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Evaluating service quality dimensions as antecedents to outpatient satisfaction using back propagation neural network

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Abstract Nowadays the ability to provide outpatient services with exceptional quality is paramount to long-term survival of hospitals, as the revenues from outpatient services are predicted to equal or exceed inpatient revenues in the near future. Identifying the relative weight of different dimensions of healthcare quality service which concur together to determine outpatients satisfaction is very important, as it can help healthcare managers to allocate resources more efficiently and identify managerial actions able to guarantee higher levels of patients' satisfaction. This study proposes the use of Artificial Neural Network (ANN) as a knowledge discovery technique for identifying the service quality factors that are important to outpatient. An ANN model is developed on data from a panel of outpatients of public healthcare services.

Keywords Service quality · Outpatients satisfaction · Artificial neural network

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1 Introduction

There is growing interest in evaluating patient satisfaction to highlight aspects of care that need improvement and increase continuously quality of health care and health outcomes [1]. There are many different reasons underlying this interest. Basically capturing the voice of the patient/client is an essential element of policy planning and provides a valuable knowledge platform for an effective and efficient management of care. Feedback from patients/clients can influence the quality improvement policies and provides an opportunity for organizational learning and development. It provides crucial information on what the patients/clients' expectations are and how they perceive the quality of care [2].

Additionally the rapidly increasing cost of healthcare and the imperative for effectiveness are calling healthcare organizations to improve their ability to retain/attract patients [3], to guarantee high quality services and contain costs. In addition nowadays patient satisfaction is considered by healthcare organizations as a key performance driver for getting accreditation. In 1994 the Joint Commission of Accreditation of Health Care Organizations has embraced patient/client satisfaction as a valid indicator and mandated in its 1994 standards for accreditation that organizations gather, assess, and take appropriate actions on information that relates to patient/client's satisfaction.

The American College of Healthcare Executives reported in the results of its annual survey [4] that the patient satisfaction is in the top 10 items of greatest concerns of hospital CEOs. On the other hand "satisfying patients' needs is the first step toward having loyal patients, so hospitals that strive to ensure their patients are completely satisfied are more likely to prosper" [5, p. 93].

In this scenario, governments and regulatory authorities increasingly require healthcare organizations to evaluate

patients' experience. This is critical in order to increase public knowledge about whether the healthcare system is being effectively managed, resources well allocated, and efforts are implemented to make sure improvements are achieved in those areas where performance information has raised concerns [6].

Despite the interest in measuring patient satisfaction is increasingly widespread, the definitive conceptualization of satisfaction with healthcare has still not been achieved and the understanding of the process by which a patient becomes satisfied or dissatisfied remains unanswered [7, 8]. In particular, Crow et al. [7] suggested that satisfaction is a relative concept and that it only implies adequate service. More generally, as underlined by Gill and White [9], in the healthcare sector the satisfaction is a multidimensional concept, not yet tightly defined.

Over time the notion of patient satisfaction has been linked to health quality and considered as a part of health outcome quality [10].

Several studies have shown that there are many different service quality dimensions affecting patient satisfaction. For example waiting time, real or perceived, is often found to influence satisfaction of the patients [11, 12]; inclusion of patients in the decision-making process, as well as the degree of such participation, has been found to be strongly associated with overall satisfaction [13]; similarly patient perception of the time spent with doctor [13] and clarity of answers/information received from medical staff have been found strongly associated with overall satisfaction [7, 14].

Most of the studies investigating the factors influencing patient satisfaction have analyzed these factors singularly and by using traditional statistical techniques.

Regardless the different foci of investigation, these various studies highlight that several dimensions of healthcare service quality intervene in the formation of overall patients satisfaction. Moreover these dimensions contribute differently in affecting the satisfaction.

Identifying the relative weight of the different dimensions of healthcare quality service which concur together to determine patients satisfaction is very important as it can help managers to find out which service dimensions are crucial to satisfy patients. This, in turn, can result in more effective resource allocation and managerial actions, able to guarantee higher levels of patients' satisfaction. More generally knowing the relative influence of service quality dimensions on patient satisfaction is critical for its implications for decision making.

Yet, despite nowadays patients' voice begins to play a greater role in the design of healthcare service, a comprehensive understanding of key quality dimensions from the patients point of view has not received sufficient attention so far.

This study proposes the use of Artificial Neural Networks (ANNs) as a knowledge discovery technique for identifying the service quality factors that are important to patients; and

allows to investigate their links to patient satisfaction. The basic reason for using the ANNs is justified by the acknowledgement that the evaluation of service quality by patients is highly subjective, complicated and resulting from complex cognitive processes, mental models and individual behaviors.

ANNs are information processors that emulate the functioning of central nervous system. Some previous studies [e.g. 15, 16] have shown that ANNs might be more accurate than traditional statistical methods in analyzing customers' evaluation of service quality dimensions as they simulate the functioning of customers' mind. Especially Behara et al. [15], in their study on the measurement of service quality, have demonstrated that ANNs' forecasting results are often better than the ones with traditional statistical methods. They pointed out that NNs have the potential to be a valuable approach to understand customer evaluation of service quality.

More generally, as underlined by Ozcan [17], in today's complex and dynamic healthcare arena, the use of quantitative methods, e.g. ANN models, that support managers to understand complex issues and to analyse, design and implement organisational changes to achieve efficiency and high quality of care of patients, is very important. These methods can help healthcare managers to analyse accurately current situations and make appropriate changes to improve efficiency and quality of care.

Drawing upon the above considerations, this study tries to gain a twofold objective: 1) to develop an ANN model to accurately predict patients' overall satisfaction of service quality; 2) to rate different dimensions of service quality based on their relative contribution to the patients' overall satisfaction, by using sensitivity analysis of NN.

This paper focuses on the outpatient satisfaction since nowadays the importance of outpatient services to most hospitals continues to escalate [18]. As highlighted by Jackovitz [19] the number of ambulatory outpatients is much larger than the number of inpatients, and revenues from outpatient services are predicted to equal or exceed inpatient revenues in the near future. Therefore the ability to provide outpatient services with exceptional quality is paramount to long-term survival of hospitals. The paper is structured as follows.

First, a brief introduction about healthcare quality and patient satisfaction is provided. Second, the methodology of research is provided. In particular the ANN model grasping the dependencies between patients' perceived service quality and their overall satisfaction, is presented. The model data are based on an outpatient satisfaction survey carried out at a number of Italian public ambulatories. Finally, conclusions and limitations of the research are discussed.

The open source package Java development kit has been used in this study for working with ANN.

2 Healthcare quality and patient satisfaction

Traditionally assessment of medical care have not considered patients feedbacks. The emphasis has been basically on technical and physiological aspects of care provision. Nowadays assessing healthcare services only in terms of clinical effectiveness can present some constraints. The imperative for cost reduction, efficiency and high quality services are pushing healthcare organizations to enhance their ability to satisfy and retain/attract patients [3, 20].

Furthermore, in line with the principles of new public management paradigm, governments and regulatory authorities increasingly require healthcare organizations to evaluate patients' experience in order to increase public knowledge about effectiveness and efficiency of the healthcare system. For example, assessing patient satisfaction has been mandatory for French hospitals since 1998. Moreover, during the last decade this evaluation has become common in several countries. Nowadays eliciting feedbacks from patients is an essential element of policy planning and provides a valuable knowledge platform for an effective and efficient management of care and a better use of available resources [21].

Especially knowing which factors influence satisfaction is very important for healthcare managers, since it can influence healthcare results and healthcare institutions financial results [22]. Additionally patient judgment on medical care also contributes to medical outcomes. In this regard Gasquet et al. [23] argue that, in the case of outpatients, it has been clearly shown that satisfied patients are more likely to cooperate with treatment, to maintain a continuing relationship with a practitioner and thus enjoy a better medical prognosis. MacStravic [24] showed patients' satisfaction influences the willingness of following doctor's prescription, which in turn influences patients' future satisfaction with healthcare results.

Although the use of patient satisfaction measures in the health sector is nowadays quite widespread, the definitive conceptualization of satisfaction with healthcare is still missing and the understanding of the process by which a patient becomes satisfied or dissatisfied remains unanswered [7–9]. Jackson et al. [21] outline that the factors individual patients use to deem themselves satisfied remains largely unknown. In this regard the same authors analyze the predictors of patient satisfaction and conclude that immediately after the visit, patient satisfaction is strongly influenced by patient-doctor communication variables; while by 2-weeks outcome of the patients' presenting symptom has an increasingly greater effect. At all time points, satisfaction is influenced by both patient age and functional status.

A further important issue concerns the relationships between service quality and customer satisfaction. This relationship is not fully investigated by the literature. As

underlined by Iacobucci et al. [25], sometimes the terms quality and satisfaction are used interchangeably (both in industry and academia), as if the two are essentially one evaluative construct (p. 278). Sometimes they are employed as distinct notions. "For example, some service quality researchers describe satisfaction as a more specific short term evaluation (e.g., evaluating a single service encounter) and quality as a more general and long term evaluation. In contrast some customer satisfaction researchers posit quality as the more specific judgment and a component of satisfaction, the broader evaluation" (p. 278–279).

With specific reference to healthcare sector, Gill and White [9] argue that there is a continued misuse and perpetuation of the inter-changeability of the concepts of quality and satisfaction.

Lee et al. [26] argued that studies seeking to assess the components of the quality of care in health services predominately continue to measure patient satisfaction. While a study by Gotlieb et al. [27] on patient discharge offer evidences of a clear distinction between perceived service quality and patient satisfaction.

The current ambiguity regarding the relationships between quality and satisfaction can be somewhat related to the fact that healthcare sector research into patients' perceptions of the dimensions of service quality has been limited. In addition there is still no consensus on how to best conceptualise the relationship between patient satisfaction and their perceptions of the quality of their healthcare.

On the basis of the above reflections it appears especially important to better understand the meaning of the constructs of service quality, perceived quality and satisfaction, and clarify what are the quality dimensions that give rise to patients satisfaction.

Identifying the relative importance of the different dimensions of healthcare service quality in determining outpatient satisfaction goes in this direction.

3 Method

3.1 Data gathering

This paper focuses on the understanding of key service quality dimensions from the outpatients point of view. In this study the unit of analysis is represented by the outpatients of ambulatory care services in public hospitals. The focus on outpatients is basically related to the fact that the use of ambulatory services is growing and ambulatory care services are becoming extremely important for the survival of hospitals. On the other hand, as outlined by Jackovitz [19] people gain exposure to a healthcare facility primarily from outpatient contacts. Many facilities have an outpatient/inpatient ratio of at least 10:1. High quality

outpatient services are therefore crucial because opinions of the healthcare facility are formed at each encounter. Negative impressions can have severe consequences on the number of future visits. Therefore since the provision of high quality services is extremely important to the long-term viability, knowing how the different dimensions of service quality influence outpatient satisfaction is essential.

Source of data regarding outpatients satisfaction and their evaluations of ambulatory service quality used in this study, is the amount of questionnaires collected during a survey carried out during the 2011 at 22 public ambulatory services. The survey covered a period of 6 months and was one of key initiatives implemented by a panel of Italian public hospitals in order to comply with the accreditation requirements in accordance with some recent national laws.

The survey questionnaire consists of 9 items measuring the service quality and one single item concerning the patient's overall satisfaction with service quality. The items cover several aspects of service quality such as for example reception and facilities, making appointment, time waiting, consultation with the doctor, relationship with nurses and technicians, and so on.

The questionnaire also comprises data on socio-demographic profile. All the questions are on a three point Likert scale. Patients were asked to fill the questionnaire immediately after the consultation.

Among the 745 collected questionnaires, only 547 questionnaires were completely filled and then suitable for the study.

3.2 Neural networks

Neural Network (NN) is a mathematical model or methodological tool inspired by the structure and processes of central nervous system. It consists of artificial neurons or nodes which stand for the processing elements of biological neural networks, i.e. neurons, axons, dendrites, and synapses. Accordingly ANNs are a computational simulation method for a connectionist model of learning.

Since their inception in the 1950s, there has been a wide application of this methodological tool in various fields such as economics, medical science, statistics, geology, computer science, manufacturing and so on [e.g. 28–30]. Recently ANNs have been applied to a variety of business areas such as accounting and auditing, finance, management and decision making, marketing [e.g. 31]. Especially a number of successful business applications of the NN have been tested to assess financial services [see e.g. 32–34]. Further applications concern the analysis of different service sectors. In particular several studies have been produced in the transportation service sector [e.g. 35–37]. Further applications of the NN can be found in the investigation of education [38, 39], healthcare [40, 41], and communication [42, 43].

Undoubtedly the application of NN to model issues related to services is emerging in the scholarly literature. This is particularly valid with reference to qualitative and intangible aspects of services.

What has attracted the most interest in the use of ANNs is their ability to be used to model complex relationship between inputs and outputs that 'learns' from observed data.

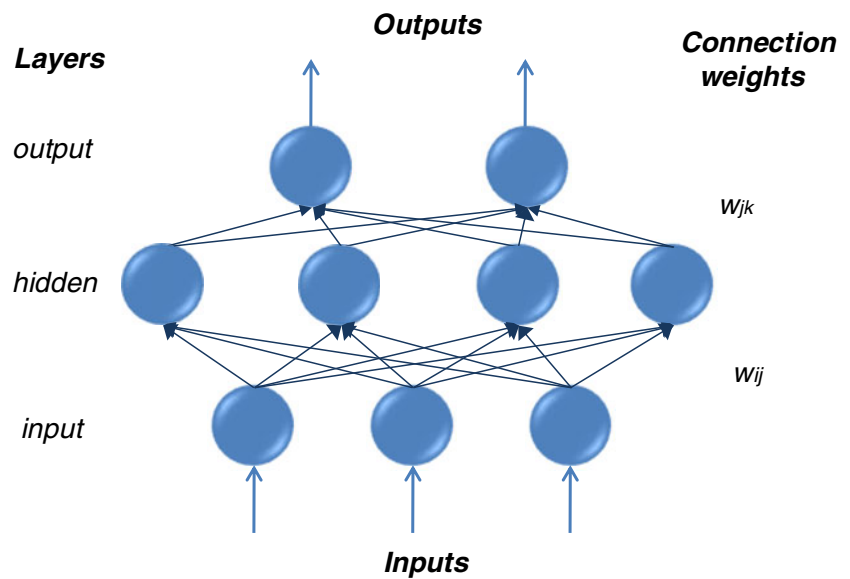
ANN models present an organization similar to that of a human brain. In fact they aim to model human intelligence in its totality [44]. They provide a method for incorporating and processing qualitative knowledge and formalizing learning process in an explicit manner. The elements of an ANN model are processing elements named neurons (or artificial neurons). These neurons are connected among them and are set on layers to form a network. Then neurons get data from the surrounding neurons, perform some computations, and pass the results to other neurons.

Connections between neurons have weight associated with them. These network's interconnection weights store the knowledge in an implicit manner. In fact, the ANN model learns by determining the interconnection weights from a set of given data. In particular, to a given inputs' configuration, the network associates outputs' configuration, against the targeted one. The "synaptic" weights are modified in the network in order to minimize the obtained error.

Furthermore ANNs can change their behavior adapting themselves to contingent environment (i.e. the problem); accordingly they are able to learn. One of the most successful ANN model is known as multilayered perceptrons (MLPs). A MLP is a feed-forward ANN model that maps sets of input data onto a set of appropriate output. The MLP consists of multiple layers of nodes (neurons) in a directed graph, with each layer fully connected to the next one. The input layer consists of input (independent) variables in which each variable is represented by one node. The hidden layer consists of hidden nodes that facilitate the propagation of feed-forward information from the input layer to output layer. The hidden layer captures and processes the non linear relationships among the variables. In general there could be one or more hidden layers between the input and the output layers. Finally the output layer corresponds to the dependent variable(s). The output layer has one node for each output (see Fig. 1).

Each neuron receives a weighted sum from each neuron in the prior layer and provides an input to every neuron of the next layer. The MLP training process consists in the calculation of the network weights. This is carried out using a set of input values and the corresponding output variable (s) values called the data set.

The input values enter in the network through neurons of the input layer. The input values are presented to the network as sets of inputs and corresponding output data. Such

Fig. 1 The MLP schema

sets are called facts. Then the network is trained with the data sets for the addressed problem in order to establish the correct weights. The most common training procedure is the back propagation algorithm [45, 46], which has become the accepted standard in training the network [47]. It minimizes the error measure during the training process and works by starting with random connection weights, presenting sets of inputs to the network and letting the network compute the outputs. The calculated outputs are then compared with known correct values and a formula, which allows to update the network weights. Different runs are performed until the calculated outputs get close to the correct values. This supports the network learning in order to predict the output pattern. Then through the back propagation the network weights are updated by propagating the error backward through the network to determine how to best update the interconnection weights between individual neurons. This allows to improve the predictive accuracy of the network.

The back propagation learning algorithm forms the basis for model development in this study.

3.3 Network configuration and experiments

Three layers build the ANN model: input layer, one hidden layer and the output layer.

Applying the back propagation learning methodology in order to model the non-linear relationship between input and output parameters, the sigmoid function has been used as an activation function connecting the parameters of the network.

The parameters of the network have been determined through several simulations. The better compromise between the quality of the output and the computational time is reported in the paper.

The input layer concerns the inputs of the network; in our case the input layer has been composed by nine neurons as the inputs investigated. The hidden layer included 10 neurons. On the other hand, the output layer involved only one neuron as single output. The parameters of the network to take into account are as follows:

- learning rate: 0.2;
- training cycle: 1,000,000.

The neural network has been implemented in an open source package: the java development kit. The inputs data have been normalised according to the sigmoid function, which has been used in each neuron. In this study, the inputs have been normalized by the ratio of the input value to four. This led to obtain the input values as reported in Table 1.

The normalization process avoided two limit values 0 and 1. These two values would have to reduce the level of learning of the ANN. The training process led to the following performance indexes of the NN model:

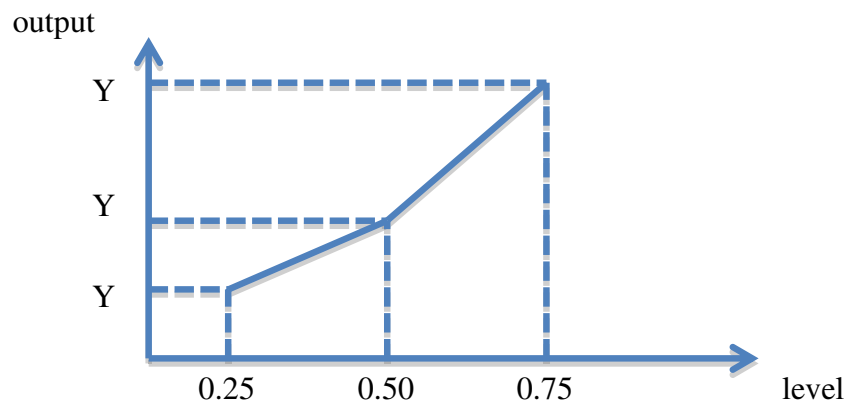
- average error: 5.38 %.
- maximum value of error: 31.20 %.

Then the experimental results show that the proposed ANN model can properly model outpatients overall satisfaction of service quality.

Table 1 Normalized inputs

	Input value	Normalized input value
Value low	1	1/4=0.25
Value medium	2	2/4=0.5
Value high	3	3/4=0.75

Fig. 2 Generic output of a factor with three levels



4 Identifying key dimensions of outpatient satisfaction

The ANN model has been used to estimate the relative weight of the service quality dimensions in determining outpatients' overall satisfaction. It allows capturing the non-linear and complex relationships among the service quality dimensions and supports the ranking of the predictors of satisfaction.

In the following the adopted procedure is presented.

After training the network, how each input affects the output of the problem has been evaluated. In particular, it has been considered all the combinations among the input values (0.25; 0.5; 0.75). The trained neural network has been performed for 19683 combinations.

The adopted methodology has used the Design of Experiment (DoE) which is particularly suitable in order to discover interactions among factors [also in simulations experiments, e.g. 48]. The experiments have been conducted with three levels factor and the evaluation has focused on the linear and quadratic effect of the factors.

Then, the effect of each input has been assessed focusing on the linear effect and quadratic effect. Figure 2 shows the linear and quadratic effect for a generic factor.

The linear effect is computed as:

$$y_3 - y_1 \quad (1)$$

The quadratic effect is computed as:

$$Eq = (y_3 - y_2) - (y_2 - y_1) \quad (2)$$

The linear effect highlights how the total improvement of the factor changes the output. While the quadratic effect highlights how the improvement changes when the effect passes from level 1 (0.25) to level 2 (0.5) compared to the improvement when the effect passes from level 2 to level 3 (0.75). Table 2 reports the results in terms of linear and quadratic effect. The effects have been computed over the average of the effect evaluated modifying all the others effect.

The analysis has provided valuable information about the effects of each investigated service quality dimension on outpatient's satisfaction. From the analysis of the results the following issues can be drawn.

The greater linear effect points out that the more important effect is the "Respect of privacy". Other important factors (linear effect greater than 10 %) are: "Accessibility, comfort and cleanliness of environments", "Attention from medical staff" and "Clarity and completeness of information and explanations provided by healthcare professionals". This means that changes in these elements most significantly affect outpatients overall satisfaction. They represent key service quality dimensions of outpatients satisfaction to be considered for designing management initiatives aimed to enhance service quality.

The importance of quality dimensions concerning the relationships with doctors and the provision of information and communication confirms the results of a number of

Table 2 Simulation results analysis

Effect/input	Linear	Quadratic
Booking service (opening hours, waiting on the phone / at the counter, courtesy of operators, received information)	-2.17 %	-1.93 %
Waiting time from booking date to consultation appointment	-8.29 %	-13.59 %
Admission services and ticket payment (waiting at the counter, courtesy of operators, received information)	8.21 %	-1.50 %
Promptness of medical consultation	-8.69 %	-3.39 %
Accessibility, comfort and cleanliness of environments	15.61 %	1.66 %
Attention from medical staff (accuracy of the visit, courtesy, helpfulness, professionalism)	11.87 %	-4.19 %
Clarity and completeness of information and explanations provided by healthcare professionals	10.42 %	6.76 %
Attention received from nurses, and rehabilitation/technical staff (helpfulness, promptness, professionalism)	-4.63 %	12.93 %
Respect of privacy	21.51 %	-5.79 %

previous studies [e.g. 21, 49, 50]. In particular our empirical findings appear aligned with the results of the literature carried out by Williams et al. [50] who have highlighted that the links between communication behavior of doctors and patient satisfaction are positively related to patient satisfaction. The authors also found that there is evidence that doctor-patient relationships and the expression of affect during the consultations are important factors in patient satisfaction. Especially the studies have indicated that the higher patient – centeredness and empathy during the consultations with patients play an important role in patient satisfaction.

Focusing on the lower value of linear effect (absolute value), it is possible to identify the minor effects on the output. In this regard, the “indifferent factor” is the “Booking service”.

A further interesting finding of the application of the ANN model regards the comprehension of how the improvement of key service quality dimensions along the three levels contribute to enhance overall satisfaction. Especially the quadratic effect allows determining which factor is important to focus the attention on in order to support patient satisfaction improvement.

As reported in Table 2, it is possible to infer that among the most important factors, the “Clarity and completeness of information and explanations provided by healthcare professionals” is characterized by a continuous improvement when the level is improved. Similar behaviour characterises the effect of the “Accessibility, comfort and cleanliness of environments”, thought with a lower impact on the improvement of the output.

The findings of this study provide insights for healthcare managers since they can inform decision-making regarding the allocation of resources as well as about the kind of management initiatives to be implemented with the aim of improving patient satisfaction.

5 Conclusions

Nowadays the ability to provide outpatient services with exceptional quality is crucial to long-term survival of hospitals [19] particularly considering that the revenues from outpatient services are predicted to equal or exceed inpatient revenues in the near future. Assuring patient satisfaction with hospital outpatient or ambulatory services can mean to have patient patronage and loyalty [51]. In such a prospect identifying the relative weight of different dimensions of HC quality service which concur together to determine outpatients satisfaction is very important since this can help managers to find out which service dimensions are crucial in order to satisfy patients.

This paper acknowledging the distinctive property of the ANN in capturing the nonlinear and complex relationships

proposes its application in order to grasp the links between some key service quality dimensions and the outpatient satisfaction. Especially the ANN allows to solve the critical issue of identifying those service quality dimensions which most significantly contribute to outpatients satisfaction. The empirical application of the ANN to the Italian context of public healthcare ambulatories shows that the relationship between doctors and outpatient (i.e. “Attention from medical staff”; “Clarity and completeness of information and explanations provided by healthcare professionals”; “Respect of privacy”) strongly affects the outpatient satisfaction.

In order to support and expand the findings of this study the authors call for further empirical investigations of the application of the NN approaches and models in order to assess the outpatient satisfaction. Particularly important is the application of the NN models in different cultural contexts with the purpose of understanding the context sensitivity of the identified insights and increase the generalisability of this study.

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