

Impact of a nursing information system in clinical practice: a longitudinal study project

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Key words: Clinical information system, nursing informatics, nursing records, multimethod approach

Parole chiave: Sistema informativo clinico, informatica infermieristica, documentazione infermieristica, approccio multimetodo

Abstract

Background: The implementation of adequate clinical information systems helps to deal with the immense flow of health data to ensure the continuity of care and access to a safe and high-quality healthcare system. Currently there is an increasing awareness of the importance of evaluating and measuring the impact of such systems in clinical practice. Implementations often fail, due to inadequate interaction between technology and human elements.

Methods: This article describes a research project aimed at evaluating the impact of a clinical nursing information system (CNIS), called Professional Assessment Instrument (PAI), in clinical practice. The study will evaluate PAI Quality, Nurses Satisfaction, PAI Use, Nurses and Environment Characteristics, Net Benefits and Nurses' Experiences related to the PAI use. A theoretical model developed for this research will guide the study. A quali-quantitative longitudinal design will be performed involving two hospitals over a 9-month period. To measure different dimensions that affect the success/failure of CNIS we will use different tools/methods of data collection (questionnaires, psychometric tools, surveys and focus groups).

Expected Results: This study will evaluate the impact of a CNIS in hospitals providing an overview of the factors which can help and hinder the implementation of an information system.

Conclusions: The results of the study will support interventions to improve and implement clinical information systems designed to computerize nursing data, with positive effects on public health and research in general, providing further evidence for health policy.

Introduction

The volume of information produced by healthcare institutions is constantly growing, so that the use of information technology to support the process and the

management of information is an urgent necessity (1, 2). Furthermore, the increase of "fragile" patients requires that the healthcare system manages information to ensure the continuity of care and the creation of an effective information flow (3).

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Currently, the progress of information technology offers many opportunities for the skill development of healthcare professionals and, considering the present epidemiological and sociodemographic transition, it is crucial for nurses to become familiar with health information systems. In fact, nurses can obtain important information from the use of nursing information systems. However, the lack of use of a standard nursing language hinders nurses regarding the organized and systematic collection of data (4, 5) that could be used in clinical practice, research activity and health policy development (6).

For these reasons, many healthcare organizations consider even more important the implementation of clinical information systems in order to improve the accuracy, completeness and quality of documentation, as this has repercussions on the quality of care (7-10). However, the implementation of clinical information systems is associated with the risk of failure and, as a result of this, several researchers have studied the impact of such systems in clinical practice (11).

Many studies evaluating the impact of CNIS have been driven by research designs without an underlying theoretical basis. Furthermore, most of the study designs used were descriptive or correlational (12). Kaplan et al. (13) emphasized the importance of longitudinal and both quantitative and qualitative approaches to study complex phenomena such as the impact of a health information system.

Considering these important dynamics such as the need to develop a clinical information system and the awareness of "adverse reactions" in the use of technology, we have developed a research project. This project initially came about due to collaboration between the University of Rome Tor Vergata and the Public Health Agency of the Lazio Region and currently

continues with a collaboration between the University of Rome Tor Vergata and the Center of Excellence for Nursing Scholarship of Rome.

The aim of the project is to create and then to test a CNIS, called Professional Assessment Instrument (PAI), which allows nurses to document the nursing process by means of an electronic system, using a standard nursing language (nursing diagnoses, nursing interventions and nursing outcomes). The particularity of PAI is to provide suggestions to the nurses regarding such diagnoses, interventions and outcomes (14).

The purpose of this article is to present a study that aims at evaluating the impact of PAI in clinical practice.

The study intends to achieve the following results:

1. to measure PAI quality, User Satisfaction and Net Benefits;
2. to measure Nurses' Attitudes towards Computerization, towards Nursing Process and towards Nursing Diagnosis before and after the PAI use;
3. to measure, should it exists, an association between PAI quality, User Satisfaction and Use;
4. to measure, should it exists, an association between User Satisfaction and Net Benefits;
5. to investigate nurses' experiences during PAI use.

Literature review

Many studies have examined nurses' attitudes towards computerization. The studies of Smith et al. (15) Lee et al. (16) and Smith et al. (17) showed how the implementation of an information system in a healthcare organization can be complex since the introduction of a CNIS produced negative attitudes in nurses. In contrast, Moody et al. (18) observed

positive attitudes after the implementation of an information system, especially in nurses experienced in computer use. Other researchers (19-22) also identified the variables that correlate with positive attitudes towards computerization such as younger age, lower nursing seniority, more education in nursing, more experience in computing and greater use of computers.

It was observed that nurses' attitudes towards computerization could also depend on how nurses consider the nursing process and nursing diagnosis since most of the CNIS uses them both. In fact, Ammenwerth et al. (23) demonstrated the existence of a strong correlation between positive attitudes towards the nursing process and an overall positive attitude towards the CNIS.

Few studies were conducted to assess nurses' attitudes towards standard nursing languages. Junttila et al. (24) noted that nurses over 40 years of age with previous clinical experience 10 to 19 years, post-basic nursing education and with previous knowledge of nursing diagnosis were most positive in their attitudes towards nursing diagnosis. In the study of Hasegawa et al. (25) positive attitudes towards nursing diagnosis were closely correlated with years of nursing diagnosis use, while the diagnostic knowledge and competency were not associated with nurses' attitudes. Similar results were shown in a Brazilian study (26) in which positive attitudes toward nursing diagnosis positively correlated with diagnosis use but not with diagnostic competency. Da Cruz et al. (27) evaluated whether the introduction of NANDA-International (NANDA-I) taxonomy changed nurses' attitudes towards nursing diagnosis. The study results suggested that the use of NANDA taxonomy can improve nurses' attitudes towards diagnosis use. The implementation of a standard terminology such as nursing

diagnosis can be problematic because it can be considered difficult and unfamiliar to clinical nurses (28, 29); therefore it is important to monitor nurses' attitudes towards nursing diagnosis (30).

Many studies that evaluated the impact of a CNIS measured the accuracy of the documentation after its implementation. The results of these studies showed an improvement in the completeness of documentation after a period of time that varied between 3 and 18 months post-implementation (7, 15, 31, 32). Although currently few studies have investigated the relationship between the accuracy of the documentation and the effect on patient outcomes (33), several authors agree that a relationship exists (34, 35).

In studies evaluating a CNIS it is essential to use both a quantitative and qualitative approach. The use of a multimethod approach allows us to focus on different aspects and to consider issues not foreseen at first. In a North American study (36) a qualitative and quantitative approach allowed the identification of CNIS quality dimensions, and the integration of collected data showed that CNIS quality had an influence on its use and nurses satisfaction.

Many studies have investigated nurses' experiences in the use of a CNIS with qualitative methods such as interviews, focus groups and observations. Ammenwerth et al. (7) through interviews and observations noted that the CNIS reduced the time spent in documenting care and improved communication between physicians and nurses. Timmons (37) using semi-structured interviews identified a "resistive compliance" with an ambiguous attitude of nurses towards the use of the CNIS. In an Australian study conducted with focus groups (38) nurses expressed predominantly negative experiences to the CNIS since it was not able to capture "real nursing", it was dif-

difficult to use and did not improve neither their clinical practice nor patient care. In another study with in-depth interviews (39) nurses reported positive experiences as they believed that the CNIS improved their knowledge, experience and judgment with respect to patient care.

Conceptual framework

Literature reports that the DeLone and McLean Model of Information Systems Success (40) is one of the most widely studied models (12, 41, 42) to evaluate the effectiveness of information systems. This model was developed to describe the success factors of an information system and includes six dimensions: 1) System Quality, 2) Information Quality, 3) Service Quality, 4) Intention to Use/Use, 5) User Satisfaction, 6) Net Benefits. This model, initially created to evaluate information systems in general is currently of significant interest in medical and nursing information technol-

ogy (36, 41, 43). However, the model was problematic in classifying outcomes in case of failure of information systems. In fact, it was observed that the model is based on a deterministic outlook that does not take into account the dimensions of the organizational culture and context that should be considered when the model is used within healthcare settings.

In this sense, the Despont et al. (42) Model of Human-Computer Interaction, covers the deficiencies of the DeLone and McLean Model, and specifically introduces the contingent factors related to organizational culture and context. This model includes five dimensions: 1) User Characteristics, 2) Development Process, 3) Context of Use and Environment Characteristics, 4) Clinical Information System Characteristics, 5) Impacts.

The integration of the DeLone and McLean Model and the Despont Model provided the conceptual framework to guide this study and was called the CNIS Successful/Unsuccessful Model. As already

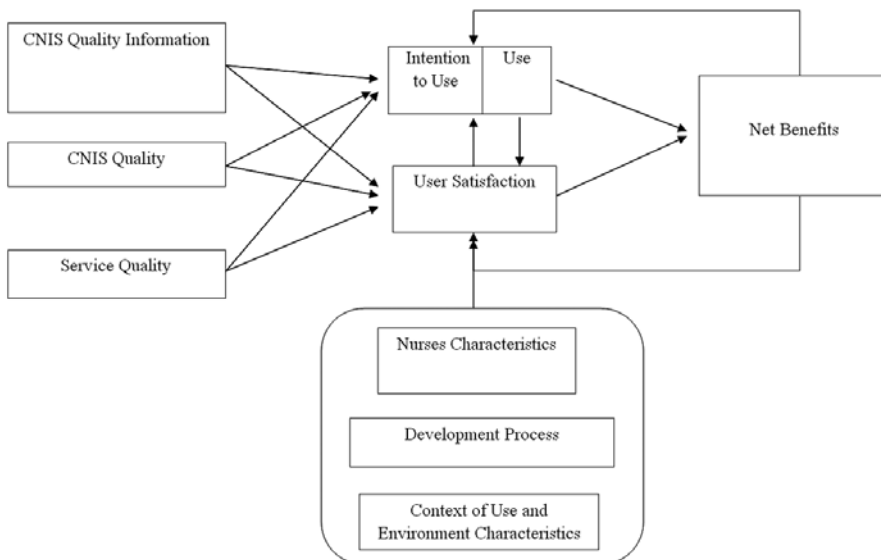


Figure 1. CNIS Successful/Unsuccessful Model
 Note. CNIS = Clinical Nursing Information System

supported by Booth (12), the integration of two such models has enormous potential because it takes into account the impact of the technological element whilst evaluating the interaction between humans and technology.

As shown in Figure 1 we hypothesize that CNIS Quality, Information Quality and Service Quality have a direct effect on Intention to Use/Use and on User Satisfaction; we hypothesize that the Intention to Use/Use are interdependent with User Satisfaction. Furthermore, we hypothesize that these two dimensions have a direct effect on Net Benefits from the point of view of the individual and organizational benefits and that Net Benefits in turn affect Use and User Satisfaction. Finally, we hypothesize that User Satisfaction is influenced by Nurses' Characteristics, the Development Process and the Context of Use and Environment Characteristics.

Methods

Design

The study design will be qualitative and quantitative. We will use a quantitative longitudinal design to achieve the objectives 1-4 and a qualitative design for objective 5.

Instruments

The following tools/methods of data collection, many of which will be developed specifically for this study, will be used.

Questionnaire to measure PAI Quality

A questionnaire will be developed by the research team to measure nurses' perceptions regarding the dimensions of PAI quality. The questionnaire will be based on literature review and previous focus groups conducted in a pilot study. Three dimensions of PAI quality (Information

Quality, System Quality and Service Quality) will be identified through the use of specific items. The questionnaire will first be tested on a group of nurses.

Survey to measure PAI Use

A survey will be developed by the research team to measure the number of entries and frequency of use of PAI.

Questionnaire to measure User Satisfaction

A questionnaire to measure User Satisfaction will be developed by the research team on the basis of literature review and focus groups conducted in an earlier pilot study. Before use, the questionnaire will be tested for content validity.

Questionnaires to measure nurses characteristics

Four questionnaires will be used to measure nurses characteristics: a socio-demographic questionnaire and three questionnaires that measure nurses attitudes towards computerization, nursing diagnosis and attitudes towards the nursing process.

1. Socio-demographic questionnaire

The questionnaire developed by the researchers measures socio-demographic variables (age, gender, education, years worked), variables related to computer use (education, hours, place and purpose of computer usage), variables related to the nursing process (education and nursing process use), and variables related to nursing diagnosis (degree of availability for nursing diagnosis use, education and nursing diagnosis use).

2. Questionnaire to measure Nurses Attitudes Towards Computerization

The Nurses' Attitudes Towards Computerization (NATC) questionnaire measures nurses attitudes towards computerization (44). The NATC consists of 20

items. Responses are rated using a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree), with total possible scores ranging from 20 to 100. Higher total scores indicate more positive attitudes towards computerization. Items assess aspects such as the degree to which the use of computers can improve or worsen patient care quality, computer efficiency, patient privacy. The psychometric properties of the NATC have been widely demonstrated in many studies (22, 44-47). The psychometric properties of the NATC were also satisfactory in Italian version (48).

3. Questionnaire to measure Positions on Nursing Diagnosis

The Positions on Nursing Diagnosis (PND) is a semantic differential scale that measures nurses attitudes towards nursing diagnosis (30). The scale comprises 20 items (bipolar adjective pairs). Each item is scored from 1 to 7. The total score ranges from a minimum of 20 to a maximum of 140, with higher scores indicating a better attitude towards nursing diagnosis. The validity and reliability of the PND has been demonstrated by the authors (30) and by a subsequent study that validated the PND also in the Brazilian context (49). The PND was also tested in Italian and showed adequate reliability and validity (50).

4. Questionnaire to measure Nurses' Attitudes Towards Nursing Process

The Nurses' Attitudes Towards Nursing Process (NATNP) is a questionnaire that measures nurses attitudes towards the nursing process (51). The NATNP has 20 items. Responses are rated using a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree). Items assess aspects such as the degree to which the nursing process can improve or worsen patient care quality, the efficiency of

the nursing process, the nurses acceptance of the nursing process. The validity and reliability of the questionnaire has been demonstrated in some studies (23, 51). In the Italian version of the NATNP two questions regarding the Kardex system were eliminated because they were not adequate to the Italian context, with the approval of the original author. Then, five questions were added and content validity of the modified version of NATNP was obtained by a panel of experts. The Italian version of the questionnaire has 23 items and the total score ranges between 23 - 115; higher scores indicate a better attitude towards the nursing process.

The NATC, the PND and the NATNP were all translated from English into Italian by two researchers and then back-translated into English by a native speaker of English, blinded to original items, with expertise in healthcare English. Then the questionnaires were all sent to their original authors who checked the translation accuracy.

Survey for Development Process

A survey will be developed to indicate the hours of training provided, the days of supervision and the organizational support provided and field notes will be taken to assess nurses participation in PAI development.

Survey for the Context of Use and Environment Characteristics

A survey will be developed to indicate the wards that participated in the study, patient type, the models of care delivery (functional care, team nursing care, primary nursing etc.), the nurse-to-patient ratio.

Instruments to measure Net Benefits

Two quantitative instruments and one qualitative instrument will be used to measure the Net Benefits of the PAI: 1)

an instrument to measure nursing documentation accuracy, 2) an instrument to measure Nursing Minimum Data Set elements and 3) focus groups to investigate perceived general benefits in the use of PAI.

1. D-Catch

The D-Catch instrument assesses the accuracy of nursing documentation (52). It comprises six items that quantify the accuracy of: 1) nursing documentation structure, 2) nursing assessment, 3) nursing diagnosis, 4) nursing interventions, 5) nursing outcomes and 6) nursing documentation legibility. The score format for each item is an 8-point, Likert scale with a sum score of quantitative and qualitative criteria. Items 1 and 6 are quantified by only quality criteria with a 4-point, Likert scale.

The D-Catch was tested for validity and reliability (52). The Italian version of the D-Catch was obtained by a translation and back-translation process. The validity and reliability of the D-Catch were showed to be adequate also in the Italian version. The inter-rater reliability was calculated using the intraclass correlation coefficient which was between 0.85 and 0.99. Construct validity assessed using explorative factor analysis with principal axis factoring and promax rotation identified three factors.

2. Survey for Nursing Minimum Data Set

A survey will be developed to identify the nursing diagnoses and nursing interventions documented before and after the use of PAI.

3. Focus groups

Interviews with focus groups will be conducted to collect qualitative data on the nurses' experiences in the use of PAI. The focus groups will be used to further investigate dimensions regarding: PAI

quality, Use/Intention to Use and, User Satisfaction. The perceived general benefits of PAI use related to the dimension of Net Benefits will be investigated only by means of focus groups.

Sample and setting

The study will be performed in two hospitals (a general hospital and a university hospital). More than one ward within each hospital will be selected. All the nurses in the selected wards will be asked to participate in the study.

Procedure

Participants will be studied for 9 months. Repeated measurements on each of the dependent variables (PAI Information Quality, PAI Quality, Service Quality, Intention to Use/Use, User Satisfaction, Nurses' Attitudes and Accuracy of documentation) will be performed (Table 1). The questionnaires to measure PAI quality and User Satisfaction will be administered after a period of 3, 6 and 9 months into the trial. The questionnaires NATC, NATNP and PND will be administered 15 days before the beginning of the trial and then after a period of 3, 6 and 9 months into the trial.

The D-Catch will be used to evaluate nursing documentation during the pre-trial period and the trial period after 3, 6 and 9 months. A sample of approximately 30 documentations will be analyzed in each period and in each ward. The data collection using this instrument will be carried out by two external reviewers, who will work in pairs. The reviewers will be trained in the use of the instrument and will independently evaluate the documentation; this method of data collection will reduce the reviewers subjectivity and assess the inter-rater reliability of the evaluation.

During and at the end of the trial, there

Table 1 - Dimensions, instruments and data collection times

Dimensions	Measures	Instruments	Nurses	PAI	Nursing documentation	Time (months)
PAI Information Quality	Perceived quality	Questionnaire	X			3,6,9
		Focus group	X			3,9
PAI Quality	Perceived quality	Questionnaire	X			3,6,9
		Focus group	X			3,9
Service Quality	Perceived quality	Questionnaire	X			3,6,9
		Focus group	X			3,9
Intention to use/Use	Use (objective)	Use survey		X		3,6,9
	Intention to use	Focus group	X			3,9
User Satisfaction	Perceived satisfaction	Questionnaire	X			3,6,9
		Focus group	X			3,9
		Socio-demographic characteristics	Questionnaire	X		
Nurses Characteristics	Nurses attitudes towards computerization	NATC Questionnaire	X			0,3,6,9
	Nurses attitudes towards nursing diagnosis	PND Questionnaire	X			0,3,6,9
	Nurses attitudes towards nursing process	NATNP Questionnaire	X			0,3,6,9
Development Process	Training hours; Supervised days; Organizational support; Nurses participation	Survey				
Context and Environment	Wards; Patient type; Models of care delivery; Nurse-to-patient ratio	Survey				
	Nursing documentation accuracy	D-Catch			X	0,3,6,9
Net Benefits	Nursing Minimum Data Set	Survey			X	0,3,6,9
	Perceived benefits	Focus Groups	X			3,9

Note. PAI = Professional Assessment Instrument

will be focus groups (53) with nurses. The focus groups will be performed after 3 and 9 months from the start of the trial. The focus group team will be composed of one moderator and two observers. All nurses that will test PAI will participate in the focus groups and each group will be composed of no more than 6/8 nurses. The interviews will last approximately 1.5 hours, will be recorded and notes will be taken when necessary.

Training and technical support

Training sessions for the use of the PAI will be carried out before the start of the study. All nurses who will test the system will follow a 10 hours training course. During the first weeks, nurses will be supervised by a member of the research team. Furthermore, in the case of need, technical and computer support will be provided during the trial.

Ethical considerations

All participating nurses will receive information regarding the purpose of the study and will be informed on the free participation. All data relating to both patients and nurses will be treated confidentially and only for scientific purposes. The anonymity of the subjects will be assured using numeric codes to identify the data, which will be accessible only to the researcher. Consent for the study will be obtained from the hospital Health Direction of the various facilities.

Data analysis

Two types of statistical analysis will be performed for quantitative data: descriptive and inferential. With respect to the descriptive statistical analysis indices of central tendency and dispersion (me-

ans, frequencies, standard deviations and range) will be calculated both in relation to socio-demographic data of the sample, both in reference to the instruments used. With regard to inferential statistical analysis the following statistical tests will be used: chi-square, t tests, Spearman's r, ANOVA and multiple regression. The level of significance is set at $p < 0.05$. The approach of qualitative content analysis to identify recurring themes in the participants experience will be used for qualitative data. For the analysis of quantitative data SPSS software version 19 will be used. For qualitative data software Atlas.ti version 6.2 will be used.

Discussion

Two useful approaches for evaluating a CNIS are qualitative and quantitative. In fact, the adoption of a quali-quantitative longitudinal design provides the opportunity to evaluate an information system using data collected from multiple sources that complement each other giving a more complete view of a multidimensional phenomenon (54). In addition, putting together data collected from a variety of different sources increases the robustness of research results through a process known as "triangulation" (13). This study will combine both quantitative data (questionnaires and surveys) and qualitative data (focus groups) since for an efficient evaluation of a CNIS it is necessary to study more than one dimension. One of the main reasons for using a qualitative approach is the possibility that this method of research allows us to understand how users perceive and evaluate the system and what this means to them (55). Furthermore, the quantitative methodology will provide numerical comparisons and statistical analyses of data with valid and reliable instruments, making it possible to

measure changes over time. Therefore, the use of multiple methods (quantitative and qualitative) will also allow us to consider issues not foreseen at the beginning of the study and a deeper understanding of a complex phenomenon such as the interaction between information technology and the human element. Since it is unlikely that one single dimension is decisive in the overall success of the CNIS, to make a correct evaluation each dimension of the Successful/Unsuccessful Model will be measured varying the measurement of time from dimension to dimension. Each dimension is expected to be successful (41).

Conclusions

This study will evaluate the impact of a clinical information system that uses a standard nursing terminology in hospitals. It will provide an overview of the factors helping and hindering the implementation of an information system. The study will help to identify users' attitudes towards the system and how they change over time. It will also assess whether the use of such a system improves the accuracy of nursing documentation and it will provide an overview of the functionality of the system. This knowledge is important because it will provide a basis for interventions to improve and then implement clinical information systems designed to computerize nursing data in a standard way. Finally, from the present study we expect to obtain a minimum data set of elements with uniform definitions and categories concerning the specific nursing dimension. It is expected that the systematic use of a nursing report will be able to provide possible combinations of uniform data comparable across various healthcare settings and various patient populations, making it possible to evaluate

the contribution of nursing care regarding all elements of healthcare results. Future research should evaluate the impact of the PAI on patient outcomes, nursing practice and its cost-effectiveness. In addition, it should evaluate how PAI promotes/improves the diagnostic reasoning of nurses and at the same time an evaluation of professional contents present within the PAI (nursing diagnosis, interventions, outcomes and clinical complications).

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Riassunto

L'impatto di un sistema informativo infermieristico nella pratica clinica: un progetto di studio longitudinale

Introduzione: L'implementazione di adeguati sistemi informativi clinici favorisce la gestione dell'enorme flusso di dati sanitari al fine di garantire continuità assistenziale e accesso a un sistema sanitario sicuro e di alta qualità. Attualmente esiste una crescente consapevolezza di quanto sia importante la valutazione e la misurazione dell'impatto di tali sistemi nella clinica poiché la loro implementazione è spesso a rischio di insuccesso a causa dell'interazione tra elemento tecnologico e umano.

Metodi: Questo articolo descrive un progetto di ricerca avente come obiettivo la valutazione dell'impatto di un sistema informativo infermieristico clinico (SIIC) denominato Professional Assessment Instrument (PAI) nella pratica clinica. Nello specifico lo studio valuterà la Qualità del PAI, la Soddisfazione nell'Uso e l'Uso del PAI, le Caratteristiche degli Infermieri e del Contesto Ambientale, i Benefici Netti e le Esperienze degli Infermieri connessi all'utilizzo del PAI. Lo studio che sarà guidato da un modello teorico specificatamente sviluppato per questa ricerca adotterà un disegno longitudinale qualitativo che coinvolgerà due ospedali e durerà 9 mesi. Per misurare le diverse dimensioni che influiranno sul successo/insuccesso del SIIC verranno utilizzati diversi strumenti/metodi di raccolta dati (questionari, strumenti psicometrici, schede di rilevazione, focus groups).

Risultati attesi: Questo studio consentirà di verificare l'impatto di un SIIC all'interno di strutture assistenziali, fornendo una visione dei fattori favorevoli ed ostacolanti l'implementazione di un sistema informativo.

Conclusioni: I risultati prodotti offriranno un valido supporto per migliorare e successivamente implementare sistemi informativi clinici volti ad informatizzare i dati infermieristici, con positive ricadute per la sanità pubblica e la ricerca in generale, fornendo inoltre ulteriori elementi per le scelte di politica sanitaria.

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