A quantitative analysis of the impact of a computerized information system on nurses' clinical practice using a Realistic Evaluation framework

Cristina Oroviogoicoechea
PhD MSc RGN
Director of the Nursing Research and Innovation Unit
Clinica Universitaria
Universidad de Navarra
31080 Pamplona
Spain
e.mail: corovio@unav.es

(address for correspondence and proofs)

Roger Watson
PhD RN FAAN
Editor-in-Chief, Journal of Clinical Nursing
Professor of Nursing
Centre for Health & Social Care Studies and Service Development
School of Nursing and Midwifery
University of Sheffield
Sheffield S5 7AU
UK
Tel: +44114 226 9624
e.mail: roger.watson@sheffield.ac.uk

ABSTRACT

A quantitative analysis of the impact of a computerized information system on nurses' clinical practice using a Realistic Evaluation framework

Objective. To explore nurses' perceptions of the impact on clinical practice of the use of a computerised hospital information system.

Design. A realistic evaluation design based on Pawson and Tilley's work has been used across all the phases of the study. This is a theory driven approach and focuses evaluation on the study of what works, for whom and in what circumstances. These relationships are constructed as context-mechanisms-outcomes configurations (CMO).

Measurements. A questionnaire was distributed to all nurses working in in-patient units of a university hospital in Spain (n= 227). Quantitative data were analysed using SPSS 13.0. Descriptive statistics were used for an overall overview of nurses' perception. Inferential analysis, including both bivariate and multivariate methods (path analysis), were used for cross-tabulation of variables searching for CMO relationships.

Results. Nurses (n=179) participated in the study (78.8% response rate). Overall satisfaction with the IT system was positive. Comparisons with context variables show how nursing units' context had greater influence on perceptions than users' characteristics. Path analysis illustrated that the influence of unit context variables are on outcomes and not on mechanisms.

Conclusion. Results from the study looking at subtle variations in users and units provide insight into how important professional culture and working practices could be in IT (information technology) implementation. The socio-technical approach on IT systems evaluation suggested in the recent literature appears to be an adequate

theoretical underpinning for IT evaluation research. Realistic evaluation has proven to be an adequate method for IT evaluation.

Key words: computers; information systems; information technology; patient records; nurses; nursing; realistic evaluation; socio-technical approach; evaluation studies.

INTRODUCTION

The evaluation of information technology (IT) in nursing is relevant due to the rapid implementation of IT systems in healthcare. Nevertheless, such evaluation can be considered to be in its early stages. Limited insight has been developed and many relevant questions for effective design and implementation remain unanswered [1]. Investment in IT is significant and, to guarantee effectiveness, evaluation is crucial.

One of the main problems identified in the literature in relation to the utility of IT systems is the lack of adaptation to workflow and, therefore, IT systems not being clinically relevant, but being designed for legal or management purposes [2]. Patient care should be the main aim of an IT system, it has to be clinically relevant and adapted to workflow. Healthcare organisations should consider clinicians' input to IT development or adaptation [3]. This approach resembles the paradigm change in evaluation of IT systems from a technical to a socio-technical approach, where users and context become key aspects in evaluation [4].

Kaplan and Shaw [5], in a literature review of evaluation research of IT systems, recognise the lack of frameworks that help to develop theories to guide further research and implementation. More empirical data, based on theoretical frameworks, both from IT and evaluation research could help us to learn from and translate research between

settings. Integration of results from different studies using a theoretical framework could help the accumulation and theory development of IT implementation in healthcare.

The complexity of IT evaluation research and the recommendations made from previous studies, such as the importance of taking into account context variables and the use of multiple methods for a wider approach [4, 6, 7, 8], make realistic evaluation a promising approach to IT evaluation research [9]. Grounded on theory-based evaluation research, realistic evaluation understands causality in terms of generative mechanisms; causal relationships are not straightforward, as context factors can modify outcomes: mechanisms should be in the right context to produce the expected outcomes [10]. Furthermore, the aim of the evaluation is not to demonstrate simply that the intervention, in this case the IT system, works but to understand how it works and what the links are between context, mechanisms and outcomes. Kaplan and Shaw's [5] recommendations for IT evaluation highlight the following: "Thus evaluation needs to address more than how well a system works. Evaluation also needs to address how well a system works with particular users in a particular setting, and further, why it works that way there, and what *works* itself means" (p. 220).

Critical realism opens up a new approach within social science research. "Reconceptionalising social and human sciences from a realist philosophical standpoint offers the possibility of understanding and, to some extent, explaining the regularities of the social world while avoiding the dead ends of positivism" [11] (pp 935). Critical realism has informed the work carried out in different fields: economics, housing organisations, education, evaluation, etc [11, 12]. The potential of critical realism is

widely recognised in organisational studies [13, 14], although it still has few empirical applications. In IT system evaluation research it is still, largely, absent but could be applied to overcome some of the problems with traditional approaches [1, 9].

The present study was designed to provide an insight into nurses' experiences using a computerised hospital information system in clinical practice in a teaching hospital in northern Spain. Discussion of the study with the hospital board was conducted to obtain permission to carry out the study and the hospital ethics committee approved the study. A realistic evaluation design was used to make sense of the complex relationships between variables included in the evaluation of IT systems and provide a wider view of the long-term impact. Being an under-used method in this area of research, the study provides insight into the utility of realistic evaluation for IT system evaluation research. The study involved both quantitative and qualitative data and this paper presents results from the quantitative analysis.

Description of the setting

The setting is a 400 bed highly specialised teaching hospital situated in northern Spain providing services in every medical speciality and has approximately 14,500 hospital admissions with an average stay of 6 days. In 1998 the hospital decided to develop and implement an integrated computerised hospital information system to manage clinical, administrative and financial aspects of the hospital. In January 2000 the system went live, initially with what was already computerised in the old system; since then the remaining functions have been introduced. The nursing documentation was fully computerised in 2001.

The system was self-developed whereby IT developers, who were hospital staff, worked closely with clinicians and were aware of hospital workflow and context when developing the system. The patient is the centre of the system, which provides a bi-directional communication across the whole organisation, accessing and entering data wherever it is required and generated. The system is integrated with a common way of documenting and accessing information across the hospital by all members of the clinical team.

The system incorporates different functionalities to enhance effectiveness of healthcare professionals such as alerts and reminders. The entire system is password driven to ensure the security and integrity of records. Nursing functionality includes mainly: access to previous patient information; nursing record: assessment, care plan, evaluation, fluid balance, clinical variables, etc.; medication administration; co-ordination and management of patient orders and tests; access to medical record and access to test results.

AIMS

The aims of the study are:

- to provide a comprehensive evaluation of the nurses' perspective on the use of an integrated electronic patient record and variations between different wards, units and nurses
- to evaluate the impact of the IT system on nurses' clinical practice
- to analyse the system characteristics that positively and negatively influence clinical practice

and, considering the method that is used:

- to analyse the appropriateness of realistic evaluation for IT systems evaluation research

DESIGN AND METHODS

Within the theory-driven approaches to evaluation, realistic evaluation was developed from the philosophical perspective of critical realism [10, 15]. In realistic evaluation, "The main aspect is that of generative mechanisms based on causality being, not external, but an internal potential of the programme or intervention that is activated in the right conditions" [1] (pp 572). Evaluation tries to uncover causal relationships between context, mechanisms and outcomes: what works for whom in what circumstances [10]. Theory is constructed as different configurations of context-mechanism-outcomes that explain the phenomena under study. In this study, realistic evaluation provides not just the methodology but also the theoretical framework. From this perspective, an IT system has to provide the reasons and resources to enable users to obtain the outcomes and it is the action of the different stakeholders that makes the IT system works [9].

Due to the lack of sound research to guide initial development of hypotheses based on context-mechanism-outcomes (CMO) configurations, a theory formulation and development design is used [10]. "Even in circumstances where the relevant mechanisms affecting the programme outcomes are not yet identified, the realist inquirer may strive to analyse the available data in the search for explanations, and to pave the way for the identification of the relevant mechanisms in the future" [16] (p. 22). Based on a literature review [1], the study looks at the specification of the different contexts, mechanisms and outcomes involved in nurses' use of a computerised program

in clinical practice and brings about a possible model based on CMO configurations that could guide further research. A realistic approach is used across all data analysis and the study combines different methods to understand nurses' perspectives and underlying mechanisms.

The study took place in the following phases:

- Specification of contexts, mechanisms and outcomes was achieved through an extensive questionnaire specifically developed for the study and distributed to all nurses working in the in-patient nursing units. The questionnaire included most of the aspects related to the implementation of IT systems in clinical practice from the system, the user and the organisation perspective. Details about questionnaire development and validation have been published elsewhere [17].
- Results from the questionnaire were analysed looking for regularities; apparent associations that explain possible CMO configuration.
- Cross-case analysis of the results from the perspective of different units and nurses' characteristics was carried out to design a possible model. This model was based on cases with demonstrable varying differences in user and organisational factors.

Data analysis

Data were entered and analysed (bivariate and multivariate) using SPSS 13.0. Variables were classified as context, mechanisms and outcomes (Table 1) and compared for differences and relationships following the realistic evaluation design. Comparisons and

correlations among variables were carried out to test possible context, mechanisms and outcomes relationships that could guide further development of CMO configurations.

Table 1. Classification of variables into context, mechanisms and outcomes

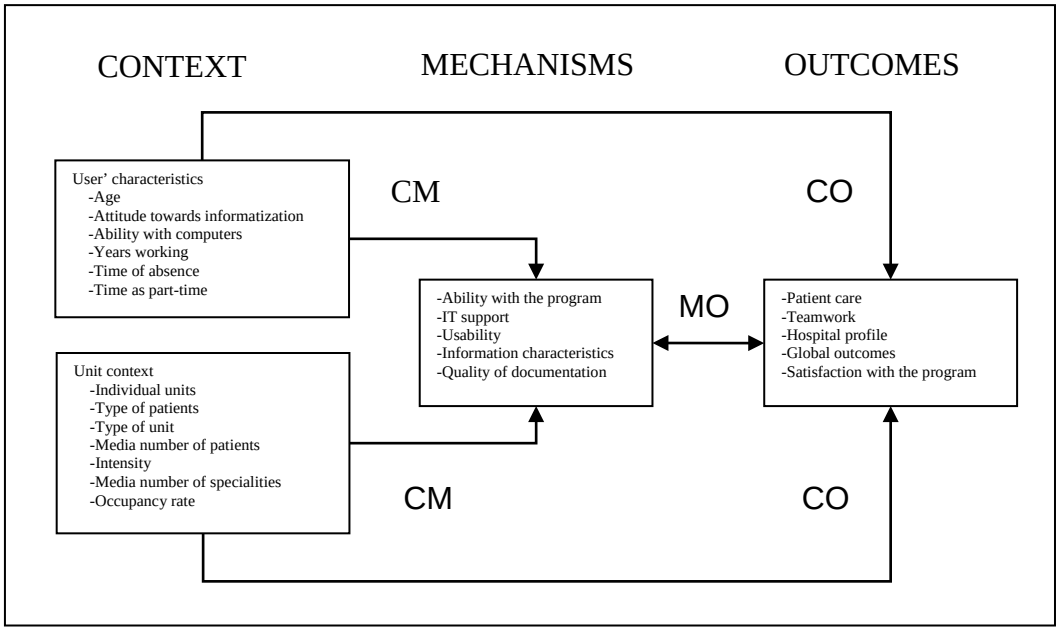
Aspects	Areas	Description
CONTEXT	Users characteristics	Age, attitude towards information technology, ability with computers, years working, time of absence, time working as part-time
	Unit characteristics	Type of unit, type of patients, occupancy rate, Diagnosis Related Groups (DRG) weight
MECHANISMS	IT support	Relationship with the personnel of the IT department, cooperative attitude of the IT personnel, IT personnel understand problems, suggestions are taking into account, response time to introduce an improvement is adequate, changes introduced have importance for daily work
	Usability	It is easy to use and to learn how to use it, it is easy to know how to do what you need to do, data registered are important for the care of the patients, the program is integrated in daily work information accessed from the program makes work easier
	Information characteristics	Access to the information where and when it is needed, reliability of the data documented, completeness and updated
OUTCOMES	Impact on communication	communication in the nursing team, in the health team and consideration of nursing work
	Impact on patient care	coordination of care, facilitate patient care, individualised care, continuity of care, decision-making
	Hospital profile	Research and hospital image
	Users' satisfaction	Satisfaction

Initial mechanisms and outcomes items were tested and modified by factor analysis before being used in the quantitative analysis. Mechanisms items generated a 3 factor solution: IT support, usability and information characteristics. Cronbach's value for

each factor range from 0.77 to 0.66. Outcomes generated also a 3 factor solution: impact on patient care, communication and hospital profile. Cronbach's value for each factor range from 0.85 to 0.64 [17].

Mechanisms and outcomes were considered the dependent variables and only those considered ordinal and interval were used for analysis. Data include multiple item Likert scales to measure them. Multiple item scales, strictly speaking, are ordinal but can be considered interval and most researchers currently treat them as such [18]. Scores of the items included in the different scales were summed and a total mean calculated for each of the scales and used for the analysis. Context variables, both unit and users, were the independent variables. Figure I shows the variables included in the analysis and the directions of the analysis.

Figure I. Variables and directions of the statistical analysis



Non-parametric tests (Kruskal-Wallis and Mann-Whitney) were used for ordinal data (ability with computers and satisfaction with the program) and parametric tests

(ANOVA and t-test) for interval data (scales of the different factors for mechanisms and outcomes). For the comparison of two means, Levene's test was used to choose the appropriate p value depending on whether the variances were equal or not. Post-hoc Bonferroni testing was carried out with the ANOVA to identify where the statistically significant difference in variances were. For correlation between ordinal and interval level independent variables Pearson's correlation was used.

Statistical significance of 0.05 and the Bonferroni test were used to minimise Type I error, and Type II error was controlled using Cohen's power analysis that establishes the sample size in relation to significance criterion, the statistical power and the effect size [15]. The sample size of the study was adequate for the different tests used for alpha= 0.01, power= 0.80 and a medium effect size.

Subsequent to the bivariate inferential analysis, multivariate analysis was used to assess the simultaneous relationship among variables. Path analysis, an extension of the regression model, was conducted. According to Bryman and Cramer [14] "Path analysis entails the use of multiple regression in relation to explicitly formulated causal models" (p. 313). A hypothetical model is constructed based on statistical results or a theoretical approach and the model is represented in a path diagram that makes explicit the likely connections between variables. The observed variables are linked by causal paths represented by causal arrows and, as Loehlin [20] notes, cause is understood in general terms.

"The aim of path analysis is to provide quantitative estimates of the causal connections between sets of variables" [18] (p. 314). A straightforward approach to performing a path analysis is using multiple regression [21]. Estimates, or path coefficients, are

numerical values that indicate the relative strength of the causal influence and are standardised regression coefficients. The unexplained variance for the dependent variables is calculated by subtracting the R^2 of the regression model from 1. This approach to path analysis does not provide an index of fit of a model, but R^2 gives a measure of how well the model is likely to fit in the population. Values higher than 0.3 can be considered as moderate or strong fit [22].

RESULTS

Nurses working in the in-patient area of the hospital (n=227) were invited to complete the questionnaire and 179 questionnaires were returned (78.8%). Nurses in the study were relatively young with 68.8% below 36 years. The mean number of years working was 10.1 (SD 7.5). In relation to nurses' experience with computers, they considered their ability with computers as good with a mean of 6.5 (SD 1.39) on a scale from 1 (low) - 10 (high). Most of them had a computer at home (76.9%) and their attitude towards information technology, not just in nursing but in society, was positive for the majority (96.5%). Because of the low responses for indifferent and negative attitudes both were unified as "negative" for analysis.

Support from the information system department was positively perceived by nurses, mean = 1.82 (SD 0.49) in a Likert scale from 1 (strongly agree) - 5 (strongly disagree). Nurses feel confident in the use of the program, ranking their ability with the program a mean value of 7.45 (SD 1.06).on a scale from 1 (low) - 10 (high). Usability includes aspects related to the easy-to-use characteristics of the program and how it is integrated in daily work. Nurses agreed that it is easy to use the program in their daily work. The mean value obtained in a Likert scale from 1 (strongly agree) - 5 (strongly disagree) was

1.74 (SD 0.47). Information characteristics encompassed quality of the content and aspects related to accessibility of data and information. Information characteristics had a mean value of 2.1 (SD 0.5) on a Likert scale from 1 (strongly agree) - 5 (strongly disagree). While being positive, it is the least valued factor compared with the rest of the areas.

Nurses were satisfied with the program, with a mean value of 7.37 (SD 1.13) on a scale from 1 (low) - 10 (high). Outcomes in relation to the impact of the program on aspects of their job were also positively valued with a mean of 2.05 (SD 0.46) for general outcomes on a Likert scale from 1 (very positive) - 5 (very negative). Impact on hospital profile, that is in the use of the program for research and in the image of the hospital, was the most positively valued aspect (mean=1.88; SD 0.63), followed by impact on patient care (mean=2.05; SD 0.51) and teamwork (mean= 2.18; SD=0.62). When asked the key question for satisfaction: if they would go back to paper records or reintroduce paper records, 79.8% responded ’no’ and only 7.5% wanted to go back to paper. From the 12.7% of nurses who ‘did ‘not know’ most of them were nurses with no experience of the paper record.

Inferential analysis

Bivariate correlations were carried out to verify the relationship between the mechanisms, system characteristics and the outcomes. Highly significant results were shown for all the variables except for ability with computers which had no significant correlation with patient care and hospital profile (Table 2). There is a close relationship between mechanisms and outcomes, therefore, outcomes can be considered as possibly explained by mechanisms.

Table 2. Pearson's correlation coefficients for mechanisms and outcomes

	Satisfaction with the program	Patient care	Teamwork	Hospital profile	Global outcomes
IT support	-0.419**	0.365**	0.419**	0.254**	0.436**
Usability	-0.537**	0.498**	0.521**	0.321**	0.576**
Information characteristics	-0.470**	0.511**	0.458**	0.284**	0.558**
Quality documentation	-0.406**	0.489**	0.340**	0.276**	0.491**
Ability with the program	0.426**	-0.150	-0.266**	-0.111	-0.212**

** p< 0.01

Relationships between nurses' characteristics and mechanisms and outcomes

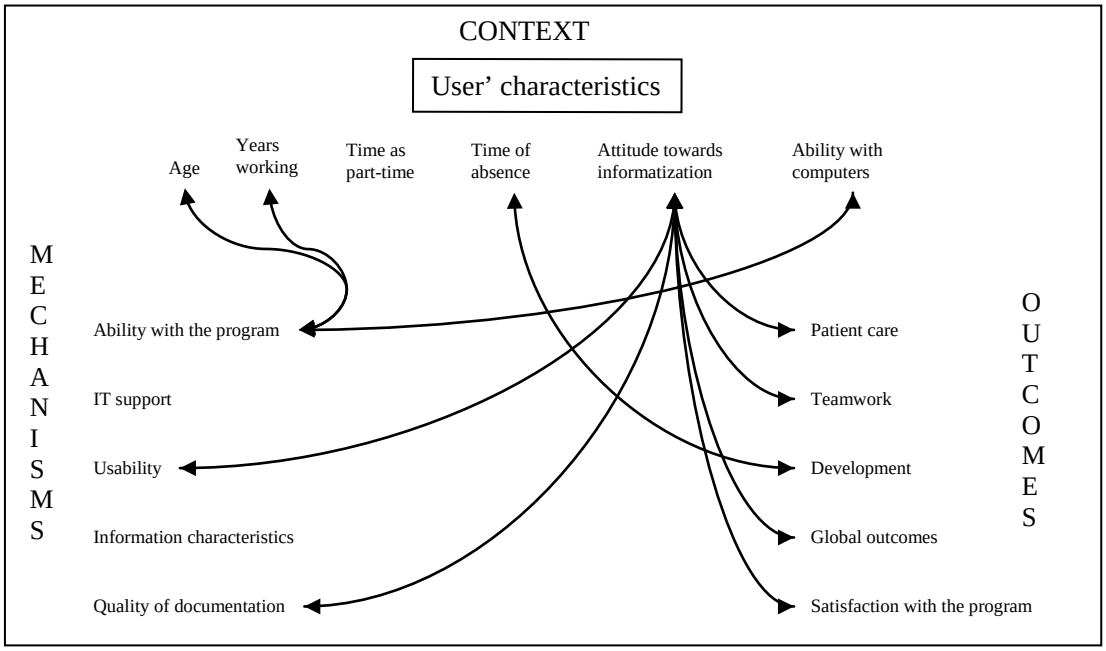
Results from comparison between mechanisms and nurses' characteristics did not produce significant results, except for ability with the program, that was highly significant for most of the nurses' characteristics variables. Comparison within age categories were significant (X^2=26.241, df= 6, p<0.001); mean value for ability with the program tended to be more positive in younger nurses (Appendix A). In the same way, years working and ability with the program had a negative correlation (r= -0.238, p<0.001): the more experience as a nurse, the less ability. As expected, nurses who consider themselves good with computers feel confident in the use of the program (r= 0.524, p<0.001).

Attitude towards introduction of information technology is the only users' characteristic that had significant difference based on usability (t= 2.988, df=167, p=0.003) and quality of documentation (t= 3.495, df= 164, p=0.001). Nurses with a positive attitude

had lower mean values and, therefore, more positive perception of all the mechanisms variables, especially for usability and quality of documentation (Appendix B).

Attitudes towards the introduction of technology is also the only user characteristic with significant results related to outcomes, both for satisfaction with the program (Z= -3.085, p=0.002) and all the factors included in the outcome analysis (patient care, teamwork, hospital profile and general outcomes). It was highly significant for all variables, except for hospital profile, where significance is only $p< 0.05$. Nurses with a positive attitude towards the introduction of technology have a better perception of the impact of electronic system in their daily work (Appendix C). Figure II summarises results of the analysis of CMO looking at users' characteristics as context. Lines represent comparisons and relationships with significant values $p< 0.01$.

Figure II. Representation of the significant relationships between users' characteristics, mechanisms and outcomes



Relationships between units' characteristics and mechanisms and outcomes

Support from the information technology department is the mechanism most related to unit characteristics. Mean values of IT support are more negatively perceived in ICU than general wards ($t= 4.770$, $df= 167$, $p<0.001$). On the basis of individual units, ANOVA demonstrated significant differences ($F= 4.717$, $df= 11$, $p<0.001$). Bonferroni testing showed that this difference lay only between ICU and most non-ICU units. Testing on the basis of type of patient, ANOVA showed significant differences ($F= 7.990$, $df= 3$, $p<0.001$); Bonferroni testing showed a difference between ICU and other types of patient. Therefore, the difference in support from IT on the basis of unit characteristics seems mainly to be accounted for by differences between ICU and other areas. Similar results can be observed for information characteristics, although significance when comparing within individual units is only $p< 0.05$. Context variables more related to workload, such as occupancy rate and intensity of patients, had no influence in assessment of mechanisms.

As with mechanisms, unit characteristics seem to have more influence than users' characteristics on outcomes, but results point out that differences are explained not just by the distinction between general wards and ICU and, therefore, type of patients and individual units have also some impact on outcomes. Differences between general wards and ICU are only highly significant for teamwork ($t= 3.792$, $df= 169$, $p<0.001$). Type of patients has significant differences in patient care ($F= 4.676$, $df= 3$, $p=0.004$), teamwork ($F= 7.987$, $df= 3$, $p<0.001$) and mean score for outcomes ($F= 6.018$, $df= 3$, $p=0.001$) (Appendix D). Comparisons of individual units also have significant values

for patient care (F= 2.646, df= 11, p=0.004), teamwork (F= 3.115, df= 11, p=0.001) and mean score for outcomes (F= 3.083, df= 11, p=0.001).

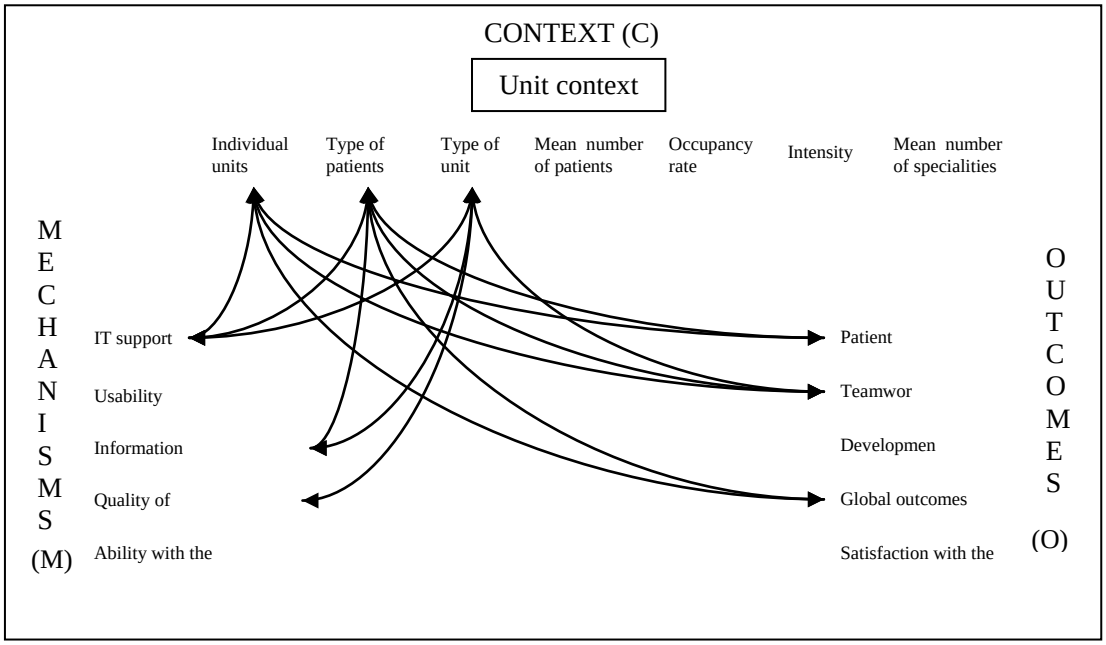
Unit characteristics in relation to workload have less impact although some significant values ($p< 0.05$) were found (Table 3). It is interesting that the negative correlation between the number of specialities, a reference to the diversity of patients in the unit, and satisfaction with the program, show that the more specialities involved, the lower the satisfaction with the program. On the other hand, occupancy rate has a significant positive correlation: more busy units are more satisfied with IT. Figure III summarises results of the analysis of CMO looking at units' characteristics as context. Lines represent comparisons and relationships with significant values $p< 0.01$.

Table 3. Pearson's correlation coefficients for mechanisms and nursing units activity variables

	Satisfaction with the program	Patient care	Teamwork	Hospital profile	General outcomes
Mean number of patients	-0.126	0.109	0.064	0.019	0.094
Intensity patients (GRD)	-0.067	0.012	0.063	0.104	0.050
Mean number of specialities	-0.199*	0.171*	0.138	0.028	0.164
Occupancy rate	0.205*	-0.084	-0.210*	-0.026	-0.144

* $p< 0.05$

Figure III Representation of the significant relationships between units' characteristics, mechanisms and outcomes



Results from path analysis

Context variables included in the path analysis are those with significant results in the bivariate analysis. Because of the high correlation among factors included in mechanism related to the IT system (IT support, usability and information characteristics), to simplify the analysis a mean value (IT environment) for the factors has been used; ability with the program has been considered separately because of the theoretically developed causal paths in the model. Also, outcomes variables have been represented in one item by calculating a mean value for the outcomes factors and satisfaction with the program. Despite differences in the measure of the variables, a high correlation among them justifies the calculation of a mean value for all of them.

Satisfaction with the program variable was recoded to have the same direction from positive to negative values as the outcomes scores.

A hypothesised model was constructed based on significant relationships from the bivariate analysis and following the CMO configuration pattern. Unit variables with a significant relationship in the bivariate analysis are type of unit and type of patients, but only type of patients has been included in the analysis as it already includes a category for critical care patients. Type of patients was transformed into a dummy-coded variable before being included in the analysis. Medical/surgical patients was considered the reference category as it is the least specific category, having both medical and surgical patients.

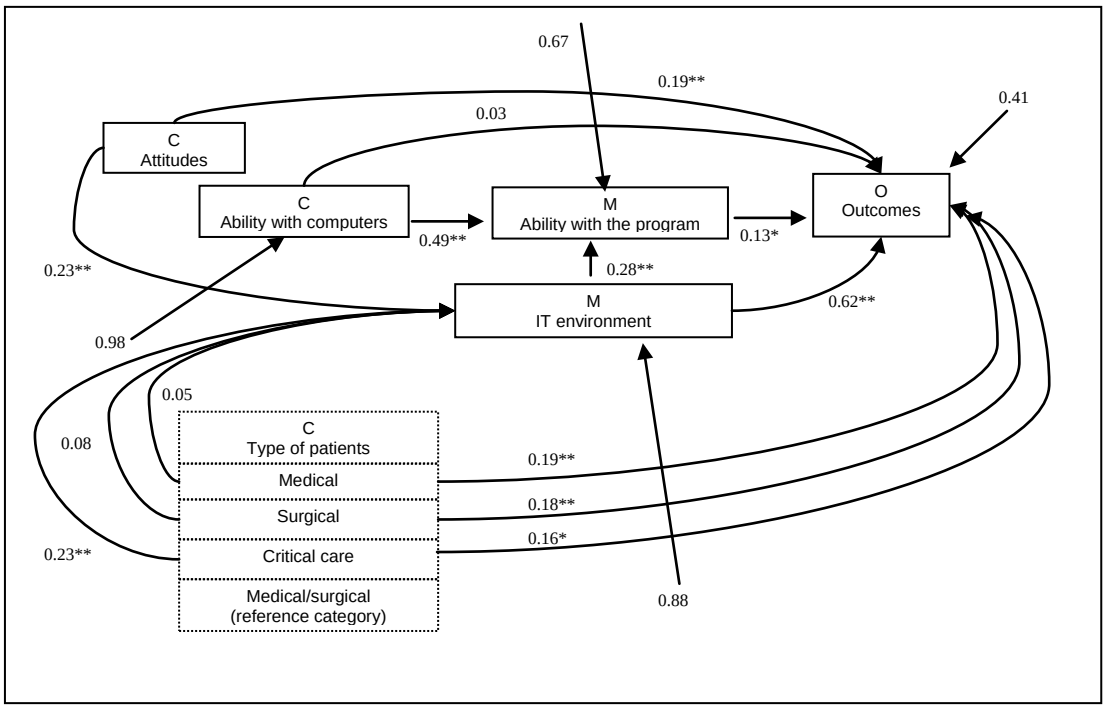
Multiple linear regression analysis was carried out for each of the equations shown in Box 1). The significance level of $p< 0.05$ was used for the standardised beta regression coefficients and for the adjusted R^2 which indicates the explained variance for each of the dependent variables. Results are represented in Figure IV. The total unexplained variance for outcomes as a dependent variable is E= 0.41. There is a significant impact of both mechanisms and context variables on outcomes. The biggest influence is made by IT environment ($\beta= 0.62$, $p< 0.01$). In the same way, when IT environment is removed from the model, the unexplained variance increases significantly (E= 0.70) if compared with the unexplained variance resulted from taken out attitudes (E= 0.45).

Box 1. The structural equations designed for the analysis are:

- Ability with computers = (B) attitudes + E_4
- IT environment = (B) attitudes + (B) Medical + (B) Surgical + (B) Critical care + E_3
- Ability with the program = (B) attitudes + (B) ability with computers + (B) IT environment + E_1
- Outcomes = (B) attitudes + (B) ability with computers + (B) ability with the program + (B) IT environment + (B) Medical + (B) Surgical + (B) Critical care + E_2

(B corresponds to the path coefficient and E to the unexplained variance)

Figure IV. Path analysis of significant relationships between context, mechanisms and outcomes



*p≤ 0.05; ** p≤ 0.01

Attitudes have both a direct effect on outcomes (β= 0.19, p= 0.001) and an indirect effect through IT environment (β= 0.23, p= 0.002). Ability with computers has only an indirect effect on outcomes through ability with the program (β= 0.49, p< 0.01). Unit characteristics have only a direct effect on outcomes and they do not have a significant influence on mechanisms, except for critical care patients.

It is interesting to note that some differences can be found when the path diagram is applied separately for satisfaction with the program and outcome factors. The total unexplained variance increases to E= 0.55 for satisfaction, and to E= 0.49 for outcome factors. Although still being highly significant, changes in the influence of IT environment can be observed. Satisfaction is less influence by IT environment (β= 0.48, p< 0.01) than outcome factors (β= 0.63, p< 0.01). On the other hand, unit characteristics do not have a direct effect on satisfaction but have a direct effect on outcome factors. Lastly, ability with the program has a direct effect on satisfaction (β= 0.27, p< 0.01) but not on outcome factors.

DISCUSSION

The main aim of the study was to provide a comprehensive evaluation of using an IT system in clinical practice from the nurses' perspective. This was achieved using realistic evaluation as a method and as a theoretical framework. From this perspective it appears that IT systems have to provide the reasons and resources to enable users to obtain the outcomes and it is the action of the different stakeholders that makes them work [9]. The study has, therefore, been an exploratory first step for further research on IT implementation. Results show a positive perception of nurses in relation to the impact of the IT system in clinical practice. Overall satisfaction with the program is

high and only 7.5% of the nurses wanted to return to paper records. There are very slight differences in the perception of the different mechanisms and outcome factors, all of them are positive and teamwork as an outcome is considered the least benefit from the IT system.

Comparisons of results to look at possible differences between the different contexts variables provide interesting conclusions. Individual characteristics appear not to have an impact on mechanisms and outcomes, except attitudes towards the introduction of technology. The unit context has an influence on both in bivariate analysis, but multivariate analysis show that the influence is on outcomes and not on mechanisms.

Most recent frameworks for IT evaluation focus on social relationships and the socio-technical approach. Therefore, this approach, as described by Berg, is considered as a strong theoretical foundation [23]. It addresses context, users and functionality and considers the mutual influence of the system and the context, being an iterative process. Realistic evaluation in this study has proved to be, from the evaluation research perspective, an adequate method to acknowledge these issues. Context and functionality have been examined and the mutual influence between context and the IT system became apparent in data analysis.

Clear-cut CMO configurations were not developed as a result of the study. Nevertheless, results acknowledge the multidimensional nature of IT systems and the influence of contextual factors. Venkatesh et al [24], in the development of the Unified Theory of Accepatnce and Use of Technology, suggest the importance of contextual analysis on IT implementation because of the effect of social influence constructs in the model. They recommend for future research to study “the degree to which systems

perceived as successful from an IT adoption perspective (i.e., those that are likely and highly used by users) are considered a success from an organizational perspective" (pp. 470). IT systems implementation can be considered as an open system where how the IT system works interact with mechanisms in place; realistic evaluation seems to be a method that could help to uncover underlying mechanisms that help to explain how and why an IT systems works. Nursing units with clear-cut differences - for example, ICU with the most negative perception of outcomes compared with medical and surgical units with differences in the impact of the IT system on communication within the health team - could provide the context for in-depth case analysis to understand underlying mechanisms further that bring about these differences. As Kazi [16] says: "The gold standard for the realist evaluator is not just 'what works', but 'what works, for whom and in what contexts', recognising that an explanation at any one time requires further investigation and further explanation" (p. 160).

One of the criticisms of evaluation studies is that they tend to be undertheorised [5]. The use of frameworks has been recommended as a way forward to contribute to theory development [25]. Classification of items into the context, mechanisms and outcomes structure of realistic evaluation has helped to clarify how variables are understood and used for analysis. It gives a comprehensive evaluation of how variables predict outcomes or influence them. Realistic evaluation approaches to theory development based on realistic cumulation provides the foundation for integration of findings from different studies and contributes to generate theory across studies where "individual studies can build into cumulative bodies of generalizable and transferable knowledge" [5] (p. 225). Carlsson [26] points out the major contribution that critical realism could

have in: “(1) IS (information systems) evaluation research, (2) artefact construction and design science, and (3) studies on IS discourses” (p. 334).

Limitations

Success could be explained by context variables different from those at user and unit level. Organisational variables (technology culture, innovation, leadership) and other variables (user involvement in IT design and implementation, type of IT system) are common to all the units in the study so comparison to acknowledge their impact has not been feasible.

Discrimination of users’ characteristics in relation to their impact on IT system implementation could have been influenced by the homogeneity of the sample. Despite being all the population of in-patient nurses in the hospital, almost 70% was less than 36 years old, good ability with computers and a positive attitude towards the introduction of technology. Other studies have similar results but, because of sample characteristics in this study, results in relation to users’ characteristics should be taken cautiously.

The study has intended to provide a wider picture on IT implementation and within realistic evaluation we have chosen a more extensive research design. As Kazi [16] points out, a more extensive approach is required to “address research questions regarding the regularities, patterns and distinguishing features of a population” (p. 32) but it could lack explanatory depth. Interesting issues have been raised during data analysis and discussion but further research is needed for in-depth understanding of them.

Finally, this was a cross-sectional study and therefore limited in providing insight into changes during the process of IT implementation. In addition, being a single case study, generation of robust theory about relationships between context, mechanisms and outcomes is not possible; “generating robust theory is normally a lengthy procedure” [11] (p.415).

Contributions to practice

This study contributes to fill in a gap on IT evaluation research because of inadequate research into the reality of workplaces, and, therefore, to highlight “key features of the work which appear relevant to the participants and which have consequences for any future deployment of technology” [27] (p. 322). Results from the study looking at subtle variations in users and units provide a grasp of how important professional culture and working practices could be in IT implementation.

This study demonstrates the potential of realistic evaluation as an adequate approach for IT system evaluation. Results acknowledge the multidimensional entity of IT systems and the influence of contextual factors. IT systems implementation can be considered as an open system where how the IT system works interact with mechanisms in place; realistic evaluation seems to be an adequate method to uncover underlying mechanisms that help to explain how and why an IT systems works.

Generalisation of results is not possible but the use of a framework to guide the evaluation process improves reliability and increases rigor in research [23]. The study provides the first step in realistic accumulation and makes it possible to consider transferability of the results to other cases. The study provides a theoretical rationale

that facilitates decision-making about how to adapt this experience to specific circumstances [9].

CONCLUSIONS

The study has provided a wider picture of the impact of IT systems in clinical practice. It can be considered a successful story of IT implementation that has demonstrated not just a positive outcome but has also provided explanations through cross-tabulation of outcomes variables against other variables, those related to how the IT system works and the context where it is implemented. Although variables related to culture, norms, values and work patterns have not been explicitly included, the influence of the work environment became apparent as a result of the analysis. Activity variables have no influence on nurses' perception whereas differences in individual units or more conceptual grouping of units are significant. These aspects need to be explored more systematically to understand their role on IT implementation.

The novelty of the socio-technical approach on IT systems evaluation suggested in the recent literature appears to be an adequate theoretical underpinning on IT evaluation research. It acknowledges the relevance of the user perspective and context as essential aspects on IT implementation.

Realistic evaluation has proven to be an adequate method for IT evaluation. Effectiveness of IT implementation cannot be reduced to outcome variables as context and user factors could determine implementation. Understanding how and why an IT system works has a greater impact on future design and implementation than simply knowing that it works. On the other hand, structuring data around the concepts of

context, mechanisms and outcomes and exploring possible relationships has provided a comprehensive approach to disentangle the complexity of IT evaluation research.

What was already known in the topic:

- IT system implementation in healthcare needs to be clinically relevant and adapted to workflow
- The socio-technical approach suggests that there is a mutual influence between the context and the IT system
- Theoretical frameworks could help to move forward evaluation research on IT implementation

What this study added:

- The unit context has an influence on nurses' perception of the impact of IT implementation
- The use of a theoretical framework helps to clarify the complexity of IT evaluation research
- Realistic evaluation is a useful theoretical framework for IT evaluation research from the socio-technical perspective

Authors contribution: Design (CO, RW), data collection (CO), data analysis and interpretation (CO, RW), writing and revision of the manuscript (CO, RW).

Competing interests: none.

REFERENCES

[1] Oroviogoicoechea C, Elliott B, Watson R, Review: evaluating information systems in nursing, J. Clin. Nurs. 17(5) (2008) 567-75.

[2] Urquhart C, Currell R, Reviewing the evidence on nursing record systems, Health Informatics J. 11(1) (2005) 33-44.

[3] Bostrom AC, Schaffer P, Dontje K, Pohl JM, Nagelkerk J, Cavanagh SJ, Electronic health record. Implementation across the Michigan Academic Consortium, Comput. Inform. Nurs. 24 (2006) 44-52.

[4] Berg M, Implementing information systems in health care organisations: myths and challenges, Int. J. Med. Inform. 64 (2001) 143-56.

[5] Kaplan B, Shaw NT, Future directions in evaluation research: people, organizational and social issues Methods Inf. Med. 43 (2004) 215-31.

[6] Ammenwerth E, Graber S, Herrmann G, Burkle T, Konig J, Evaluation of health information systems- problems and challenges, Int. J. Med. Inform. 71 (2003) 125-35.

[7] Van der Meijden MJ, Tange HJ, Hasman A, Determinants of success of inpatient clinical information systems: a literature review, J. Am. Med. Inform. Assoc. 10 (2003) 235-43.

[8] Heathfield HA, Evaluating clinical systems: the social programme perspective. Health Informatics J. 7 (2001) 8-12.

[9] Carlsson, SA. Advancing information systems evaluation (research): a critical realist approach. Electronic Journal of Information Systems Evaluation 6(2) (2003) 11-20.

[10] Pawson R, Tilley N. Realistic Evaluation. London: Sage Publications Ltd, 1997.

[11] Connelly JB, Evaluating complex public health interventions: theory, methods and scope of realist enquiry, J. Eval. Clin. Pract. 13 (2007) 935-941.

[12] Clarke A. Evaluation research. An Introduction to Principles, Methods and Practice. London: Sage Publications Ltd, 1999.

[13] Leca B, Naccache PA, critical realist approach to institutional entrepreneurship. Organization 13(5) **(**2006) 627-651.

[14] Reed M, Reflections on the "realist turn" in organisation and management studies, J. Manage. Stud. 42(8) (2005) 1621-1644.

[15] McEvoy P, Richards D, Critical realism: a way forward for evaluation research in nursing? J. Adv. Nurs. 43 (2003) 411-20.

[16] Kazi M. Realist Evaluation in Practice Health and Social Work. London: Sage Publications, 2003

[17] Oroviogoicoechea C. A realistic evaluation of the impact of a computerised information system on clinical practice: The nurses' perspective. PhD thesis. University of Sheffield, UK. 2008

[18] Bryman A, Cramer D. Quantitative Data Analysis with SPSS 12 and 13. Hove, East Sussex: Routledge, 2005.

[19] Cohen J, A power primer, Psychological Bulletin 1 (1992) 155-59

[20] Loehlin JC. Latent Variable Models: An Introduction to Factor, Path, and Structural Equation Analysis 4rd edn. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2004.

[21] Cramer D. Advanced Quantitative Data Analysis. Philadelphia: McGraw-Hill Education, 2003.

[22] Muijs D. Doing Quantitative Research in Education with SPSS. London: Sage Publications, 2004.

[23] Currie LM, Evaluation frameworks for nursing informatics, Int. J. Med. Inform. 74 (2005) 908-16.

[24] Venkatesh V, Morris MG, Davis GB, Davis FD, User acceptance of information technology: toward a unified view, MIS Quart. 27 (2003) (3) 425–478

[25] Chiasson M, Reddy M, Kaplan B, Davidson E, Expanding multi-disciplinary approaches to healthcare information technologies: What does information systems offer medical informatics? Int. J. Med. Inform. 76S (2007) S89-S97.

[26] Carlsson SA. Using Critical Realism in IS Research. In: Whitman ME and Woszczynski AB (eds). The Handbook of Information Systems Research. Hershey PA: Idea Group Publishing Ltd, 2004.

[27] Jenkings KN. Problems encountered in integrated care records research. Health Informatics J. 10(4) (2004) 314-24.