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An importance-performance analysis of hospital information system attributes: A nurses' perspective

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ABSTRACT

Purpose: Health workers have numerous concerns about hospital IS (HIS) usage. Addressing these concerns requires understanding the system attributes most important to their satisfaction and productivity. Following a recent HIS implementation, our objective was to identify priorities for managerial intervention based on user evaluations of the performance of the HIS attributes as well as the relative importance of these attributes to user satisfaction and productivity outcomes.
Procedures: We collected data along a set of attributes representing system quality, data quality, information quality, and service quality from 154 nurse users. Their quantitative responses were analysed using the partial least squares approach followed by an importance-performance analysis. Qualitative responses were analysed using thematic analysis to triangulate and supplement the quantitative findings.
Main findings: Two system quality attributes (responsiveness and ease of learning), one information quality attribute (detail), one service quality attribute (sufficient support), and three data quality attributes (records complete, accurate and never missing) were identified as high priorities for intervention.
Conclusions: Our application of importance-performance analysis is unique in HIS evaluation and we have illustrated its utility for identifying those system attributes for which underperformance is not acceptable to users and therefore should be high priorities for intervention.

1. Introduction

Information systems (IS) have the potential to address numerous problems in healthcare delivery, patient safety, and clinical practice. This may be especially so if IS can be successfully implemented at the point of care [11,17]. Unfortunately, health workers have numerous concerns about IS usage and its implications for their work [5–7,37,50,59,58]. Problems with health workers' acceptance and satisfaction are now regarded among the most significant barriers to the diffusion of IS within health settings [15,34,53]. Tracking the needs of health workers and understanding the attributes of an IS that are most important to their satisfaction and productivity have thus become important components within health IS evaluation and research [4].

An IS user's evaluation of system attributes can influence their affective satisfaction and in turn their usage behaviours [19]. More satisfied users have been associated with deeper levels of engagement with a system's functionality [3,31,35], which is important to achieving higher-order benefits from IS implementations [20]. In the hospital context, nurses comprise the largest group of workers and, as generators and users of health information, need to interact frequently with hospital IS systems [61]. Therefore, improving nurses' satisfaction with hospital IS (HIS) and ensuring that HIS embed attributes necessary for nurse productivity are critical issues for hospital administrators and HIS providers. However, there are few studies in the hospital context that examine how multiple IS system attributes correlate with both user satisfaction and productivity outcomes for nurses (see [12,29]). Past studies have also not adequately examined the relative importance of different HIS attributes to nurse-user outcomes in a manner that distinguishes between those attributes for which underperformance is acceptable to nurse users, those attributes where high performance must be maintained, and those attributes that must be prioritized for intervention. One recent attempt to prioritise HIS attributes from the nursing perspective used a fuzzy analytic hierarchy approach [36]. However, this approach is based on a very small sample size and does not identify priorities with reference to a criterion variable. Without understanding the system attributes most important to users' satisfaction and productivity, efforts to improve HIS performance cannot be effectively prioritized. Consequently, there is

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risk that the intended impacts of HIS on nursing outcomes will be compromised.

The purpose of this study is therefore to identify priorities for managerial intervention by determining which attributes of an integrated hospital information system (HIS) are most important to the satisfaction and productivity of nurses who use the system in day-to-day clinical practice. Our study is undertaken within an importance-performance analysis (IPA) framework [42]. We utilize both quantitative and qualitative data collected from a public hospital in South Africa to understand nurses' evaluations of the *performance* of the hospital information system along the identified attributes, and the relative *importance* of these attributes to nurses' satisfaction with the system and its impacts on their productivity. Our results identify those system attributes requiring the most immediate attention, which can help health care administrators to direct scarce resources in a manner that reduces the risks of system failure, user frustrations and resentment.

2. Conceptual background

The attribute-level performance of an IS has long been recognized as fundamental to user satisfaction and IS success outcomes (e.g. [9,19,33,62]. The DeLone and McLean model of IS success provides a particularly useful organizing framework for understanding system attributes relevant to users. According to this model, attributes along dimensions of technical system quality, stored data quality, information output quality, and support service quality are important to a user's evaluation of a system [19,20,51]. Application of the DeLone and McLean model to HIS research and evaluation has been advocated (e.g. [54,12,13], and found useful in past studies of nurse users [48,49,40]. We therefore draw on the DeLone and McLean [20] IS success model as the theoretical underpinning from which to conceptualize a set of system attributes along which nurse users are expected to evaluate an HIS. Such evaluations are expected to influence two outcome variables, namely user satisfaction and productivity.

2.1. User satisfaction and productivity

User satisfaction is the affective response or attitude of a user towards a specific information system application [67]. Low levels of user satisfaction can reflect as resentment, frustration and tension that lead to inefficiencies in system usage [14] whilst high levels of satisfaction can promote not just 'better' IS usage but also influence the quality of a user's work life [2]. User satisfaction has been identified and empirically supported as a relevant indicator of health IS acceptance [30,65], and should be an important component of any HIS evaluation [2].

A user's evaluation of the benefits of IS use to his or her job performance and task productivity is another important component of their post-usage response [55,62,64]. Such evaluation is particularly important in the HIS context where evidence of productivity impacts has been mixed [12]. Some studies suggest that HIS improves productivity by providing health workers with more time for interacting with patients and engaging in direct patient care [38,46,52,60]. However, other evidence suggests that HIS systems are often accompanied by burdens of data entry, make routine tasks more difficult, interfere with workflow, and have a negative effect on time spent with patients [7,34,37,50,53].

According to the IS success model, HIS attributes reflecting system quality, data quality, information quality, and service quality are important predictors of these user satisfaction and productivity outcomes.

2.2. HIS attributes

System quality is a user's experience of the system from a technical, design and operational perspective [22]. This is reflected in a user's evaluation of system attributes such as ease of use, reliability and response time. These attributes have been found important to healthcare IT acceptance in a number of contexts [6,11,27,32,37,63]. Slow response time and difficulties in HIS use can result in severe dissatisfaction and eventually lead to the shutdown of an HIS system [57].

Data quality exists when the data records stored within a system are considered complete and correct [22]. Improving the availability, completeness and accuracy of electronic records is one of the primary motivations for the introduction of IT systems within healthcare settings. Correctness and integrity of an HIS database is thus a key user requirement essential to the realization of HIS benefits [16,47].

Information quality refers to the content and format of the system's outputs so as to ensure they are usable, sufficiently detailed, meaningful, easy to read and understand, and therefore helpful for task completion and decision making [21,45,22]. Health workers expect HIS to increase the availability of quality information to empower them to do a better job in diagnosis, treatment, and delivery of care [63,47,36]. Nurses' perceptions of information output quality are therefore important in the evaluation of HIS systems [48].

Service quality refers to the availability and responsiveness of support provided to users of the system as well as training opportunities [20]. Gruber et al. [24] systematic review identified user support as highly important for the success of clinical IS implementations, while others show user support as reducing user resistance [28]. A longitudinal study found that training and user support are among the most important factors contributing to nurses' acceptance of an IS in both early and later stages of implementation [39].

Having conceptualized the HIS attributes that can potentially impact on user satisfaction and productivity, we proceed in the next section to describe the study's research methods. We outline our application of importance-performance analysis to determine which HIS attributes are most important to the satisfaction and productivity of nurse users within the context of a public hospital in South Africa.

3. Methods

3.1. Study context

The empirical setting for our study is a public hospital in South Africa. The hospital has regional hospital status and had approximately 570 beds at the time of data collection with a staff complement of about 2200. The hospital services include general surgery, orthopaedics, ENT, ophthalmology, general medicine, radiotherapy and oncology, coronary care, high care, obstetrics/maternity gynaecology, paediatrics, as well as a number of support services including inter-alia radiology, laboratory, social work, and physiotherapy services. The hospital sits in the middle of a larger public hospital network consisting of district hospitals and clinics that refer into the hospital. The hospital acquired its first HIS in 1989, and eleven months preceding our study upgraded to a system that provided full electronic medical record functionality with additional modules for other clinical, administrative, ancillary, and financial applications.

Our data collection took place during transition from the new system's shakedown phase to the onward and upward phase [41]. During this period, monitoring and evaluation of system perfor-

mance is necessary to make adjustments, eliminate errors and stabilize the system before routine use can occur [44].

Our targeted respondents were nurses from across the hospital's wards. Nurses use the HIS system inter-alia to capture clinical and patient data; order tests, medication, patient meals, imaging and therapeutic services; monitor bed availability; transfer patients to other sections of the hospital including the mortuary; process admissions and discharges; and mark rooms and beds for cleaning. An important use is also the capture of the matron's report, which is a handover report detailing key issues that occurred during the shift pertaining to the ward and patients.

3.2. Importance-performance analysis

The importance-performance analysis (IPA) technique was first outlined in the marketing literature [42], and has since been applied in a wide variety of product and service contexts as a basis for setting management priorities and determining how scarce resources might best be allocated [43]. IPA is primarily a quantitative technique for making diagnostic observations of user experiences by assessing individual satisfaction along a set of attributes (in our case, system attributes) and then prioritizing improvement efforts according to each attribute's relative importance to users [8,56]. The technique supported our objective of identifying priorities for managerial intervention based on user evaluations of the performance of HIS attributes as well as the relative importance of these attributes to user satisfaction and productivity outcomes.

The IPA technique proceeded in three phases. In the first phase of our IPA, the set of system quality, data quality, information quality and service quality attributes on which to obtain user feedback was determined by literature review. Seventeen attribute items were adapted from Gable et al. [22] and Chang et al. [16].

In the second phase of our IPA, attribute *performance* scores were derived from surveys where users were asked to provide their perception of HIS performance along each of the seventeen attributes. Although attribute *importance* scores could also be derived from a survey procedure, the derivation of importance scores from statistical methods has been argued to be more appropriate given the tendency of respondents to rate all attributes as having high importance [1]. A statistical approach calculates importance scores based on the effects of attribute performance on one more outcome variables through techniques such as partial correlation, multiple regression or structural equation modelling [8]. Attributes having larger statistical effects on the outcome variable are inferred to have greater importance. Following Gustafsson and Johnson [25], we used the partial least squares (PLS) approach to structural equation modeling. PLS offered a distinct advantage over other techniques as a means for deriving attribute importance scores in our importance-performance analysis. This is because PLS allowed us to model both the higher-order attribute dimensions and their individual attributes as manifest indicators. This latent variable measurement and structural modeling procedure reduces the problems caused by collinearity among the attribute items that would be confronted in more simplistic regression procedures [25]. PLS further provided for an initial test of the reliability and validity of the measurement model, the calculation of item loadings, weights and latent variable scores, and a test of path coefficients linking the latent variables. The calculation of the attribute importance scores was then achieved by multiplying each attribute item's PLS weight (attribute-level loadings after rescaling) with the PLS path coefficient linking the relevant attribute dimension to user satisfaction in the first instance, and user productivity in the second [25].

In the third phase of our IPA, the performance and importance scores for each attribute were used to create an IPA matrix. A typical IPA matrix, or priority map, is separated into four quadrants. The four quadrants are, 'concentrate here' representing attributes of high importance-low performance; 'maintain' representing attributes of high importance-high performance; 'possible overkill' representing attributes of low importance-high performance; and 'lower priority' representing attributes of low importance-low performance [42]. This mapping of attributes allows for easier prioritization of interventions based on each attribute's relative performance and importance to users. The quadrants were constructed based on mean splits [8].

3.3. Survey procedure and ethical considerations

Clearances were obtained from the relevant university and hospital ethics review boards. Permissions to undertake the study were also obtained from the Provincial Health Department and hospital management. Suitable dates for data collection were agreed with the nursing manager. Data collection took place over five days between 08h00 and 16h00. The survey was administered via an interview protocol. Nurses were approached by the researchers in their respective wards where the authorisation letter and the participant information sheet were handed out for consent. Once all consenting nurses in a specific ward had been surveyed, the next available ward was approached. Using this procedure, we were able to obtain 172 responses from this convenience sample of the nursing staff. However, after eliminating responses with large amounts of missing data as well as those from nurses who were ascertained not to be actual users of the system, 154 useable responses remained for analysis.

The structured questionnaire instrument used seven-point Likert scales to capture perceptions from the nurse users on the performance of the system attributes reflecting system, data, information, and service quality. The seventeen system attributes are detailed in Table 4. Adopting the attributes from literature was important to ensuring content validity. The questionnaire also captured user satisfaction and user productivity on seven-point Likert scales. User satisfaction was initially a six-item scale with items from Bhattacherjee [10] and Wixom and Todd [66] however an initial principal components analysis resulted in the dropping of one satisfaction item. The remaining five items captured whether users were (1) satisfied with the system, (2) pleased with using the system, (3) found it enjoyable, (4) a favourable experience, and (5) had a positive attitude towards it. User productivity was a six-item scale from Torkzadeh and Doll [62] reflecting levels of agreement on whether the system (1) increased productivity, (2) made work easier, (3) reduced workload, (4) saved time, (5) allowed more to be accomplished, and (6) enabled more time to be spent in productive nursing activities. Prior to distribution, the questionnaire's face validity was established by having a senior nurse in charge of HIS training and a nurse manager confirm that the questionnaire items were clear and meaningful to the user group.

We extended the quantitative IPA analysis by incorporating a mixed-methods research design. An open-ended question asked nurses whether they had any additional comments to make regarding their experiences and perceptions of the system. This qualitative data collected from users allowed us to enhance understanding of required interventions based on richer descriptions regarding users' problems with system attributes. Thematic analysis of responses to the open-ended survey question was used in order to shed further light on the attributes most salient to users and to better understand the nuances of user perceptions. The tone of the comments and the emotiveness of the language helped provide insight into users' emotional states, e.g. frustration, as they interacted with the system.

The open-ended responses were thematically coded by one of the authors using the attribute dimensions of system, data, information and service quality as a thematic framework to guide

data analysis. Sub-themes were identified from the literature (e.g. responds quickly). Themes not previously identified from the literature were also allowed to emerge from the qualitative analysis, providing new insights into how system attributes lead to favourable and unfavourable user experiences. A second author reviewed this coded qualitative data. Consensus was achieved that the content of the comments was reflected in the major themes and identified sub-themes, and that no potential sub-themes were omitted.

4. Results

4.1. Sample profile

Ninety percent of the respondents were female, which is generally reflective of the nursing population in South Africa. Over 50% of the nurses have more than 10 years of experience in nursing. About 40% have spent more than 10 years at the hospital under study, with 90% having spent at least four or more years at the hospital. The nurses surveyed cover a large area of hospital activity. Of the responses, 34.4% were from general medicine wards, 11.7% from surgical wards, 8.4% from intensive and high care wards, 8.4% from maternity and neonatal wards, 7.8% from outpatient facility, with the remainder from trauma, orthopaedics, gynaecology, paediatric, radiology services and others.

4.2. Quantitative findings and importance-performance analysis

The quantitative data analysis involved several procedures. To facilitate easier interpretation, the user evaluations of attribute performance were first rescaled to a range of 0–100. Next, the partial least squares (PLS) approach was employed to carry out a confirmatory factor analysis (CFA) and test of the measurement model. This was used to assess whether constructs representing the four attribute dimensions (system quality, data quality, information quality, service quality) and the two outcomes (user satisfaction, productivity) adequately account for the observed variance in the individual measures. The results are summarized in Table 1.

All items loaded highly on their respective constructs, and all loadings were significant at the $p < 0.001$ level. This evidenced suitable convergent validity. In addition, the average variance extracted or AVEs for each construct were sufficiently high (above 0.50) or close enough to be considered acceptable. The square roots of the AVEs were also greater than the observed correlations amongst the latent variables (see Table 2) and thus discriminant validity was also ensured. Cronbach's alpha internal consistency scores were all above 0.60, considered adequate for exploratory studies. Moreover, composite reliability scores, calculated using Fornell and Larcker's formula which takes into account actual factor loadings, were all above the recommended 0.70 [26]. Thus adequate scale reliability was also demonstrated (see Table 1).

Index values for each of the constructs calculated by PLS as a weighted average of the attribute items appear in Table 1. These values show that there was generally a high level of satisfaction among the 154 nurses with the satisfaction index at 79.14 (out of 100). Overall perceptions of the system's contribution to productivity had a slightly higher average score at 81.72. Data and system quality were the poorer performing attribute dimensions with users scoring them each at approximately 78 out of 100.

Having established the reliability and validity of the measurement model, PLS was then used to derive importance scores for use in the IPA analysis. This required that the PLS path coefficients linking the four attribute dimensions to user satisfaction and productivity outcomes be estimated. For this analysis, the latent constructs including user satisfaction and productivity were modelled in the reflective mode with individual measurement items as manifest indicators. Results, as shown in Table 3, confirm significant relationships between user satisfaction and system quality, information quality and service quality. Furthermore, system quality was the only attribute dimension not significantly associated with productivity.

These PLS path coefficients were then used to determine the importance of each of the seventeen system attributes to both user satisfaction and productivity outcomes. This was achieved by multiplying each attribute item's PLS weight with the relevant PLS path coefficient. For example, the importance of the system quality attribute "easy to use" (SQ1) to the user satisfaction outcome is calculated as $0.296 \times 0.314 = 0.093$.

These importance scores together with each individual attribute's performance score were used to produce an IPA matrix

Table 3
PLS path coefficients.

	Path coefficients (satisfaction)	Path coefficients (productivity)
System quality	0.314 (3.28)***	0.138 (1.62)
Data quality	0.114 (1.52)	0.259 (2.62)**
Information quality	0.284 (3.64)***	0.171 (1.86)*
Service quality	0.261 (3.77)***	0.213 (2.15)*
R-squared	0.591	0.367

Bootstrapping with 1000 re-samples used to produce *t*-values in brackets.
One-tailed significance *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table 1
Attribute dimensions and dependent constructs.

	Number of attributes/items	Index values	Cronbach's alpha	Composite reliability	Lowest factor loading	Average variance extracted
System quality	5	78.72	0.68	0.79	0.62	0.43
Data quality	3	78.37	0.63	0.80	0.69	0.57
Information quality	5	80.20	0.73	0.82	0.66	0.48
Service quality	4	81.69	0.72	0.83	0.70	0.54
User satisfaction	5	79.14	0.81	0.87	0.72	0.56
User productivity	6	81.72	0.81	0.86	0.58	0.52

Table 2
Discriminant validity and construct correlations.

	System quality	Data quality	Information quality	Service quality	User satisfaction	User productivity
System quality	0.656					
Data quality	0.621	0.755				
Information quality	0.597	0.496	0.693			
Service quality	0.332	0.297	0.508	0.735		
User satisfaction	0.641	0.528	0.661	0.544	0.748	
User productivity	0.472	0.493	0.491	0.423	0.569	0.721

Table 4
Individual attribute performance and derived importance scores.

	Performance index	Weights	Importance (satisfaction)	Importance (productivity)
System quality				
[The system] is easy to use (SQ1)	81.385	0.296	0.093	0.041
[The system] is easy to learn (SQ2)	76.082	0.351	0.110	0.048
[The system] is always up and running (SQ3)	72.186	0.254	0.080	0.035
[The system] responds quickly enough (SQ4)	74.567	0.270	0.085	0.037
[The system] includes features and functions necessary for my work (SQ5)	83.874	0.340	0.107	0.047
Data quality				
Patient records in [the system] are always complete (DQ1)	78.842	0.524	0.060	0.136
Patient records in [the system] are never missing (DQ2)	76.515	0.321	0.037	0.083
Patient records in [the system] are always correct (DQ3)	79.177	0.464	0.053	0.120
Information quality				
Information output from [the system] is always available to me when I need it (IQ1)	72.835	0.284	0.081	0.048
Information output from [the system] is detailed enough (IQ2)	78.723	0.301	0.086	0.052
Information output from [the system] is easy to understand (IQ3)	82.035	0.338	0.096	0.058
Information output from [the system] is easy to read (IQ4)	82.576	0.267	0.076	0.046
Information from [the system] is in a form that is readily usable for my work (IQ5)	82.468	0.259	0.073	0.044
Service quality				
Support provided to users of [the system] has been sufficient (SE1)	78.323	0.422	0.110	0.090
I have been provided with the help I need to use [the system] (SE2)	80.714	0.348	0.091	0.074
Training on the use of [the system] has been sufficient (SE3)	80.693	0.233	0.061	0.050
There is always someone to turn to if we need help with [the system] (SE4)	86.169	0.344	0.090	0.073

for prioritizing managerial intervention. The performance and importance data presented in Table 4 was used to map the attributes into one of four groups depending on their performance (high/low) and importance (high/low) to nurses. A mean split was used to distinguish between the high/low categories on each dimension.

The results from Fig. 1 show that two system quality attributes, namely responsiveness (*responds quickly enough*) and ease of learning (*easy to learn*) fall into the 'concentrate here' quadrant for user satisfaction. Underperformance is thus problematic given their importance to user satisfaction outcomes. One information quality attribute (*detail*) and one service quality attribute (*sufficient support*) are also priorities for intervention to increase user satisfaction. The two lowest performing attributes relate to reliability (*up and running*) and the availability of outputs. They are thus deserving of attention. Their position within the IPA quadrant of lower-priority suggests however that intervening here won't increase satisfaction as significantly as might be achieved by improving, for example, system responsiveness. Fig. 2 shows that for user productivity outcome, three data quality attributes (*records complete*, *correct* and

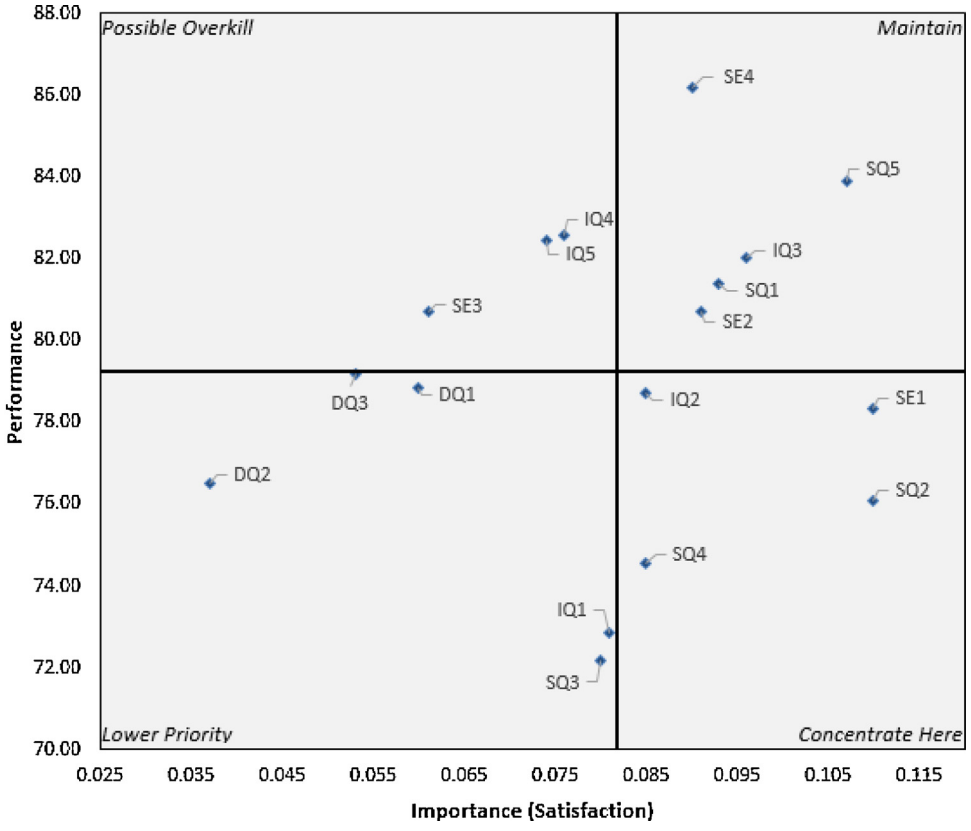

Fig. 1. IPA result: user satisfaction outcome.

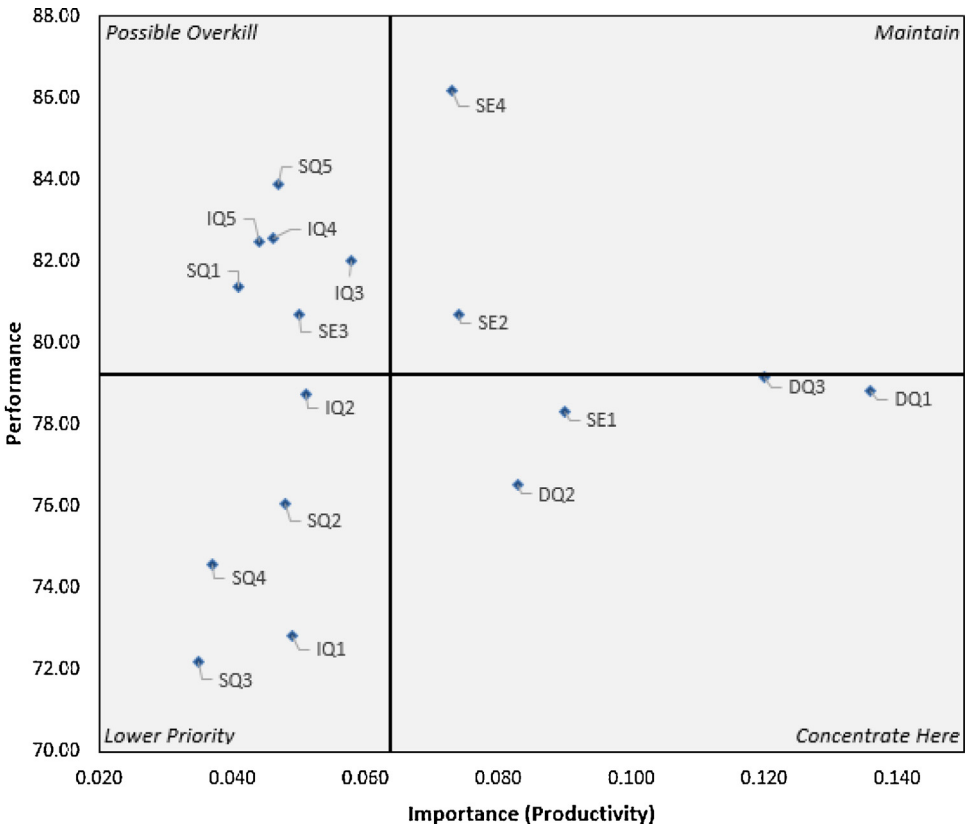

Fig. 2. IPA result: user productivity outcome.

never missing) fall into the 'concentrate here' quadrant, as does the service quality attribute of *sufficient support*.

Training appears in the 'possible overkill' quadrant for both satisfaction and productivity outcomes. Information outputs also appear sufficiently *usable* and *easy to read*. Certain attributes, e.g. *provided with help*, fall into the 'maintain' quadrant for both outcomes, while currently acceptable performance on the *easy to use* attribute is important to maintain for continued user satisfaction. We gain greater insights into underperforming attributes that require more immediate intervention through our qualitative results presented in the next section.

4.3. Qualitative perceptions

Fifty-eight percent of the 154 usable respondents included a comment. All comments related directly to the system in some way. Eighty-seven percent of comments were negative. Of the 13% of comments that showed some positivity, 67% also had a negative element (ambivalence), resulting in only 4% of comments being entirely positive. Thus, despite overall satisfaction, there are issues with the system that negatively affect this satisfaction in some way. Percentages of favourable and unfavourable comments per theme are summarised in Table 5. Attributes from Table 4 are given italicised in brackets in the text.

The majority of comments (82%) related to system quality. Of these, 88% were negative (95% including ambivalent comments). The most important negative issues regarding system quality were response time, reliability, and form input space.

Of system quality comments, 53% related to poor response time of the system (*responds quickly*).

> *"The system is slow most of the time, doesn't make work easier."* (Nurse in post-natal ward, 6 yrs' experience)

Of particular concern was the lack of responsiveness during emergency situations.

Table 5
Summary of qualitative responses by variable/theme[a].

Overall comments	Favourable-4%	Ambivalence-9%	Unfavourable/negative-87%
System quality (82% of comments)	5%-ease of use	7%-"[matron's report] space too small...easier to use than older system"	88%-response time, reliability and form input space (of which-53%-response time, 19%-reliability, 34%-input space for matron's report)
Data quality (6%)	0%-no comment	0%-no comment	100%-records not complete (often attributed to input space)
Information quality (2%)	0%-no comment	0%-no comment	100%-not detailed enough, not available
Service quality (10%)	0%-no comment	0%-no comment	100%-access to and availability of support
Emerging themes			
Availability (22%)	5%-at theatre	0%-no comment	95%-insufficient computers, many users
Previous system comparison (26%)	35%-preference for new system (ease of use)	4%-"both have advantages"	61%-preference for previous system (better response time and input space)

[a] Some comments express more than one theme. Percentages of favourable, ambivalent and unfavourable comments are for each theme given in the left-most column.

"Takes time to respond, not reliable in emergency situations." (Nurse in general medicine, 11.5 yrs' experience)

Nineteen percent of system quality comments expressed reliability concerns in terms of the screen freezing or the system being down (*up and running)*.

"The system is always down during busy time (peak hours), slow to respond." (Nurse in Occupational Health, 15 yrs' experience)

"System freezes a lot, more computers needed." (Nurse in male surgical ward, 1 yr experience)

This may not affect satisfaction to the extent that slow response time does because nurses can carry out alternative activities when the system is down, but not when waiting for the system to respond to inputs and requests.

Of system quality comments, 34% expressed displeasure regarding the input space for the matron's report ("matron's report has to be abbreviated"). This increases effort when entering a matron's report (*easy to use*). These issues regarding input space may lead to data quality (*records complete)* limitations (6%) due to the need to use abbreviations and perhaps the need to omit data.

"Matron's reporting space is too small. A proper reportcan't be written." (Nurse in general medicine, 13 yrs' experience)

"Insufficient space for medical terms." (Nurse in paediatric ward, 10 yrs' experience)

Satisfaction with system quality may be affected by process issues embedded into the system design (*easy to use*). For example, there are issues with having to restart a process when mistakes are made, the number of clicks and answers to questions required to complete a process, and handling of exceptions such as ordering one meal.

"Make an easier way to correct mistakes rather than starting the whole process afresh." (Nurse in female medical ward, 6 yrs' experience)

"There's no option for ordering a once off meal." (Nurse in female medical ward, 30 yrs' experience)

The availability of enough computers emerged as an important theme across a wide range of departments (22% of comments). This is an attribute of the system's operation that is different from system's qualities of reliability, responsiveness and ease of use included in the quantitative model. Availability issues, in addition to the slow response time and system downtime, were often attributed by users to overuse of the system due to large numbers of users.

"More computers needed for more users." (Nurse in Trauma Dept., 5 yrs' experience)

"Computers not enough, department is busy." (Nurse in Accident & Emergency, 7 yrs' experience)

Service quality was also an important issue for some (10%). Comments showed that it was difficult to access support for system issues (*support sufficient*) during night shifts and at weekends. The availability of only one technician for the whole hospital also emerged as an issue affecting service quality satisfaction.

"Problem with assistance as there's only one technician in the whole hospital." (Nurse in male surgical ward, 7 yrs' experience)

"Technicians are not around all the time when assistance is needed, especially during night shift." (Nurse in orthopaedic clinic, 19 yrs' experience)

Several respondents (26%) also referred to the previous system that had been in place. Of these, 61% preferred the previous system to the current one, which was largely attributed to the issues with the current system's response time. Of those that preferred the newer system, this was largely attributed to ease of use.

A minority of comments reflect a certain ambivalence towards the new system in terms of both having advantages.

"System is slow, causes delays, but preferred to last one." (Nurse in male medical ward, 13 yrs' experience)

"Prefer old system which was faster, new system slow though it still makes life easier." (Nurse in day surgery, 22 yrs' experience)

Thus, although the user satisfaction index (79.14) is fairly high, there are certainly very salient issues with regards to system quality.

There were few comments regarding the system's implications for productivity (10% of comments). These comments were specifically with regards to the impact of system quality issues such as response time and reliability on productivity as a result of delays incurred and the limited time available to nurses to interact with the system.

"The system is very slow, causing delays" (Nurse in female medical ward, 30 yrs' experience)

Some respondents also gave insights into how doctors' usage of the system was indirectly influencing their own satisfaction and productivity. For example, one nurse expressed a desire for doctors to get their own system password.

"Doctors should obtain their own codes in order for them to order their own refills." (Nurse in Intensive Care Unit, 15 yrs' experience)

Another respondent implied that the system is of more benefit to doctors than nurses.

"The system is benefiting doctors not nurses." (Nurse in male surgical ward, 7 yrs' experience)

The use of the system may therefore have an unintended consequence of altering the working relations between doctors and nurses.

5. Discussion and conclusion

Health workers have numerous concerns about IS usage. Addressing these concerns requires understanding of the system attributes most important to their satisfaction and productivity. Our study examined nurses' evaluations of the performance of an integrated hospital information system along a set of attributes representing system quality, data quality, information quality, and service quality. We also considered the relative importance of these attributes to nurses' satisfaction with using the system and to their productivity. The empirical setting for our study was a regional public hospital located in South Africa. After running IT systems for a number of years, the hospital upgraded to an integrated HIS eleven months prior to our empirical study. Our PLS results showed that system quality, information quality, and service quality were important to user satisfaction with data quality and service quality also being particularly important to user productivity. However, by extending these results with an importance-performance analysis, we also identify which specific system attributes are highest priorities for intervention (i.e. where under performance is not acceptable to users), which attributes must be maintained, and which are of lower priority because underperformance appears more acceptable to users. Interestingly, different outcomes are associated with different system attributes. For user satisfaction,

we show that system quality has the largest effect on satisfaction with the attributes of responsiveness and ease of learning requiring immediate intervention. Qualitative evidence was consistent with these quantitative findings, with system quality issues dominating the comments, with particular emphasis on system responsiveness. These results generally support conclusions elsewhere that system quality attributes are salient to user satisfaction (e.g. [23] and important to ensuring a successful implementation [57]. On the dimension of information quality, our IPA results show that information cannot only meet requirements for availability and format but must be sufficiently detailed to ensure user satisfaction.

We also find that service quality attributes are important to satisfaction. Support and service quality has emerged as a factor important to satisfaction in numerous prior studies (e.g. [18,24,48]. Sufficient support was the only attribute that our IPA analysis identified as under-performing relative to its importance for both satisfaction and productivity outcomes, and is thus a service attribute in need of immediate intervention. In particular, as revealed by our qualitative evidence, nurses were concerned over too few technicians available at the hospital and that they are not available during night shifts. Thus, although support might be available, it is not necessarily sufficient and therefore deserves attention.

For user productivity, our results show that data quality problems require immediate intervention. Given their importance to productivity outcomes, we find an urgent need to respond to problems with the completeness and availability of records. As found in the qualitative data, problems with completeness appear to result from system limitations around input space, particularly for the matron's report. These results also demonstrate the importance of considering data quality attributes in HIS evaluations [16,47], and highlights their role as a basis for HIS benefits.

We also identified system attributes that require continued maintenance to ensure performance does not decline. Specifically, we found that satisfaction can be sustained by maintaining the system's ease of use and continuing to ensure outputs are easy to understand. Moreover, for continued satisfaction and productive use of the system, it is necessary to ensure that help provided to users is maintained. Attributes such as training may be considered overkill, with only two respondents mentioning training in their qualitative comments, thus resources and attention might be diverted elsewhere, e.g. from training to more on-hand technical support.

By using a mixed-methods design we were able to triangulate our qualitative and quantitative findings and obtain a better understanding of why certain attributes are priorities for attention, and how interventions should be directed (e.g. technicians at night, more technicians, and improved matron's reporting space). The qualitative element also enabled identification of other areas requiring intervention. For example, a lack of available workstations was of concern in some units, while other nurses highlighted how use of the system has the potential to impact on working relations between doctors and nurses.

There are some limitations to the study that should be noted. First, data was collected only from nurse users who were accessible during the period of data collection. Second, a selection bias may exist where the decision of a respondent to participate was related to that individual's perceptions of the HIS. Third, our results are based on nurse users of a vendor-based HIS package implemented in a public hospital in South Africa. The results are not necessarily generalizable outside this hospital context and user group. We were however successful in collecting data from a large number of nurses in different hospital wards who interact with the HIS as a regular and necessary part of their job. Moreover, we have shown the utility of the IPA technique for planning interventions in health care. Different types of health care workers e.g. physicians, technicians and pharmacists, and users of different types of packages in other hospital contexts may have differing attribute priorities that can be uncovered using the IPA technique. Fourth, usage in our context was mandatory and results may differ in contexts of voluntary use where users may revert to paper-based systems or be able to implement workarounds. We determined attribute priorities based on their importance to two outcome variables (satisfaction and productivity), future studies may wish to consider other user outcomes such as job enrichment.

To our knowledge this is the first study of HIS users that applies importance-performance analysis to understand the HIS attributes most important to their satisfaction and productivity. IPA can help healthcare authorities and researchers to understand the performance and importance of HIS system attributes, determine the areas of highest priority from the perspective of users, and plan appropriate interventions to provide for improved performance. System attributes targeted for intervention can then be analysed in detail to identify causes of under-performance, and we propose that the IPA technique be incorporated into the HIS evaluation toolkit.

Summary table

What was already known on the topic?

- Health workers have numerous concerns about system usage and its implications for their work.
- IS attributes include system quality, data quality, information quality, and service quality.
- IS attributes are important to user satisfaction.

What this study added to our knowledge?

- IPA technique is useful in HIS evaluation to direct managerial priorities by identifying system attributes in urgent need of attention.
- System, data, information, and service quality attributes have differing levels of importance for user satisfaction versus productivity outcomes.
- Underperformance in data quality is unacceptable for the productivity of nurses, while underperformance in system responsiveness and support is unacceptable to the satisfaction of nurses .

Conflicts of interest

No conflicts to declare.

Authors' contributions

Authors contributed equally to the conceptualization of the study. Cohen wrote the paper and was predominantly responsible for carrying out the quantitative analysis. Coleman wrote the paper and was predominantly responsible for carrying out the qualitative analysis. Kangethe was responsible for data collection and this work formed part of his Master's research studies. Cohen and Coleman also finalized the paper for submission.

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