

(ii) The capacity to explain the users' rights and duties is a very high priority area (direct action) because of the low required effort for largely expected effectiveness.

(iii) Visiting is a satisfaction criterion requiring medium/medium-high attention, especially concerning the number and the scheduling of visits for which there is considerable room for improvement or, equivalently, largely expected effectiveness. The required effort is more considerable in the visits' timetable, which is a must-be requirement, *i.e.*, customers take this for granted and become dissatisfied whenever this scheduling and working hours overlap. Following the suggestion of Smith et al. [107], the hospital may opt for open visitation (liberal visiting) to improve customer satisfaction. It is interesting to note that both the visits' duration and the support to close relatives are *status quo* attributes for the customers, revealing a well-conducted family-centered strategy in the hospital [108].

(iv) Food is another area deserving medium priority actions. Notably, customers are deeply dissatisfied with food quality in terms of preparation, temperature, and taste. Although they could be satisfied with food diversity, this subcriterion demands a considerable effort for improvement. Food quality has been repeatedly reported as one of the biggest problems in inpatient services in Portuguese public hospitals, despite its importance for satisfaction [110–112]. Therefore, the hospital should implement some strategies to enhance the quality of foodservice.

(v) Communication skills of clinical staff (mainly doctors and nurses) deserve some enhancement strategies, with a medium priority. The capacity to communicate in a respectful, clear, direct, and explicit way to the customers and other professionals (interprofessional communication) is compulsory to promote trust, compliance, satisfaction, and patient safety [124]. A medical decision becomes unethical whenever the patient is not informed of any detail of the care process (informed consent). This communication with both youngsters and their parents depends on each health condition; for example, Essig et al. [125] report that the communication needs of children with cancer and with their parents are rarely met, despite the severity of illness. Lopez et al. [126] provide some strategies to improve communication between providers, patients, and families for children undergoing pediatric cardiac surgery. These strategies include coordinating care using a multidisciplinary care conference, composed of the responsible doctor, nurses, and other related staff and brochures and videos, to inform families and improve their understanding of their child care. Should these strategies be employed in the hospital, customer satisfaction will likely be improved.

(vi) Finally, facilities should similarly be ameliorated. A significant margin for improvement is expected for subcriteria like comfort and amenities, including hobbies, the inpatients' privacy, and adequacy and conservation of furniture. Interestingly, these subcriteria are must-be requirements so that customers will not become satisfied even if nurseries are comfortable and privacy is respected. However, these customers become dissatisfied otherwise.

6. Managerial implications

Nowadays, hospital managers (and healthcare managers and policymakers, in general) have potent tools to evaluate their customers' global and partial satisfaction [35]. Surveys constitute one of those tools. However, just looking at rates associated with those customers' judgments provides no useful information to be used by hospital managers [12,31,32]. Hospitals, either for- or not-for-profit businesses, depend on robust data-driven strategies to enhance their customer satisfaction and, as such, improve their health status [18,19]. Knowing what virtually drives (dis)satisfaction means that managers may act over critical success factors of their business instead of wasting resources on improving dimensions contributing just a little for satisfaction and profit [28].

We may retain several managerial implications from our analysis, recalling, however, the fact that these implications reveal the central tendency of the customers' judgments (Greco et al., 2014; [49]). First, hospital managers get essential and useful information underlying data, but it is not directly observable. The most relevant example is each criterion's weight that we may interpret as the criterion's impact on the *average* customer satisfaction. In the present case study, we identified food (diversity and quality in preparation, temperature, and taste), kindness, sympathy, readiness, and availability of volunteers, and the capacity of the health care service to provide useful information to the customer on behalf of the inpatient as the most relevant determinants of customer (dis)satisfaction. Let us consider the quality of food as a structural measure of hospital quality (Donabedian, 2005). This criterion is in line with King et al. [36], who concluded that relatively dissatisfied parents most often mentioned structural elements as dissatisfaction determinants. No study evaluated in our literature review mentioned food served in the ward as necessary for the patient. It can, of course, be the result of the different methodologies adopted all over the extensive literature about patient satisfaction. It is interesting to note

Table 3

Main outcomes from MUSA.

Criteria	Subcriteria	Weights [0, 100%]			Classification according to Kano's model	Demanding index[a]
		Overall	Dissatisfied	Satisfied		
1. Capacity of providing useful information	1.1. Children's treatment guidelines	3.40%	3.79%	3.36%	Must-be	−8% (ND)
	1.2. Children's rights and their families' duties	4.91%	3.79%	7.07%	Attractive	−28% (ND)
	1.3. Means of complaint and suggestion	3.13%	3.47%	3.34%	Must-be	−12% (ND)
	Overall	**11.44%**	**11.06%**	**13.77%**	**Attractive**	**−20%** (ND)
2. Facilities	2.1. Cleanliness and hygiene	0.58%	0.68%	0.60%	One-dimensional	−5% (N)
	2.2. Comfort and amenities	0.99%	1.20%	0.41%	Must-be	31% (D)
	2.3. Privacy of children and their families	0.82%	1.25%	0.34%	Must-be	19% (D)
	2.4. Adequacy and conservation of furniture and outfit	1.14%	1.57%	0.65%	Must-be	17% (D)
	2.5. Protection against noise	0.57%	1.47%	0.09%	Must-be	22% (D)
	2.6. Room temperature	0.63%	1.00%	0.17%	Must-be	1% (N)
	2.7. Existence of hobbies	0.84%	1.00%	0.67%	Must-be	1% (N)
	Overall	**5.57%**	**8.17%**	**2.94%**	**Must-be**	**21%** (D)
3. Visits	3.1. Visiting time	2.97%	3.65%	1.68%	Must-be	19% (D)
	3.2. Maximum allowed length of visits	1.30%	1.81%	1.13%	Must-be	14% (D)
	3.3. Quantity of allowed visits	2.83%	2.38%	6.07%	Attractive	−12% (ND)
	3.4. Assistance to the relatives	1.92%	1.99%	2.29%	Attractive	10% (D)
	Overall	**9.02%**	**9.84%**	**11.17%**	**Attractive**	**−6%** (ND)
4. Food	4.1. Preparation, temperature, and taste of food	3.16%	4.22%	1.63%	Must-be	35% (D)
	4.2. Diversity of food	4.46%	3.79%	4.85%	Attractive	4% (N)
	4.3. Quantity of food	2.59%	3.66%	1.06%	Must-be	38% (D)
	4.4. Support during meal	2.42%	3.10%	1.12%	Must-be	27% (D)
	Overall	**12.62%**	**14.77%**	**8.66%**	**Must-be**	**34%** (D)
5. Doctors	5.1. Readiness and availability	0.72%	0.71%	0.22%	Must-be	33% (D)
	5.2. Concern with the child	0.87%	0.77%	0.31%	Must-be	39% (D)
	5.3. Kindness and sympathy	0.83%	0.68%	0.36%	Must-be	18% (D)
	5.4. Child's health condition explanation	1.49%	1.77%	0.23%	Must-be	53% (D)
	5.5. Prescriptions explanation	1.28%	1.13%	0.49%	Must-be	39% (D)
	5.6. Diagnosis explanation	2.01%	2.04%	0.45%	Must-be	44% (D)
	5.7. Further care explanation	0.86%	1.01%	0.33%	Must-be	43% (D)
	Overall	**8.04%**	**8.11%**	**2.39%**	**Must-be**	**44%** (D)
6. Nurses	6.1. Readiness and availability	1.00%	0.69%	1.31%	Attractive	39% (D)
	6.2. Concern with the child	1.35%	0.85%	1.81%	Attractive	23% (D)
	6.3. Kindness and sympathy	1.36%	0.89%	1.34%	Attractive	30% (D)
	6.4. Child's health condition explanation	2.48%	1.26%	3.21%	Attractive	19% (D)
	6.5. Nursing treatments explanation	1.14%	0.67%	2.57%	Attractive	−11% (ND)
	6.7. Further care explanation	1.59%	1.25%	2.41%	Attractive	26% (D)
	Overall	**8.92%**	**5.61%**	**12.64%**	**Attractive**	**25%** (D)
7. Auxiliary staff	7.1. Readiness and availability	2.04%	1.73%	1.46%	Must-be	18% (D)
	7.2. Concern with the child	2.21%	1.89%	1.96%	Attractive	22% (D)
	7.3. Kindness and sympathy	1.54%	1.26%	2.43%	Attractive	−9% (ND)
	7.4. Efficiency	2.57%	1.38%	4.50%	Attractive	−26% (ND)
	Overall	**8.36%**	**6.26%**	**10.35%**	**Attractive**	**−15%** (ND)
8. Administrative staff	8.1. Readiness and availability	2.57%	2.64%	2.66%	One dimensional	17% (D)
	8.2. Concern with the child and her/his family	3.30%	3.02%	4.15%	Attractive	14% (D)
	8.3. Kindness and sympathy	1.30%	1.52%	2.38%	Attractive	7% (D)
	8.4. Efficiency	1.56%	1.76%	1.79%	One dimensional	20% (D)
	Overall	**8.73%**	**8.77%**	**10.99%**	**Attractive**	**−10%** (ND)
9. Volunteering	9.1. Readiness and availability	3.39%	4.07%	3.30%	Must-be	24% (D)
	9.2. Concern with the child	4.02%	4.23%	4.30%	One dimensional	1% (N)
	9.3. Kindness and sympathy	4.22%	4.74%	3.64%	Must-be	10% (D)
	Overall	**11.63%**	**13.05%**	**11.24%**	**Must-be**	**11%** (D)
10. Diagnosis and treatments	10.1. Readiness and availability	1.05%	1.14%	1.42%	Attractive	8% (D)
	10.2. Concern with the child	0.98%	0.92%	1.34%	Attractive	−8% (ND)
	10.3. Kindness and sympathy	0.68%	0.82%	0.71%	Must-be	26% (D)
	10.4. Child's health condition explanation	1.00%	1.16%	1.17%	One dimensional	22% (D)
	10.5. Medical treatments explanation	1.54%	1.25%	1.49%	Attractive	5% (N)
	10.6. Diagnosis explanation	0.86%	0.83%	1.42%	Attractive	−24% (ND)
	10.7. Further care explanation	1.37%	1.27%	1.80%	Attractive	13% (D)
	Overall	**7.48%**	**7.37%**	**9.36%**	**Attractive**	**8%** (D)
11. Discharge process	11.1. Details regarding care and practices at home	4.28%	3.33%	3.94%	Attractive	1% (N)
	11.2. Waiting time prior discharge	3.91%	3.66%	2.57%	Must-be	28% (D)
	Overall	**8.19%**	**6.99%**	**6.50%**	**Must-be**	**33%** (D)

[a] ND – non-demanding customers ($D \leq -5\%$); N – neutral customers ($5\% \leq D \leq -5\%$); D – demanding customers ($D \geq 5\%$).
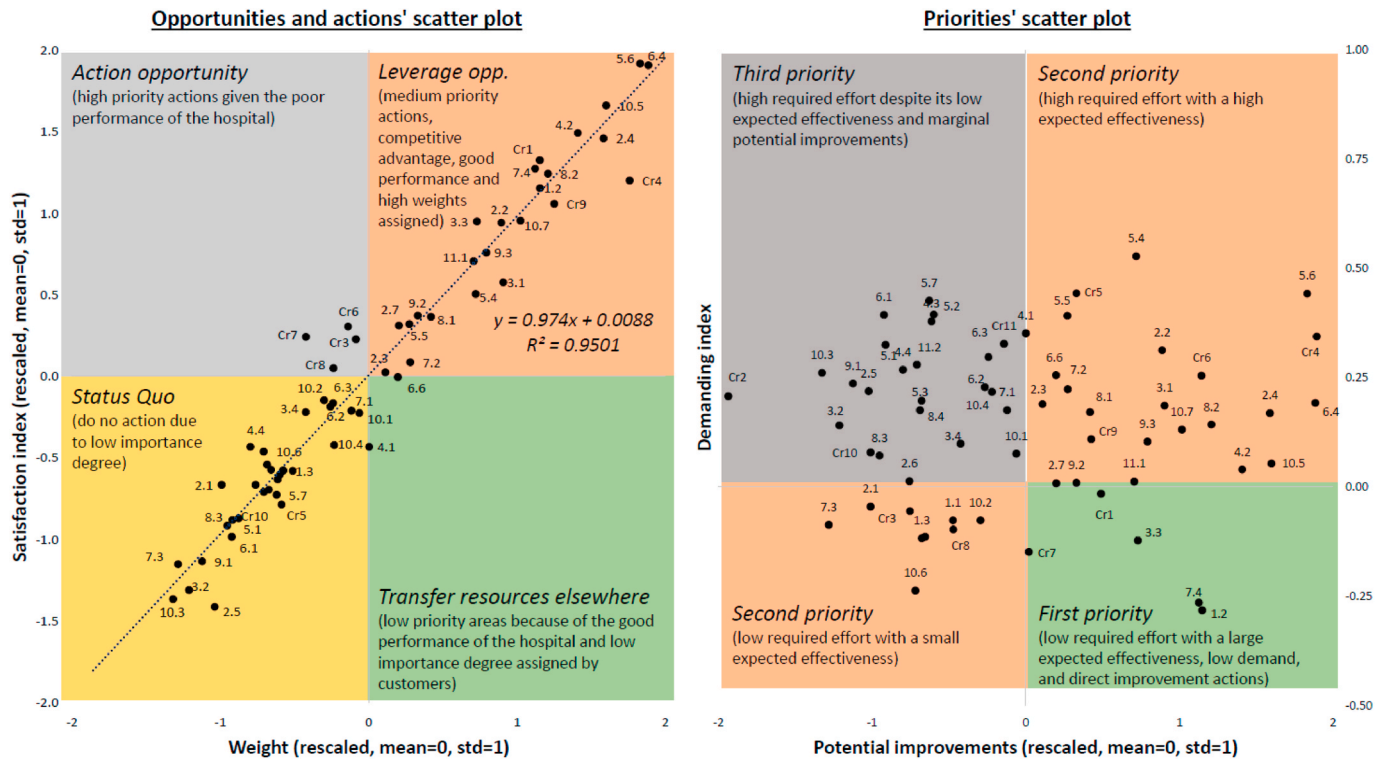
Fig. 1. Opportunities and priorities suggested to the hospital managers in the present case study.

that some studies have mentioned waiting time as a determinant of dissatisfaction [37,43,45]. King et al. [36] mention that the access (or the lack of it) to the existing services is a critical dimension associated with satisfaction. We remark that waiting time and waiting lists are associated with barriers to access. However, these results found in the literature were not confirmed by MUSA. Barsoom et al. [42] conclude that waiting time is not that important to the customer in the pediatric ward, which is in line with our findings.

In opposition, cheerfulness of care and the capacity to explain well the treatments within the hospital and at home have been pointed out as relevant criteria for dissatisfaction in several studies and our study. Barsoom et al. [42] and Davis et al. [43] mention the kindness of staff (social skills), while King et al. [36] mention the provider's information about medicines as the most crucial. Peng et al. [44] conclude that both are decisive. Previous studies are in line with our findings, although they have been mostly devoted to clinical staff, while our findings point towards the volunteers. We may argue that sometimes customers do not discern volunteers from the clinical staff, so the second criterion is also in line with these authors.

Another remarkable output of MUSA is the potential or margin for improvement of each satisfaction criterion. The smaller the margin, the smaller the hospital managers' interest in improving it if the customer's impact is small. The third output of this model is the demanding nature of customers regarding each criterion of quality. Hence, we may estimate how the value for the customers should behave when the hospital performance increases. Second, managers may rank priorities of what should be improved in line with (*i*) the highly valued criteria, (*ii*) the attributes with considerable room for improvement, and (*iii*) the high demand of customers. If a dimension is less valued or has no improvement margin, and customers are not demanding at all, then any strategy focused on that criterion is pointless. The latter adds no value to the service and is unlikely to enhance the satisfaction of customers. Naturally, these outcomes are not directly observable from the raw data provided by the surveys. Therefore, we can interpret them as latent dimensions. Third, managers get the strategic opportunities that can be

useful for a robust strategy design for business leverage. Thus, strategies for satisfaction enhancement do not depend solely on the criteria with the lowest satisfaction levels, but also on the estimated weights, the nature of each criterion, the demanding nature of the customers, and on the technical margin for improvements.

7. Concluding remarks

The current study sheds light on the potentialities of MUSA. This model constructs value functions associated with satisfaction criteria and subcriteria. It infers weights, which should be the contribution of each partial value function to the overall value function that describes customers' overall satisfaction level. Provided that the model is based on achieving a central tendency for satisfaction determinants, we can also propose strategies and find opportunities to enhance customer satisfaction.

The case study was based on a pediatric inpatient service in a Portuguese public hospital. First, a sizeable parent-child agreement was assumed, given that youngsters cannot usually unbiasedly answer such an extensive satisfaction survey. Some researchers could disagree with our approach, admitting that such an agreement, in practice, is not enough to guarantee unbiased results. Interesting further research is then to survey a few youths and compare the obtained outcomes with the current research ones. Second, this study's local population may limit the extrapolation of our results to other situations (other services in the same hospital, other Portuguese hospitals, and other countries). However, we remark that the mathematical model should be applied per health care provider as opportunities and strategies should be analyzed case-by-case. The usefulness of the model lies, precisely, in its flexibility and capacity of proposing individual strategies. Nonetheless, since strategies should be studied per service, some conflicts may arise for managers. Our results should also be confirmed using some other alternative methods available in the literature, as mentioned in subsection 2.2.

Although some shortcomings can be identified in the methods

Table 4
Opportunities and strategic priorities.

Criteria	Subcriteria	Potential improvement [0, 100%]	Satisfaction index [-100, 100]	Strategic opportunities	Strategic priorities	Ranking of strategies
1. Capacity of providing useful information	**1.1. Children's treatment guidelines**	16%	−66	Status Quo	–	–
	1.2. Children's rights and their families' duties	24%	100	Leverage Opp.	First priority	1
	1.3. Means of complaint and suggestion	15%	−100	Status Quo	–	–
	Overall	**10%**	100	Leverage Opp.	First priority	–
2. Facilities	**2.1. Cleanliness and hygiene**	10%	−48	Status Quo	–	–
	2.2. Comfort and amenities	18%	64	Leverage Opp.	Second priority	5
	2.3. Privacy of children and their families	15%	0	Leverage Opp.	Second priority	5
	2.4. Adequacy and conservation of furniture and outfit	20%	100	Leverage Opp.	Second priority	5
	2.5. Protection against noise	10%	−100	Status Quo	–	–
	2.6. Room temperature	11%	−48	Status Quo	–	–
	2.7. Existence of hobbies	15%	20	Leverage Opp.	Second priority	5
	Overall	**4%**	−100	Status Quo	Third priority	–
3. Visits	**3.1. Visiting time**	33%	67	Leverage Opp.	Second priority	4
	3.2. Maximum allowed length of visits	14%	−100	Status Quo	–	–
	3.3. Quantity of allowed visits	31%	100	Leverage Opp.	First priority	3
	3.4. Assistance to the relatives	21%	−4	Status Quo	–	–
	Overall	**7%**	38	Transfer resources	Second priority	–
4. Food	**4.1. Preparation, temperature, and taste of food**	25%	−81	Action Opp.	Second priority	4
	4.2. Diversity of food	35%	100	Leverage Opp.	Second priority	4
	4.3. Quantity of food	20%	−100	Status Quo	–	–
	4.4. Support during meal	19%	−81	Status Quo	–	–
	Overall	**14%**	93	Leverage Opp.	Second priority	–
5. Doctors	**5.1. Readiness and availability**	9%	−100	Status Quo	–	–
	5.2. Concern with the child	11%	−80	Status Quo	–	–
	5.3. Kindness and sympathy	10%	−76	Status Quo	–	–
	5.4. Child's health condition explanation	18%	−1	Leverage Opp.	Second priority	4
	5.5. Prescriptions explanation	16%	−14	Leverage Opp.	Second priority	4
	5.6. Diagnosis explanation	25%	100	Leverage Opp.	Second priority	4
	5.7. Further care explanation	11%	−89	Status Quo	–	–
	Overall	**10%**	−20	Status Quo	Second priority	–
6. Nurses	**6.1. Readiness and availability**	11%	−100	Status Quo	–	–
	6.2. Concern with the child	15%	−45	Status Quo	–	–
	6.3. Kindness and sympathy	15%	−43	Status Quo	–	–
	6.4. Child's health condition explanation	28%	100	Leverage Opp.	Second priority	4
	6.5. Nursing treatments explanation	13%	−72	Status Quo	–	–
	6.7. Further care explanation	18%	−32	Action Opp.	Second priority	4
	Overall	**12%**	42	Transfer resources	Second priority	–
7. Auxiliary staff	**7.1. Readiness and availability**	24%	−22	Status Quo	–	–
	7.2. Concern with the child	26%	2	Leverage Opp.	Second priority	2
	7.3. Kindness and sympathy	18%	−100	Status Quo	–	–
	7.4. Efficiency	30%	100	Leverage Opp.	First priority	1
	Overall	**9%**	38	Transfer resources	First priority	–
8. Administrative staff	**8.1. Readiness and availability**	29%	19	Leverage Opp.	Second priority	4
	8.2. Concern with the child and her/his family	37%	100	Leverage Opp.	Second priority	4
	8.3. Kindness and sympathy	15%	−100	Status Quo	–	–
	8.4. Efficiency	18%	−80	Status Quo	–	–
	Overall	**8%**	27	Transfer resources	Second priority	–

Table 4 (*continued*)

| Criteria	Subcriteria	Potential improvement [0, 100%]	Satisfaction index [-100, 100]	Strategic opportunities	Strategic priorities	Ranking of strategies
9. Volunteering	9.1. Readiness and availability	29%	−100	Status Quo	–	–
	9.2. Concern with the child	34%	59	Leverage Opp.	Second priority	4
	9.3. Kindness and sympathy	36%	100	Leverage Opp.	Second priority	4
	Overall	**10%**	85	Leverage Opp.	Second priority	–
10. Diagnosis and treatments	10.1. Readiness and availability	14%	−25	Status Quo	–	–
	10.2. Concern with the child	13%	−19	Status Quo	–	–
	10.3. Kindness and sympathy	9%	−100	Status Quo	–	–
	10.4. Child's health condition explanation	13%	−38	Status Quo	–	–
	10.5. Medical treatments explanation	20%	100	Leverage Opp.	Second priority	5
	10.6. Diagnosis explanation	11%	−40	Status Quo	–	–
	10.7. Further care explanation	18%	53	Leverage Opp.	Second priority	5
	Overall	**6%**	−25	Status Quo	Third priority	–
11. Discharge process	11.1. Details regarding care and practices at home	52%	100	Leverage Opp.	Second priority	5
	11.2. Waiting time prior to discharge	47%	−100	Status Quo	–	–
	Overall	**9%**	−9	Status Quo	Third priority	–
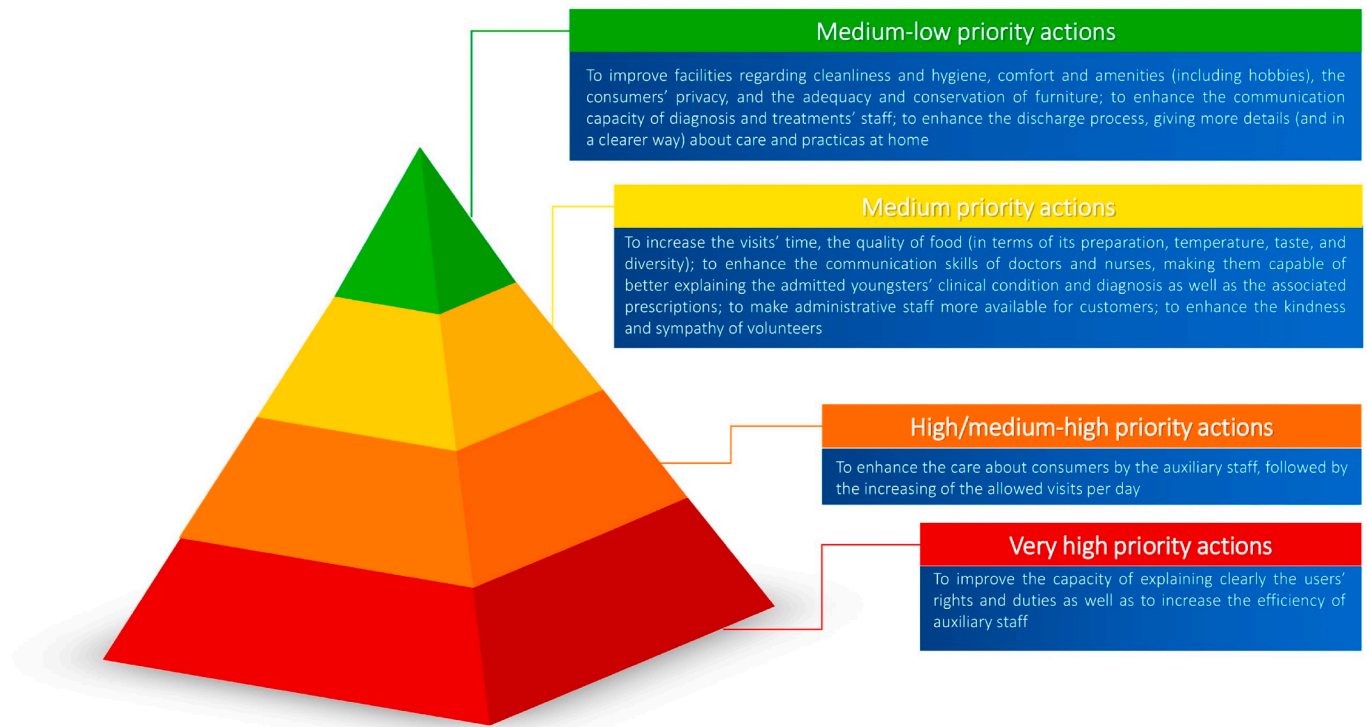
Fig. 2. Pyramid of priority actions for the present case study.

proposed elsewhere, the truth is that MUSA is not entirely flawless and needs further developments, such as imperfect knowledge of data. Indeed, the results achieved in this study should be confronted with others obtained via ordered logistic regression, principal component logistic regression [65], and multiobjective interval programming models (Marcenaro-Gutierrez et al., 2010; Henriques et al., 2019, 2020). The last alternative was already applied to explore the trade-offs among different aspects of job satisfaction, but never to the healthcare sector.

Data availability statement

Declaration of competing interest

Acknowledgments

Appendix A. Mathematical details on MUSA

A.1. An overview

MUSA follows the principles of ordinal regression analysis and aims to measure and analyze customers satisfaction and its determinants.

Let us consider the variables presented in Table A.1. If $X = \{X_1 \dots X_n\}$ denotes a set of monotonic criteria, then MUSA can be understood as a Multiple Criteria analysis problem. Moreover, if each customer's global satisfaction, Y, can be written as a normalized weighted sum of each customer satisfaction concerning all n criteria,

$$Y = \sum_{i=1}^{n} b_i X_i \text{ and } \sum_{i=1}^{n} b_i = 1 \text{ and } Y, X_i \in [0, 1], \text{ for all } i = 1 \dots n,$$

then MUSA follows the principles of (constrained) ordinal regression analysis. In view of that, $\{Y^m \prec Y^{m+1} \Leftrightarrow y^{*m} < y^{*m+1}, \ m = 1 \dots \alpha - 1\}$ and $\{X_i^k \prec X_i^{k+1} \Leftrightarrow x_i^{*k} < x_i^{*k+1}, \ k = 1 \dots \alpha_i - 1, \ i = 1 \dots n\}$, where $\prec$ represents lower preference, and stars, *, stand for optimized values.

Table A.1
The Multiple Criteria Customer Satisfaction Analysis' variables.

Variable	Description
Y	Customer global satisfaction
A	Number of global satisfaction levels
y^m	The mth value in terms of the global satisfaction scale ($m = 1 \dots \alpha$)
N	Number of criteria
X_i	Customer satisfaction in the ith criterion ($i = 1 \dots n$)
α_i	Number of satisfaction levels for the ith criterion
x_i^k	The kth value of the ith criterion
M	Total number of customers
t_j	Judgement of the jth customer for global satisfaction
t_{ji}	Judgement of the jth customer for (partial) satisfaction on ith criterion
z_m	Transformed variable: $z_m = y^{m+1} - y^m$
w_{ik}	Transformed variable: $w_{ik} = b_i(x_i^{k+1} - x_i^k)$
n_i	Number of subcriteria for the ith criterion
X_{iq}	Customer satisfaction on qth subcriterion of the ith criterion
α_{iq}	Number of satisfaction levels for the ith criterion and the qth subcriterion
x_{iq}^k	The kth satisfaction level of the ith criterion and the qth subcriterion

Admitting the existence of some error on customers' judgments, one can write her/his global satisfaction score as follows.

$$\widehat{Y} = \sum_{i=1}^{n} b_i X_i - \sigma^+ + \sigma^-, \tag{A.1}$$

where σ^+ and σ^- respectively represent the overestimation and the underestimation errors of the global value function, $\widehat{Y}$.

Grigoroudis and Siskos [35,48] identify the main objective of the Multiple Criteria Customer Satisfaction Analysis: to minimize the total estimation error, F, for all customers, $j = 1, \dots, M$:

$$F = \sum_{j=1}^{M} \left(\sigma_j^+ + \sigma_j^- \right). \tag{A.2}$$

The optimization of F in Eq. (2) requires the imposition of constraints. Keeping the Multiple Criteria Customer Satisfaction Analysis as linear and straightforward as possible, still useful and practical, constraints must be linear as well. Following Grigoroudis and Siskos, one shall utilize both z_m and w_{ik} (cf. Table A.1) for such a purpose. First, both z_m and w_{ik} must be normalized, leading to the following two constraints, where δ_1 and δ_2 are two user-defined parameters:

$$\sum_{m=1}^{\alpha-1} z_m = \delta_1, \tag{A.3}$$

$$\sum_{i=1}^{n} \sum_{k=1}^{\alpha_i-1} w_{ik} = \delta_2. \tag{A.4}$$

The third constraint implies that there is a potential gap (due to the judgment errors) between global and partial satisfaction of all customers. That can be modeled as shown in Eq. (A.5). As before, δ_3 is a parameter to be defined by the user.

$$\sum_{i=1}^{n} \sum_{k=1}^{t_{ji}-1} w_{ik} - \sum_{m=1}^{t_j-1} z_m - \left(\sigma_j^+ - \sigma_j^- \right) = \delta_3, \ j = 1 \ldots M. \tag{A.5}$$

Admitting the nonnegativity over the linear model variables ($\sigma_j^+, \sigma_j^-, w_{ik}, z_m$), the linear programming model is simply given by Eq. (A.6), where the bar, |, means "*subject to.*"

$$F^* = \min_{\{\sigma_j^+, \sigma_j^-, w_{ik}, z_m\} \geq 0} \{F \mid \text{Eqs. (A.3 - A.5)}\} \tag{A.6}$$

The number of optimal solutions in Eq. (A.6) can be vast as the linear programming model has $M+2$ constraints and $2\,M+(\alpha–1)+\Sigma_{i=1\ldots n}(\alpha_i–1)$ variables. Therefore, a post-optimal analysis for stability purposes is desired if $F^* > 0$. Let us define ε as a small (given) number, say 5% of F^*, cf. Eq. (A.6), and the new objective function:

$$G_i = \sum_{k=1}^{\alpha_i-1} w_{ik}, \ i = 1 \ldots n \tag{A.7}$$

Considering the polyhedron $\mathscr{P}$ as follows:

$$\mathscr{P} = \begin{Bmatrix} F \leq (1+\varepsilon)F^* \\ \text{Eqs. (A.3 - A.5)} \end{Bmatrix} \tag{A.8}$$

one may run the following model (A.9) n times and compute the arithmetic mean of their optimal solutions to obtain the final solution:

$$G_i^* = \max_{\{\sigma_j^+, \sigma_j^-, w_{ik}, z_m, F\} \geq 0} \{G_i \mid \mathscr{P}\}, \ i = 1 \ldots n \tag{A.9}$$

A.2. Strict preference

By means of Table A.1, both z_m and w_{ik} allow the hypothesis of indifference between two consecutive satisfaction levels. If this is not an admissible hypothesis, previous models (A.6) and (A.9) are not valid ones. Consider the transformations $z'_m = z_m - \gamma$ and $w'_{ik} = w_{ik} - \gamma_i$, such that both γ and γ_i are both strictly positive decision variables accounting for the difference between two consecutive satisfaction levels (for each criterion and subcriterion). In such a case, one has:

$$\delta_1 = 1 - \gamma(\alpha - 1) > 0 \tag{A.10}$$

$$\delta_2 = 1 - \sum_{i=1}^{n} \gamma_i(\alpha_i - 1) > 0 \tag{A.11}$$

$$\delta_3 = \gamma(t_j - 1) - \sum_{i=1}^{n} \gamma_i(t_{ji} - 1) \tag{A.12}$$

Note that Eqs. (A.10-A.12) can be obtained only if $\delta_1 = \delta_2 = 1$ and $\delta_3 = 0$ in Eqs. (A.3- A.5). By replacing z_m by z'_m and w_{ik} by w'_{ik} on Eqs. (A.3- A.5) and (A.7), and by assuming the values of δ_r, $r = 1, 2, 3$ from Eqs. (A.10- A.12), the generalized problem becomes:

$$\widetilde{F}^* = \min_{\{\sigma_j^+, \sigma_j^-, w'_{ik}, z'_m, \gamma, \gamma_i\} \geq 0} \left\{ F \left| \begin{matrix} \text{Eqs. (A.3 - A.5)} \\ \text{Eqs. (A.10 - A.12),} \end{matrix} \right. \right\} \tag{A.13}$$

$$\widetilde{\mathscr{P}} = \begin{Bmatrix} F \leq (1+\varepsilon)\widetilde{F}^* \\ \text{Eqs. (A.3 - A.5)} \\ \text{Eqs. (A.10 - A.12)} \end{Bmatrix} \tag{A.14}$$

$$\widetilde{G}_i^* = \max_{\{\sigma_j^+, \sigma_j^-, w'_{ik}, z'_m, \gamma, \gamma_i\} \geq 0} \left\{ G_i \left| \widetilde{\mathscr{P}} \right. \right\}, \ i = 1 \ldots n \tag{A.15}$$

Finally, observe that for strictly preference it would be sufficient to consider z_m and w_{ik} both strictly positive. However, we still need to impose very small thresholds to operationalize the model. Eqs. (A.13- A.15) generalize the basic MUSA model, which, in turn, results from $\gamma = \gamma_i = 0, i = 1...n$.

Different scenarios can be drawn, being noteworthy two of them. Let us consider a customer $j \in \{1 \ldots m\}$ who is deeply unsatisfied concerning all criteria and, consistent with that, concerning the entire service. Under such hypothesis and from Eqs. (A.5) and (A.12), one has $t_{ji} = t_j = 1 \Rightarrow -\sigma_j^+ + \sigma_j^- = 0$. Since $\sigma_j^+, \sigma_j^- \geq 0$, $\widetilde{F}^*$ is minimum if and only if $\sigma_j^+ = \sigma_j^- = 0$, which corresponds to drop this customer out of the sample. Likewise, a customer j, who is deeply satisfied both partial and globally, verifies $t_{ji} = \alpha_i \cap t_j = \alpha \Rightarrow \sum_{i=1}^{n} \sum_{k=1}^{t_{ji}-1} w_{ik} + \sum_{i=1}^{n} \gamma_i(t_{ji} - 1) = \sum_{i=1}^{n} \sum_{k=1}^{\alpha_i-1} w_{ik} + \sum_{i=1}^{n} \gamma_i(\alpha_i - 1) = 1$, cf. Eq. (A.11) $\cap$ $\sum_{m=1}^{t_j-1} z_m + \gamma(t_j - 1) = \sum_{m=1}^{\alpha-1} z_m + \gamma(\alpha - 1) = 1$, cf. Eq. (10) $\Rightarrow -\sigma_j^+ + \sigma_j^- = 0$. As before, this customer j can be removed from the sample. That is, MUSA only considers those customers that are not fully satisfied nor dissatisfied with the provided service.

A.3. The value hierarchy case

In few situations, as happens with the present study, criteria are aggregated in a treelike structure. In this case, each criterion may have several subcriteria, which in turn may have subsubcriteria and so on. In view of that, and considering the case of two levels only, the objective function becomes:

$$H = F + \frac{1}{n} \sum_{j=1}^{M} \sum_{i=1}^{n} \left(\sigma_{ji}^+ + \sigma_{ji}^- \right). \tag{A.16}$$

Two new constraints should then be added to Eq. (A.13).

$$\sum_{q=1}^{n_i} \sum_{k=1}^{t_{jiq}-1} w_{iqk} - \sum_{k=1}^{t_{ji}-1} w_{ik} - \left(\sigma_{ji}^+ - \sigma_{ji}^- \right) = \delta_4, \; j = 1...M, \; i = 1...n, \tag{A.17}$$

$$\sum_{i=1}^{n} \sum_{q=1}^{n_i} \sum_{k=1}^{\alpha_{iq}-1} w_{iqk} = \delta_5, \tag{A.18}$$

where $\delta_4 = \gamma_i(t_{ji} - 1) - \sum_q \gamma_{iq}(t_{jiq} - 1)$ and $\delta_5 = 1 - \sum_i \sum_q \gamma_{iq}(\alpha_{iq} - 1)$. Therefore, the new solution is given by:

$$H^* = \min_{\{\sigma_j^\pm, w_{ik}', z_m', \gamma, \gamma_i, \gamma_{iq}, w_{iqk}, \sigma_{ji}^\pm\} \geq 0} \left\{ H \left| \begin{array}{l} \text{Eqs. } (A.3 - A.5) \\ \text{Eqs. } (A.10 - A.12) \\ \text{Eqs. } (A.17 - A.18) \end{array} \right. \right\}. \tag{A.19}$$

Once Eq. (A.19) has been executed (optimized), one may achieve some critical outcomes. Weights associated with each criterion and subcriterion are as follows:

$$\begin{cases} b_i = \sum_{t=1}^{\alpha_i-1} w_{it}^*, \; i = 1...n, \\ b_{iq} = \sum_{k=1}^{\alpha_{iq}-1} w_{iqk}^*, q = 1...n_i, \; i = 1...n. \end{cases} \tag{A.20}$$

Meanwhile, the value functions for criteria and subcriteria become:

$$y^{*m} = \sum_{t=1}^{m-1} z_t^*, \; m = 2...\alpha, \tag{A.21}$$

$$\begin{cases} x_i^{*k} = \dfrac{\sum_{t=1}^{k-1} w_{it}^*}{b_i^*}, i = 1...n, \; k = 2...\alpha_i, \\ x_i^{*k_q} = \dfrac{\sum_{t=1}^{k_q-1} w_{iqt}^*}{b_{iq}^*}, i = 1...n, q = 1...n_i, \; k_q = 2...\alpha_{iq}. \end{cases} \tag{A.22}$$

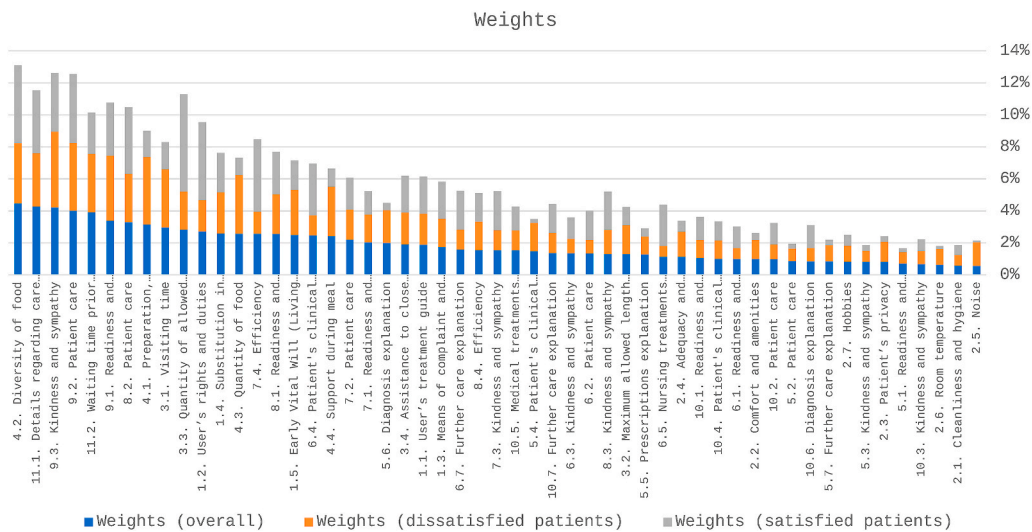## Appendix B. Additional tables and/or figures

Fig. B.1. Weights of each sub-criteria.

Table B.1
Ranking of criteria and sub-criteria according to weights estimated by the Multiple Criteria Customer Satisfaction Analysis.

		Weight (overall)
Criteria	**4. Food**	**12.62%**
	9. Volunteering	**11.63%**
	1. Capacity of providing useful information	**11.44%**
	Average (criteria)	**9.09%**
	3. Visits	**9.02%**
	6. Nurses	**8.92%**
	8. Administrative staff	**8.73%**
	7. Auxiliary staff	**8.36%**
	11. Discharge process	**8.19%**
	5. Doctors	**8.04%**
	10. Diagnosis and treatments	**7.48%**
	2. Facilities	**5.57%**
	Sum of weights (excluding average)	**100.00%**
Sub-criteria	**1.2. User rights and duties**	**4.91%**
	4.2. Diversity of food	**4.46%**
	11.1. Details regarding care and practices at home	**4.28%**
	9.3. Kindness and sympathy	**4.22%**
	9.2. Customer care	**4.02%**
	11.2. Waiting time prior discharge	**3.91%**
	1.1. User treatment guide	**3.40%**
	9.1. Readiness and availability	**3.39%**
	8.2. Customer care	**3.30%**
	4.1. Preparation, temperature, and taste of food	**3.16%**
	1.3. Means of complaint and suggestion	**3.13%**
	3.1. Visiting time	**2.97%**
	3.3. Quantity of allowed visits	**2.83%**
	4.3. Quantity of food	**2.59%**
	7.4. Efficiency	**2.57%**
	8.1. Readiness and availability	**2.57%**
	6.4. Customer's clinical status explanation	**2.48%**
	4.4. Support during meal	**2.42%**
	7.2. Customer care	**2.21%**
	7.1. Readiness and availability	**2.04%**
	5.6. Diagnosis explanation	**2.01%**
	Average (sub-criteria)	**1.92%**
	3.4. Assistance to close relatives	**1.92%**
	6.7. Further care explanation	**1.59%**
	8.4. Efficiency	**1.56%**
	7.3. Kindness and sympathy	**1.54%**
	10.5. Medical treatments explanation	**1.54%**
	5.4. Customer's clinical status explanation	**1.49%**
	10.7. Further care explanation	**1.37%**
	6.3. Kindness and sympathy	**1.36%**
	6.2. Customer care	**1.35%**
	8.3. Kindness and sympathy	**1.30%**

Table B.1 (*continued*)

	Weight (overall)
3.2. Maximum allowed length of visits	1.30%
5.5. Prescriptions explanation	1.28%
6.5. Nursing treatments explanation	1.14%
2.4. Adequacy and conservation of furniture	1.14%
10.1. Readiness and availability	1.05%
10.4. Customer's clinical status explanation	1.00%
6.1. Readiness and availability	1.00%
2.2. Comfort and amenities	0.99%
10.2. Customer care	0.98%
5.2. Customer care	0.87%
10.6. Diagnosis explanation	0.86%
5.7. Further care explanation	0.86%
2.7. Hobbies	0.84%
5.3. Kindness and sympathy	0.83%
2.3. Customer privacy	0.82%
5.1. Readiness and availability	0.72%
10.3. Kindness and sympathy	0.68%
2.6. Room temperature	0.63%
2.1. Cleanliness and hygiene	0.58%
2.5. Noise	0.57%
Sum of weights (excluding average)	**100.00%**

Table B.2

Correlation matrix associated with the outcomes of the Multiple Criteria Customer Satisfaction Analysis.

		Weights			Potential improvements	Demanding index	Satisfaction index
		Overall	Dissatisfied	Satisfied			
Weights	Overall	1					
	Dissatisfied	0.9632	1				
	Satisfied	0.8997	0.7998	1			
Potential improvements		−0.1128	−0.1513	−0.1032	1		
Demanding index		−0.1481	−0.0816	−0.4054	−0.0449	1	
Satisfaction index		0.3985	0.3143	0.4465	0.4055	−0.2793	1

Note: Italic entries identify non-significant correlation coefficients ($p > 0.05$ for the null hypothesis H$_0$: corr = 0).

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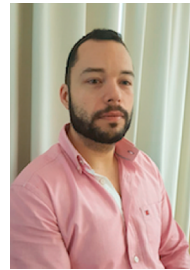
Diogo Cunha Ferreira, PhD, is Professor of Systems and Management of Infrastructure at Instituto Superior Técnico (IST) from the University of Lisbon and research member of CERIS, at IST. His areas of interest comprise the regulation and governance of public services as well as performance measurement and benchmarking of organizations.

Rui Cunha Marques, PhD, is Full Professor of Systems and Management of Infrastructure at Instituto Superior Técnico (IST) from the University of Lisbon, a research member of CERIS, at IST, and a Senior Research Associate of Public Utility Research Center (PURC) of the University of Florida. His areas of interest comprise the regulation and governance of public services as well as performance measurement and benchmarking of organizations.

Alexandre Nunes, PhD, is Professor of Public Administration at CAPP (Public Policy Management Center), Instituto Superior de Ciências Sociais e Políticas, Universidade de Lisboa, Portugal, and the technical advisor of the (Portuguese) Minister of Health. His research interests include public administration and health systems' performance.

José Rui Figueira, PhD, is Full Professor at IST (Universidade de Lisboa) and researcher at CEG-IST. Professor Figueira taught also at University of Evora, University of Coimbra, Nancy's School of Mines (where he got a Full Professor position). He is a former member of LAMSADE, INESC-Coimbra, and DIMACS (Rutgers and Princeton Universities) research centers. Professor Figueira is the co-editor of the book, "Multiple Criteria Decision Analysis: State of the Art Surveys, Springer Science + Business Media, Inc, 2016 (2nd Edition). He currently serves as a coordinator of the European Working Group on Multiple Criteria Decision Aiding. He is Associate Editor of JMCDA, he belongs to the Editorial Board of EJOR and also belongs to the advisory board of other scientific international journals. He was awarded with the Gold Medal of the International Society on MCDA in July 2017.