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Usability perception of the health information systems in Brazil: the view of hospital health professionals on the electronic health record

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Abstract

Purpose – The purpose of this paper is to validate and measure the overall evaluation of electronic health record (EHR) and identify the factors that influence the health information systems (HIS) assessment in Brazil.

Design/methodology/approach – From February to May 2020, this study surveyed 262 doctors and nurses who work in hospitals and use the EHR in their workplace. This study validated the National Usability-focused HIS Scale (NuHISS) to measure usability in the Brazilian context.

Findings – The results showed adequate validity and reliability, validating the NuHISS in the Brazilian context. The survey showed that 38.9% of users rated the system as high quality. Technical quality, ease of use and benefits explained 43.5% of the user's overall system evaluation.

Research limitations/implications – This study validated the items that measure usability of health-care systems and identified that not all usability items impact the overall evaluation of the EHR.

Practical implications – NuHISS can be a valuable tool to measure HIS usability for doctors and nurses and monitor health systems' long-term usability among health professionals. The results suggest dissatisfaction with the usability of HIS systems, specifically the EHR in hospital units. For this reason, those responsible for health systems must observe usability. This tool enables usability monitoring to highlight information system deficiencies for public managers. Furthermore, the government can create and develop actions to improve the existing tools to support health professionals.

Social implications – From the scale validation, public managers could monitor and develop actions to foster the system's usability, especially the system's technical qualities – the factor that impacted the overall system evaluation.

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Originality/value – To the best of the authors' knowledge, this study is the first to validate the usability scale of EHR systems in Brazil. The results showed dissatisfaction with HIS and identified the factors that most influence the system evaluation.

Keywords Usability, Health information system, Electronic medical record, Electronic health record, National Usability-focused HIS Scale (NuHISS)

Paper type Research paper

1. Introduction

The adoption of health information systems (HIS) is growing worldwide, but professionals' satisfaction with the usability of these systems is not improving (Gomes & Ratwani, 2019). Nevertheless, despite the difficulties intrinsic to implementing HIS, predominantly electronic health record (EHR), the use of information technology represents advances in the quality of health and patient safety (Feldman *et al.*, 2018; Kaipio *et al.*, 2020).

The International Organization for Standardization (ISO) described that "usability refers to an extent to which a system, product or service can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO, 2019). As a result, usability is often remembered as a barrier to accepting these technologies after adoption (Holden, 2011; Walter & Lopez, 2008), even though it is fundamental to optimize the benefits (BE) of using EHR (Kaipio *et al.*, 2017).

The ever-changing difficulties in using HIS are a significant source of work stress for doctors. They reported usability problems, system failures and lack of integration between systems that barely support patient documentation and data recovery (Heponiemi *et al.*, 2018, 2019; Mazur *et al.*, 2019; Melnick *et al.*, 2020; Roman *et al.*, 2017). Additionally, low levels of satisfaction related to usability result in physician dissatisfaction and exhaustion at work, reducing efficiency and having consequences for patient safety (Howe *et al.*, 2018; Roman *et al.*, 2017).

One way to improve the usability of systems is to involve doctors with new technologies to avoid human error, ensure data integrity (Lawrence *et al.*, 2019) and improve the interoperability and stability of these systems (Vainiomäki *et al.*, 2017). In addition, a greater focus of clinical end users during product design and development and optimized certification requirements is necessary to improve usability (Gomes & Ratwani, 2019). Also, it is crucial to provide physicians with sufficient time and support in their problems, learning and updating related to HIS (Heponiemi *et al.*, 2018).

Few instruments measuring such systems' usability were validated in the literature, such as Bundschuh *et al.* (2011) in Germany and Hyppönen *et al.* (2019a, 2019b) in Finland. Thus, this study aims to validate, measure the overall system evaluation and identify the impacts of HIS evaluation in Brazil. We hope the results will highlight aspects of the HIS that encourage greater engagement by professionals in the field. In addition, we seek to provide an instrument that allows more research in Brazil since the instrument has never been validated in the Brazilian context.

2. Related research

The National Usability-focused HIS Scale (NuHISS) is a scale developed and validated by Hyppönen *et al.* (2019a, 2019b) in Finland, which includes seven factors: *technical quality* (TQ), *information quality* (IQ), *feedback* (FB), *ease of use* (EoU), *BE*, *internal collaboration* (IC) and *inter-organizational collaboration*. The authors considered it a valuable tool to measure HIS usability; moreover, Kaipio *et al.* (2020) used four out of the seven scale factors (*TQ*, *EoU*, *BE* and *collaboration*) to compare the perception of doctors and nurses regarding usability, also in Finland.

Previous studies have also presented these factors with an impact on usability evaluation. *EoU* was associated with the easy, fast and practical entry of data into the system, resembling professionals' routine tasks, without additional steps that may generate rework (Castillo *et al.*, 2010; Miller & Sim, 2004) and complexity of the systems (Boonstra & Broekhuis, 2010; Singh *et al.*, 2020). Thus, usability was negatively associated with many screens for navigation in the systems (Boonstra & Broekhuis, 2010; Hudson *et al.*, 2018; Miller & Sim, 2004) and difficulties of use (Singh *et al.*, 2020; Topaz *et al.*, 2016).

Studies have also highlighted the TQ of the HIS, which reflects the response time and crashes of the systems (Hudson *et al.*, 2018; Miller & Sim, 2004; Ratwani *et al.*, 2018) and positively impacts usability. Furthermore, user-friendly systems are a characteristic of TQ and are recognized as beneficial for workers' professional and personal well-being (Heponiemi *et al.*, 2019). On the other hand, limited systems that offer nothing more than the routine of professionals (Boonstra & Broekhuis, 2010) negatively impact the usability of HIS.

IQ is another factor that influences the system's usability, as it can make it more challenging to use and result in rework, manual release and translation of digital paper records (Miller & Sim, 2004; Viitanen *et al.*, 2011). Also, the lack of a summary view of the patient's health status, prevention of errors associated with the medication request and a list of patient medication, for example, are not presented smoothly to the user (Hudson *et al.*, 2018; Kaipio *et al.*, 2017). Moreover, the delay in entering data may take more time to attend to a patient (Boonstra & Broekhuis, 2010).

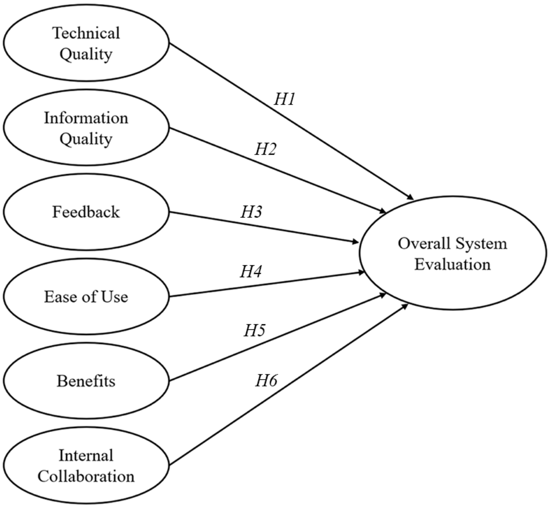
The BE the system offers to the user may influence the usability perception of HIS. For example, some studies have reported BE such as safety for the patient and professionals, quality in the service provided, efficiency and effectiveness in care and integration with other tools (Castillo *et al.*, 2010; Fennelly *et al.*, 2020; Singh *et al.*, 2020).

FB is related to users' acceptance and implementation of suggestions for HIS developers (Boonstra & Broekhuis, 2010; Heponiemi *et al.*, 2019). In addition, although doctors and nurses are willing to participate in developing HIS, appropriate methods for effectively including them and their FB seem to be lacking or underused (Martikainen *et al.*, 2020). Finally, *inter-organizational collaboration* and *IC* are recalled in studies when HIS do not integrate with other systems or equipment to facilitate automatic data entry (Boonstra & Broekhuis, 2010; Castillo *et al.*, 2010; Miller & Sim, 2004; Topaz *et al.*, 2016; Viitanen *et al.*, 2011) or when they do not offer or facilitate collaboration between professionals (Castillo *et al.*, 2010; Kaipio *et al.*, 2017; Larsen *et al.*, 2018; Viitanen *et al.*, 2011).

The positive relationship between usability and the overall evaluation of information systems merge in the literature as long as the six described usability factors facilitate and benefit information systems users. However, which factors most influence the overall evaluation of the system? This question can be answered from the hypotheses presented in the proposed theoretical model illustrated in Figure 1.

3. Context of the study

The unified national health system (SUS, in Portuguese) is provided free to the entire Brazilian population. Brazil has approximately 210 million inhabitants, 5,570 municipalities and is the fifth largest country globally [Instituto Brasileiro de Geografia e Estatística (IBGE), 2010]. The health system is divided into public (SUS), in which services are financed and provided by the government at the federal, state and municipal levels, and private (profit and non-profit), in which services are financed in various ways with public or private



Source: Elaborated by the authors

Figure 1. Proposed theoretical model

funds (Paim *et al.*, 2011). The consequence is that there are numerous information systems concerning health, generating complexity and making it difficult to monitor their usability.

Implementing digital health systems in Brazil is recent. In 2018, the Federal Government of Brazil enacted the digital health record law. It provided the digitization and use of computerized systems for the safekeeping, storage and handling of patient records (Brasil, 2018). In 2019, a secretariat of primary health care in the ministry of health was created, with new challenges for the federal management of SUS, among them the expansion of computerization of health units and the use of electronic records (Sellera *et al.*, 2020).

Studies involving Brazilian health professionals analyzed their perceptions about the contribution of EHR. In comparison with paper records, EHRs have higher quality and safety (Colleti Junior *et al.*, 2018). Besides, EHR reduces the number of papers filed and conduct errors, stores data for longer and avoids the redundancy of procedures. Furthermore, it increases service productivity and user satisfaction, facilitates intercommunication at points of attention and eliminates duplicate records in the lists of registered users (Gonçalves *et al.*, 2013; Pinto & Santos, 2020; Silva *et al.*, 2019; Vaidotas *et al.*, 2019). However, difficulties in using these systems in Brazil are also a challenge given the high cost of implementation and the need to train professionals to improve usability (Gonçalves *et al.*, 2013).

4. Material and methods

This research has a quantitative approach, operationalized through a survey applied to Brazilian doctors and nurses who use the EHR in hospitals. To measure usability, we used the 28-item HIS scale (NuHISS) (Hyppönen *et al.*, 2019a, 2019b), which include *TQ* (five items), *IQ* (five items), *FB* (three items), *EoU* (seven items), *BE* (six items) and *IC* (two items). *Cross-organizational collaboration* was excluded from this study because it practically does not exist in Brazilian associations. In other words, some systems have integration modules between institutions but no collaboration modules. In addition, we used a five-point Likert scale, ranging from "1 – totally dissatisfied" to "5 – totally satisfied". Finally, the study's dependent variable was the overall evaluation of the systems, measured on a scale from 0 to 10, being "1. I am totally dissatisfied" to "10. I am totally satisfied".

We collected gender, age and experience data under the Finnish study, whose questionnaire we translated into Portuguese and validated with two health specialists. In addition, a pilot test was conducted with 35 professionals, presenting relevant results. Appendix 1 presents this questionnaire.

Data collection occurred between February and May 2020. Participants were invited to the research through social networks and e-mails sent to postgraduate programs in health. After filtering the data through tests of univariate and multivariate outliers (*Z* and Mahalanobis scores), the sample resulted in 262 valid cases of doctors and nurses working in hospitals and using the EHR in their workplace.

We selected respondents from all regions of Brazil, mainly Southeast (42.0%) and South (33.2%). The respondents work in public hospitals (57.6%), private hospitals (11.1%) and both (31.3%). They use different brands of EHR. Also, 60.3% work only in one hospital, 27.1% in two hospitals and 12.6% in three or more hospitals. The level of education is high: 65.6% have a *stricto sensu* education (master, doctorate or post-doctorate). Most are female (64.5%), married (61.8%) and are over 30 years (76.7%). The respondents' characteristics are presented in Table 1.

Statistical analyses were performed with programming language R (version 3.5.1)/R-studio. When applicable, the chi-square test or Fisher's exact test were used to compare categorical variables and *t*-tests to compare groups. Multiple statistical R packages (corrplot, psych, lavaan) were used for the statistical analyses. Besides, we performed a

Characteristics	*n*	(%)
Gender		
Female	169	64.5
Male	93	35.5
Age group		
< 30 years	61	23.3
31–40 years	79	30.2
41–50 years	63	24.0
51–60 years	42	16.0
> 60 years	17	6.5
Number of hospitals the professional works at		
Only one	158	60.3
Two	71	27.1
Three or more	33	12.6
Type of hospital		
Public	151	57.6
Private	29	11.1
Both	82	31.3
Experience of use of the EHR		
< 10 years	109	41.6
10–20	60	22.9
20–30	53	20.2
>30 years	40	15.3

Source: Data from research

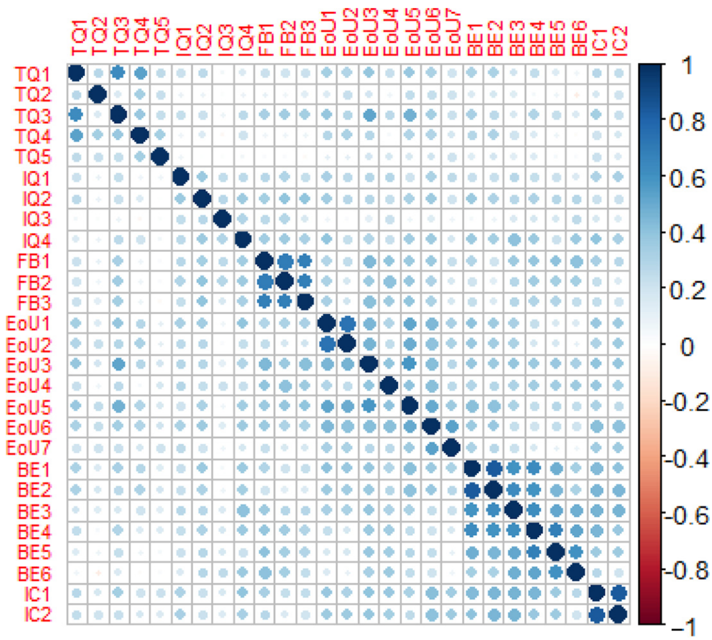
Table 1. Respondents' characteristics

confirmatory factor analysis to evaluate the quality of the instrument and multiple regression to examine the proposed hypotheses. The statistical significance was determined as $p < 0.05$.

Confirmatory factor analyses validated the relationships between measured variables and latent constructs through the model fit indexes. The goodness of fit of the SEM model was χ^2, evaluated based on the chi-square test (RMSEA, CFI, TLI). A non-significant chi-square value indicates that the model fits the data well. RMSEA value of less than 0.05 suggests a good fit and 0.08 suggests a reasonable fit. For CFI and TLI, values above 0.90 represent an acceptable fit (Kline, 2015). The structural model was tested following the model already validated by Hyppönen *et al.* (2019a, 2019b) in two steps. First, a complete model was estimated in which all items were loaded in the same underlying dimension (*null model*). In the second stage, items with low commonality or loadings were removed from the model (QT2, QT5 and the IQ factor), looking for an appropriate fit. The same fit indexes were used as in the general SEM test.

4.1 Correlations

Figure 2 presents a Pearson correlation matrix. We can observe the relationship between items that compose the same dimension. For example, *FB* and *BE* have the strongest correlations, considering the correlations of items in the same dimension. *EoU* items also have high correlations in the dimension. On the other hand, *IQ* items do not correlate with each other or with items of other dimensions. In general, the correlations in Brazil are lower than those obtained by Hyppönen *et al.* (2019a, 2019b) but have similarities in the most correlated items, with FB and BE being the strongest in both Finland and Brazil.



Source: Data from research

Figure 2.
Correlation matrix between items

5. Results

5.1 Evaluation of the structural model

The exploratory factor analysis with Varimax rotation is adequate for the data (KMO = 0.88). All items presented measure of sampling adequacy above 0.8, considered excellent (above 0.5 is already satisfactory) (Hair *et al.*, 2010). Bartlett's test, conducted in R, is significant ($p < 0.001$). The significance of this test attests that the correlation matrix is not an identity matrix. Hence, we assumed there is some relationship between the variables. However, the commonality analysis showed low values for the items TQ2 (system errors), TQ5 (missing info), IQ1 (medic list quality), IQ2 (summary view), IQ3 (patient-provided information), EoU4 (operating information) and EoU7 (nursing record).

We tested the model with the six dimensions validated by Hyppönen *et al.* (2019a, 2019b), applying confirmatory factor analysis. It is noteworthy that there were seven dimensions in the original study, but the *cross-organizational collaboration* dimension was not tested in Brazil. This model, called Model 1, showed a reasonable fit (χ^2/df = 2.88, CFI = 0.832, TLI = 0.809, NFI = 0.766, IFI = 0.834, RMSEA = 0.085 and SRMR = 0.070).

The two strongest factors (measured by the loadings of items) were *FB* and *IC* – all the item loadings were over 0.8. All items in *EoU* and *BE* factors had factor loadings of over 0.5. We observed items with small factor loadings in *IQ* (0.38 for IQ3 – *patient-provided information*) and *TQ* (0.36 for TQ2 – *system errors* and 0.37 for TQ5 – *missing information*). These very items had low factor loadings in the original study (after removing these items, the fit parameters improved: χ^2/df = 3.29, CFI = 0.837, TLI = 0.810, NFI = 0.783, IFI = 0.839, RMSEA = 0.093 and SRMR = 0.070). Although the values are still off-limits recommended by the literature, the results are better than those found by Hyppönen *et al.* (2019a, 2019b). Therefore, the model refinement is necessary, as shown below.

After removing the mentioned items, the internal reliability assessed with the final factors data alpha coefficients showed that the *IQ* factor presented the smallest internal reliability, below the one suggested by Hair *et al.* (2010), as observed in Table 2. This result is similar to Hyppönen *et al.* (2019a, 2019b), who found low alphas for this dimension in the two data collections. In Brazil, the factor with the highest loadings and alpha was *IC*, suggesting that, in this context, it is the strongest factor. This result differs from the Finnish study, which found this factor to be the last in the ranking presented by the authors, suggesting that it is the weakest.

Table 2 also shows the correlations between the dimensions in the primary cells. In the diagonal position, the table shows the AVE values. The *IQ* dimension presented discriminant validity issues, as the square root of the diagonal should be greater than the correlation between it and the other dimensions (Fornell & Larcker, 1981). Also, the AVE

	TechQual	InfoQual	FeedB	EaseU	Benef	InterCollab
Technical quality	0.519					
Information quality	0.475	0.331				
Feedback	0.360	0.700	0.690			
Ease of use	0.648	0.758	0.578	0.434		
Benefits	0.416	0.676	0.408	0.595	0.534	
Internal collaboration	0.378	0.557	0.326	0.568	0.583	0.837

Notes: Cronbach's alpha – TQ = 0.754; IQ = 0.592; FE = 0.869; EoU = 0.836; BE = 0.878; IC = 0.909.
Source: Data from research

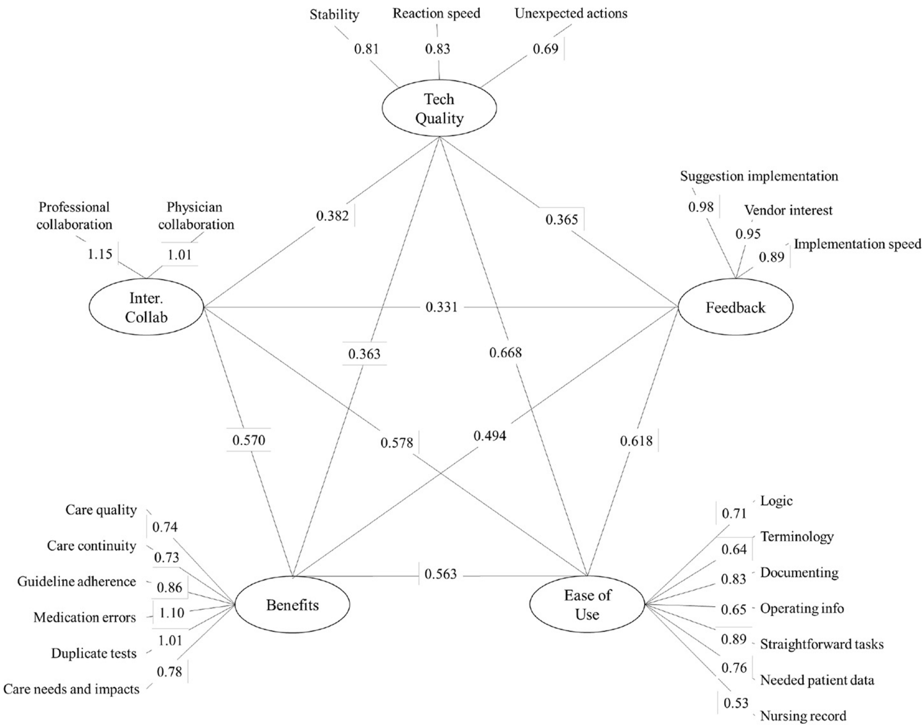
Table 2.
Discriminant validity

value for *IQ* was very low, indicating that the proportion of the items variance explained by the construct was deficient.

We excluded the *IQ* dimension from the final model and built the relationships based on the five resulting dimensions. The correlation of 0.84 between items BE1 (*IS help improve quality of care*) and BE2 (*IS help ensure continuity of care*) indicated a lack of discrimination between them. The same was observed between EoU1 (*the arrangement of fields and functions is logical on the computer screen*) and EoU2 (*terminology on the screen is clear and understandable,* e.g. *titles and labels*), with a 0.74 correlation. After these corrections, the final model showed a good fit (χ^2/df = 2.57, CFI = 0.909, TLI = 0.892, NFI = 0.860, IFI = 0.910, RMSEA = 0.077 and SRMR = 0.070). Figure 3 presents the standardized loadings. The loadings of each measure indicate whether the relationships are stronger or weaker within each dimension.

5.2 Overall system evaluation

Users assessed the overall system evaluation by assigning scores from 0 to 10. The scale was dichotomized into *low* (7 or less) and *high* (more than 7) quality estimates, in line with the study by Hyppönen *et al.* (2019a, 2019b). The results showed that the overall system evaluation was 6.7, with a standard deviation of 1.87. Half of the professionals evaluated the system with scores below 7, showing that part of the professionals is dissatisfied with EHR.



Source: Data from research

Figure 3. Confirmatory factor analysis

Thus, the survey indicated that 38.9% of users rated the system they used as a high-quality one. The high standard deviation highlights differences in users' perceptions.

Considering the dimensions assessment separately, professionals rated the systems using a five-point scale, ranging from *very dissatisfied* (one point) to *very satisfied* (five points). Based on the averages, three groups could be defined: the best-evaluated dimensions (group a), the intermediate ones (group b) and the low satisfaction ones (group c). Among these three groups, the differences are significant. *IC* and *BE* were the dimensions with the highest satisfaction, not differing from each other (paired *t*-test, $p = 0.859$). In the sequence, *TQ* and *EoU* showed no difference either ($p = 0.526$). In group c, there are aspects related to the system FB.

For comparison with the 1–10 scale, we converted the values using linear interpolation. The results indicated averages between 6.365 and 3.495 for the aspects, as seen in the last column in Table 3, highlighting the low ratings of the system usability factors (i.e. below 7).

5.3 Impact of dimensions on the overall system evaluation

We used the overall system evaluation information as a dependent variable in the relationship model. The results of the multiple regression indicated a significant effect of *TQ* ($p < 0.001$), *EoU* ($p = 0.001$) and *BE* ($p = 0.018$) on the overall system evaluation. On the other hand, *FB* and *IC* did not impact the overall system evaluation (Table 4).

The significance values of *TQ*, *EoU* and *BE* indicated that these aspects positively and significantly affect the overall system evaluation. That is to say, the higher these items assessments, the greater the users' satisfaction.

The coefficient of determination (adjusted R^2) is used to observe how the model formed can explain the current conditions. Our model R^2 value is 0.435, which means that *TQ*, *EoU* and *BE* explained 43.5% of the users' overall system evaluation. Figure 4 presents the final model.

6. Discussion and conclusions

The results showed that some of the chosen scale (NuHISS) (Hyppönen *et al.*, 2019a, 2019b) factors have been validated (now in Brazil), such as *TQ*, *EoU*, *BE*, *FB* and *IC*. However, *IQ* has not been validated either in Brazil or Finland. Given this, we consider that NuHISS can be a valuable tool to measure HIS usability for doctors and nurses and monitor the long-term usability of health systems among health professionals.

The scale validity represents the degree to which a test measures what it claims to measure. The correlation test revealed the grouping of items, although the correlations between some dimensions were stronger than others.

	Mean (five-point scale)	SD	Median	Min	Max	Mean (0–10 scale)
Internal collaboration	3.546^a	1.137	3.500	1	5	6.365
Benefits	3.534^a	0.937	3.667	1	5	6.335
Technical quality	3.383^b	0.793	3.400	1	5	5.957
Ease of use	3.352^b	0.798	3.429	1	5	5.880
Feedback	2.398^c	1.010	2.333	1	5	3.495

Different letters indicate significant differences ($p < 0.05$, paired *t*-test)
Source: Data from research

Table 3.
Satisfaction with factors

The discriminant validity analysis suggested eliminating the *IQ* dimension, reflecting the availability and format of crucial information types in the EHR system. As in the study by Hyppönen *et al.* (2019a, 2019b), the values associated with this dimension presented discrimination and internal consistency problems, with the lowest Cronbach's alpha value. Considering that the scale had already gone through previous validations outside Brazil, we opted for confirmatory factor analysis, which presented a good fit for five factors: *IC*, *BE*, *TQ*, *EoU* and *FB*.

The results suggest that health-care professionals do not perceive the support of EHR information for decision-making regarding patient care, and even the users' lack of understanding may impair trust in EHR information. Therefore, we suggest public managers develop actions to promote the use of the system and engage these professionals to raise awareness about IQ and the resources that the EHR offers to assist in decision-making.

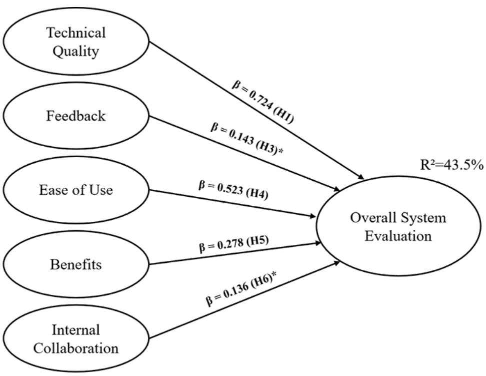
Regarding the items, we observed high loadings for *IC* and *FB*. However, in general, all items had satisfactory loadings on dimensions, evidencing their reliability for replication in future research.

We evaluated the internal consistency of factors based on reliability (Cronbach's alpha). The constructs with the highest reliability were *IC* (0.909), *BE* (0.878) and *FB* (0.869). Values above 0.6 are recommended in the literature (Hair *et al.*, 2010). The *IQ* factor was the weakest (0.592), in the boundary zone stated in the literature. Furthermore, we excluded *IQ* from the final validation because we considered only the factors that presented scale reliability (over 0.60).

	Estimate	Std. err	*t*-value	*p*-value
Technical quality	0.724	0.111	6.540	<0.001
Ease of use	0.523	0.156	3.347	0.001
Benefits	0.278	0.117	2.381	0.018
Internal collaboration	0.136	0.095	1.425	0.155
Feedback	0.143	0.102	1.402	0.162

Source: Data from research

Table 4.
Regression results



Source: Elaborated by the authors

Figure 4.
Final model

The final fit of the confirmatory model showed acceptable values, with CFI and IFI values higher than 0.9 and TLI and NFI very close to 0.9. As for the RMSEA and SRMR measures, both were below 0.08. These results suggest that the scale is appropriate for the Brazilian context in future studies.

The survey indicated that 38.9% of users rated the system they used as high quality. This result is similar to the Finnish study by Hyppönen *et al.* (2019a, 2019b), who identified that 33% classified the system they used as high quality. These results converge with studies that comment that professionals' satisfaction with the usability of these systems is not improving (Gomes & Ratwani, 2019). Because of this dissatisfaction, physicians present exhaustion at work, which may reduce work efficiency and have consequences for patient safety (Howe *et al.*, 2018; Roman *et al.*, 2017). The problem is that if physicians do not have a system that enables them to achieve efficiency, effectiveness and satisfaction, they may seek alternative solutions, like using paper to document and transfer health information. Therefore, when the system's BE are not perceived, the very decision of refusing to use the system can indicate this problem (Hyppönen *et al.*, 2019a, 2019b).

Our results also identified that the *TQ*, *EoU* and *BE* impacted the overall system evaluation, whereas *FB* and *IC* did not. Specifically, *TQ*, *EoU* and *BE* explained 43.5% of users' overall system evaluation. This finding indicates that *TQ*, *response time* and *system crashes* (Hudson *et al.*, 2018; Miller & Sim, 2004; Ratwani *et al.*, 2018), in addition to *EoU*, are factors that enhance the service provided and qualify the care provided by health professionals. Similarly, the BE of HIS also influence the overall system evaluation, whether by data safety for the patient and professional, quality in the service provided, efficiency and effectiveness in care and integration with other tools (Castillo *et al.*, 2010; Fennelly *et al.*, 2020; Singh *et al.*, 2020).

When we observe that three factors explain 43.5% of the overall system evaluation, we realize that 56.5% of the other factors may influence this evaluation and were not considered in the model proposed in this study. Therefore, it would be interesting to investigate the other factors that explain the overall evaluation of the EHR – an opportunity for further studies.

FB and *IC* did not influence the overall system evaluation. These factors result from user participation, i.e. *FB* is related to the acceptance and implementation of suggestions by users for HIS developers (Boonstra & Broekhuis, 2010; Heponiemi *et al.*, 2019), whereas *IC* occurs when there is ease of collaboration between professionals (Castillo *et al.*, 2010; Kaipio *et al.*, 2017; Larsen *et al.*, 2018; Viitanen *et al.*, 2011).

Perhaps this is why *IQ* did not validate in the sample surveyed since the insertion of the information in the HIS depends on the user's active participation. If the user does not notice that everyone works the same way, this impacts usability, as it can result in rework, manual entry and translation of paper records into digital (Miller & Sim, 2004; Viitanen *et al.*, 2011).

TQ was the aspect that influenced the overall system evaluation most. However, when presenting *satisfaction with the systems*, this aspect is in the intermediate position, indicating the need for improvement, especially about stability in terms of technical functionality (no crash, no downtime), quick response to data entry and no loss of information or documents.

Our results showed it is important to reevaluate the TQ of the EHR, as it is the most representative factor of satisfaction and may influence the employees' engagement with the use of the system and, consequently, the quality of the information provided. We emphasize that the quality of the information provided is closely related to the quality of the information received by the physician. With the correct information, professionals may be more assertive in the diagnosis and treatment of patients. Therefore, the quality of the system demands investment by the federal government.

The IC between doctors and nurses is one of the best-evaluated aspects, but its impact on the overall satisfaction of the system is not significant. This may occur because respondents understand ICs as personal activities that are not significant for the success of the EHR system.

NuHISS can be a valuable tool to measure the usability of HIS for doctors and nurses and monitor the long-term usability of health systems among health professionals. In addition, this tool enables usability monitoring to highlight information system deficiencies for public managers. As a result, the government can create and develop actions to improve the existing tools to support health professionals.

Furthermore, the results suggest dissatisfaction with the usability of the HIS, specifically the EHR in hospital units. For this reason, usability is a factor that those responsible for health systems must observe. This study is the first to validate the usability scale of EHR systems in Brazil. The results showed dissatisfaction with HIS and identified the factors that influence their overall evaluation most.

The study presented limitations because of the territorial extension and the complexity of many information systems in Brazil. We identified this limitation when observing the model fit indexes. Although adequate, the fit indexes were not as good as expected, possibly because of the variability between different public and private systems. The sample size was also small when compared to the original Finnish study.

Given the limitations, we suggest replicating the research in other countries, with other information systems and other health structures, to confirm the usability of HIS and consolidate the NuHISS. As a result, researchers will be able to identify all the specificities of the scale and discriminate the items or factors influenced by the context than those that are not.

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Appendix 1 – scales

Overall evaluation of system quality:
Usability scale
Technical quality
TQ1. The systems are stable in terms of technical functionality (no crash, no downtime).
TQ2. Faulty system function has caused or has nearly caused a serious adverse event for the patient.
TQ3. The system responds quickly to inputs.
TQ4. In my view, the system frequently behaves in unexpected or strange ways.
TQ5. Information entered/documented occasionally disappears from the IS.

Information quality
IQ1. The patient's current medication list is presented in a clear format.
IQ2. The EHR system generates a summary view (e.g. on a timeline) that helps develop an overall picture of the patient's health status.
IQ3. The system monitors and notifies when the orders given to nurses have been completed.
IQ4. Measurement results provided electronically by the patient (e.g. via the patient portal) help improve the quality of care.
IQ5. EHR systems support cooperation and communication between physicians and patients.

Feedback
FB1. The system supplier implements suggested corrections and amendments as wished.
FB2. The system supplier is interested in feedback from users.
FB3. Suggestions for corrections and amendments are implemented sufficiently quickly.

Ease of use
EU1. The arrangement of fields and functions is logical on the computer screen.
EU2. Terminology on the screen is clear and understandable (e.g. titles and labels).
EU3. Entering and documenting patient data is quick, easy and smooth.
EU4. The systems keep me clearly informed about what it is doing (e.g. saving data).
EU5. Routine tasks can be performed straightforwardly without the need for extra steps using the system.
EU6. It is easy to obtain necessary patient information using the EHR system.
EU7. The information on the nursing record is in an easily readable format.

Benefits
BE1. IS help to improve quality of care.
BE2. IS help to ensure continuity of care.
BE3. IS support compliance and adherence to the treatment recommendations.
BE4. IS help preventing errors and mistakes associated with medications.
BE5. IS help to avoid duplicate tests and examinations.
BE6. The EHR system provides me with information about the need for and effectiveness of treatment of my patients.

Cross-organizational collaboration
Answer CO1, CO2, CO3 and CO4, only if the system communicates with other health-care organizations (e.g. branch offices or other hospitals).
CO1. Information on medications ordered in other organizations is easily available.
CO2. Obtaining patient information from another organization often takes too much time.
CO3. Patient data (also from other organizations) are comprehensive, up to date and reliable.
CO4. EHR systems support cooperation and communication between physicians working in different organizations.

Internal collaboration
IC1. EHR systems support cooperation and communication between physicians and nurses.
IC2. EHR systems support cooperation and communication between physicians in your organization.
Note: the original scale in Portuguese is available for interested researchers upon contacting the authors.

	1	2	3	4	5	6	7	8	9	10	
I am totally dissatisfied	O	O	O	O	O	O	O	O	O	O	I am totally satisfied

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