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Effect of a nursing information system on the quality of information processing in nursing: An evaluation study using the HIS-monitor instrument

Elske Ammenwerth^{a,*}, Franz Rauchegger^b, Frauke Ehlers^a,
Bernhard Hirsch^c, Christine Schaubmayr^b

^a Institute for Health Information Systems, UMIT – University for Health Sciences,
Medical Informatics and Technology, Eduard Wallnöfer Zentrum 1, 6060 Hall in Tyrol, Austria

^b TILAK – Tiroler Landeskrankenanstalten, Innsbruck, Austria

^c ITH-icoserve – Information Technology for Healthcare, Innsbruck, Austria

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ABSTRACT

Objectives: To assess the changes in the quality of information processing in nursing after the introduction of a computer-based nursing information system.

Methods: 94 nurses filled out the HIS-monitor survey, comprising 41 questions and focusing on the quality of the information processing, shortly before and again one year after the introduction of a computer-based nursing information system. A McNemar–Bowker test was used to assess the changes in quality over time. The HIS-monitor instrument was formally validated by calculating Cronbach Alpha.

Results: Despite some technical problems, the quality of the information processing in nursing significantly improved after the introduction of a computer-based nursing information system in many areas. The results show improved support during patient anamnesis and care planning, higher availability and completeness of nursing documentation, better overview on the patient, better readability of nursing documentation, reduction of duplicate documentation, better workflow support with task lists and checklists, and better fulfillment of the legal regulations. The results with regard to time efforts for nursing documentation and the related impact on patient care were mixed, however. Most of the expectations of the nurses that were stated before IT introduction seem to have been realized.

Conclusions: The HIS-monitor was found to be a useful instrument, in turn showing that the quality of the information processing in nursing strongly increased after the introduction of a nursing information system.

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1. Introduction

1.1. Scientific background

Information technology (IT) in healthcare can have a strong impact on process quality and the outcome quality of health

care [1–4]. However, research also points to the fact that IT can have a negative impact, for example on workload, on communication within a professional team, or even on morbidity and mortality [5].

In nursing, IT has been introduced in recent years in many hospitals to support nurses in their daily work [6]. Several eval-

* Corresponding author. Tel.: +43 50 8648 3809; fax: +43 50 8648 67 3809.

E-mail address: Elske.Ammenwerth@umit.at (E. Ammenwerth).

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uation studies and reviews have tried to measure the effects of computer-based nursing information systems on nursing care, most of them focusing on defined issues such as the quality of nursing documentation [7–10], time needed for certain tasks [11], user satisfaction [8,12], or patient outcome [13]. The results of those studies have often shown mixed effects with, for example, the higher documentation workload of the nurses, but also increased quality of care planning.

The daily activities of nursing can be quite diverse. They comprise, as core tasks, the planning, execution, and documentation of nursing care according to the care process. However, other important tasks performed by nurses comprise order entry and scheduling, dispensing and monitoring medication usage, ward management, documentation, communication to other professionals, just to give some examples—see Ref. [14] for a detailed analysis.

Computer-based nursing information systems are being used to better support nurses in their daily work. They are either stand-alone systems or, more often, a part of a larger clinical or electronic medical record (EMR) system [15], in turn allowing nurses to access or to provide clinical information to and from other healthcare providers.

The introduction or extension of a nursing information system affects the overall information processing in a hospital. In this context, information processing is defined as comprising the generation, storing, manipulation and communication of patient-related data, information and knowledge within an institution [15]. Any change in hospital information systems should be systematically evaluated [16], to learn from it and to improve the system, to support future decision-making, to justify the expenses, to show that the system is safe for patients and users, and to contribute to health informatics as a science [17].

As discussed above, research often shows mixed or interrelated effects of nursing information systems, with improvements in one area that may be combined with worsening in other areas. To get the whole picture of the effects of a nursing information system, it seems helpful to combine specific evaluation studies that focus on specific evaluation criteria (such as time effort or documentation quality) with broader screening instruments that try to assess positive and negative effects in the overall range of nursing activities. We would like to report on the result of such a screening study.

1.2. Background of the study

In 2006, the nursing management of the University Hospitals of Innsbruck decided to introduce a computer-based nursing information system with a special focus placed on supporting the nursing care process. At that time, the University Hospitals of Innsbruck already had a comprehensive Electronic Medical Record System (based on HNA Millennium from Cerner Corporation, Kansas City, MO) for medical documentation, ward management, scheduling, order entry, administrative documentation and related tasks [18].

To ease integration, it was decided to introduce the nursing information system as a module of this Cerner EMR system. Nursing management was interested in evaluating this introduction. In particular, it wanted to obtain an overall picture of the changes in the quality of information processing in

nursing, to assess both the benefits and drawbacks in the different areas, and not only in the nursing documentation itself.

1.3. Objective of the study

The objective of this study was to assess the impact of the introduction of a computer-based nursing information system on the quality of information processing in nursing. In detail, we defined the following study questions:

1. How does the quality of information processing change after the introduction of a nursing information system?
2. Which expectations and fears did the nurses have before the introduction, and were those expectations fulfilled after the introduction?

2. Study context

2.1. Organizational setting

The University Hospitals of Innsbruck offer 1600 beds and treat around 90,000 inpatients per year [18]. Around 5100 staff members work there, 2500 of whom are nurses.

Before 2006, nursing documentation had been conducted only in a paper-based way. This paper-based nursing documentation system basically consisted of a form for nursing anamnesis, one form for care planning (listing nursing diagnosis, nursing objectives, and nursing tasks), one form for signing nursing tasks, one form for nursing reports, and one form for nursing transfers to other units. Nursing management found that this paper-based nursing documentation was of low quality, with often missing, incomplete, or outdated care plans, unreadable nursing reports, and missing nursing evaluations. Therefore, it was decided to introduce a nursing information system with a special emphasis on the nursing care process, aiming at improving the quality of nursing documentation.

2.2. System details

The computer-based nursing information system was implemented as a part of the HNA Millennium and comprised the following major functions: nursing anamnesis, allowing to reuse earlier anamnestic data (Fig. 1); nursing diagnosis based on the NANDA taxonomy; nursing care planning supported by pre-defined nursing care standards (Fig. 2); scheduling, reminding and documentation of nursing tasks; free-text nursing report writing; nursing evaluation; automatic creating of a nursing transfer report; and use of clinical pathways, comprising a set of nursing care standards, to support nursing care planning for certain patient cases.

Other nursing tasks, such as ward management and order entry, had already been supported by the HNA Millennium system beforehand. Medication ordering and documentation have not been covered yet, as they are still completely paper-based.

The typical computer equipment in each ward, typically 25–30 beds, consisted of 3–4 personal computers and laptops

Fig. 1 – Screenshot of the computer-based nursing information system, showing a part of the nursing anamnesis. On the left, different forms can be chosen that can then be completed by patient data.

(networked by W-LAN) dedicated to be used by the nurses only.

The introduction of the nursing information system started in 2006 in selected pilot units and was then step-wise deployed in all other units. At the moment (January 2010), around half of all the wards have been switched to computer-based nursing information system. All nurses received training shortly before the introduction of the system.

3. Methods

3.1. Study design

We selected the HIS-monitor instrument (see below) as a screening instrument and conducted a before-after study shortly before and one year after the introduction of a nursing documentation system. The study consisted of a quantitative and qualitative part.

3.2. Participants

All registered nurses participating in the training sessions on the new nursing information system were asked to fill out the survey immediately after the training session. This training session was typically conducted two weeks before the system introduction. After one year, all the nurses in each ward who worked with the system were again asked to complete the same survey.

3.3. Study flow

For both surveys, the respondents were asked to use a code when filling out both surveys, consisting of a combination of letters from the first names of their parents. This helped to ensure the anonymity of the survey while allowing us to match both surveys by the respondent. Only those respondents who completed both surveys were included in the further analysis. Overall, the survey was conducted in 14

The screenshot shows a software interface for nursing care planning. On the left, a tree view lists various care plans and categories such as 'Anforderungen zum Abzeichnen', 'Pläne', 'Pflege', and 'PFLEGELEITLINIE'. The main area displays a table of nursing activities with columns for 'Anforderung', 'Status', and 'Details'. The table lists numerous tasks like 'Gewichtskontrolle durchführen', 'DEKUI: Zum Lagerungswechsel anhalten', and 'Spezielle Maßnahmen zur Aspirationsprophylaxe bei Sondenkostverabreichung', all with a status of 'Angefordert'.

Anforderung	Status	Details
<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> Pflege		
<input checked="" type="checkbox"/> Gewichtskontrolle durchführen	Angefordert	Wie: Stehwaage, Häufigkeit: Jeden 4. Tag
<input checked="" type="checkbox"/> DEKUI: Zum Lagerungswechsel anhalten	Angefordert	Wie oft: 2 - 3 stündlich
<input checked="" type="checkbox"/> Spezielle Maßnahmen zur Aspirationsprophylaxe bei Sondenkostverabreichung	Angefordert	Welche: Kopftell halb hoch stellen Sonderlagen kontrollieren Magenentleerung überprüfen
<input checked="" type="checkbox"/> Kalorienreiche Snacks und Getränke zwischen den Mahlzeiten anbieten	Angefordert	Welche: Hochkalorische Trinknahrung
<input checked="" type="checkbox"/> Lagerung zur Aspirationsprophylaxe durchführen	Angefordert	Oberkörperhochlagerung, Durch Unterstützen helfen
<input checked="" type="checkbox"/> Erheben des Dekubitusrisikos (Braden-Skala)	Angefordert	Häufigkeit: Jeden 4. Tag
<input checked="" type="checkbox"/> AUFN1: Patientenaufnahme, stationäre lt. Pflr.	Angefordert	Häufigkeit: Einmal ohne Termin
<input checked="" type="checkbox"/> Pflegeassessment	Angefordert	Häufigkeit: Einmal ohne Termin
<input checked="" type="checkbox"/> Vitalzeichenkontrolle durchführen	Angefordert	Fortlaufend.
<input checked="" type="checkbox"/> Erheben der Stuhlauscheidung	Angefordert	
<input checked="" type="checkbox"/> PFLEGEBERICHT	Angefordert	
<input checked="" type="checkbox"/> Ermitteln der Stärke des Würge-/Hustenreflexes	Angefordert	
<input checked="" type="checkbox"/> Auf Alengeräusche kontrollieren	Angefordert	
<input checked="" type="checkbox"/> Beobachten des Hautzustandes auf Veränderung	Angefordert	
<input checked="" type="checkbox"/> Ernährungsprotokoll führen	Angefordert	
<input checked="" type="checkbox"/> Zu ausreichender Nahrungs-/Flüssigkeitsaufnahme anhalten	Angefordert	
<input checked="" type="checkbox"/> 5: Medikamentenverabreichung	Angefordert	
<input checked="" type="checkbox"/> 5: Beeinträchtigtes Schlucken	Angefordert	
<input checked="" type="checkbox"/> Ist motiviert die Pflegemaßnahmen zu unterstützen	Angefordert	
<input checked="" type="checkbox"/> 5: Sondenernährung	Angefordert	
<input checked="" type="checkbox"/> 5: Mechanische Faktoren (z. B. Scherkräfte, Druck, freihandentziehende Maßnahmen)	Angefordert	
<input checked="" type="checkbox"/> 5: Unausgeglichener Ernährungszustand (z. B. Fettleibigkeit, Kachexie)	Angefordert	
<input checked="" type="checkbox"/> Erkennt die individuellen Risikofaktoren	Angefordert	
<input checked="" type="checkbox"/> 5: Beeinträchtigter Stoffwechsel	Angefordert	
<input checked="" type="checkbox"/> 1: Abneigung zu essen	Angefordert	

Fig. 2 – Screenshot of the computer-based nursing information system, showing a part of the nursing care planning. Based on pre-defined nursing care plans, the nursing activities are planned.

inpatient units (including units from Hematology, Neurology, Nuclear Medicine, Ophthalmology, Orthopedics, and Surgery).

3.4. Methods for data acquisition: the HIS-monitor instrument

For this study, we used the HIS-monitor instrument [19]. It is a screening instrument to describe the quality of a hospital information system (HIS) from a global point of view, i.e. addressing the various areas, workflows, and professional groups. It was developed based on a review of other available HIS quality surveys and frameworks. It allows for a comparison of the HIS quality between the areas, groups, and points. This means that it offers a quantitative score (consisting of sub-scores) of the HIS quality.

The HIS-monitor assesses how well the overall information systems support patient care by providing the information that is needed (information logistics). HIS quality in this sense can be best assessed by asking those people who are involved in this workflow. In this view, whether a HIS is seen as “good” or “bad” can only be answered from the point of view of the stakeholder groups directly involved. These involved staff members are the real experts of HIS quality because they alone can tell how well they are supported by the various information processing tools in their daily working activities.

The overall HIS-monitor comprises 107 specific questions and 12 general questions [19].

We selected those 41 specific questions from the original HIS-monitor survey that were relevant for nurses. In addition,

we selected 10 general questions on the overall user satisfaction. Finally, we added two open-ended questions, focusing on the expectations and fears with regard to the new system before its introduction (first survey), and on the benefits and drawbacks that they experienced after introduction (second survey). Fig. 3 shows a translated extract of the survey. The complete instrument is available from the authors on request (in German).

3.5. Methods for data analysis

Data analysis comprised the calculation of the frequencies of the responses for all 41 questions using SPSS. A comparison of the first and second survey was conducted using the McNemar–Bowker-test [20] with p set to 0.05. The reliability analysis of the HIS-monitor comprises an item analysis as well as the calculation of Cronbach Alpha [21].

The free-text responses were aggregated into a category system using inductive content analysis, using MaxQDA as an analysis tool. For this, phrases were identified and generalized into a system of categories.

4. Results

The first survey (conducted immediately after the initial training sessions) was conducted in 2007 and 2008. The second survey took place one year after the first survey.

P4.2 Documentation of diagnostic and therapeutic tasks							
 <i>Imagine: You have already carried out diagnostic or therapeutic tasks for one of your patients and now want to document them. Please think especially about the information processing tools that you use for the documentation and also consider efforts for finding/accessing the tool (e.g. patient record, computer).</i>							
			tools that are predominantly used	bad seldom not adequate		good frequently adequate	
1.	How easy is it for you to get an overview which tasks already have been carried out?	<input type="radio"/> this question does not apply to me	<input type="radio"/> paper-based <input type="radio"/> IT	--	-	+	++
2.	How often does it happen to you that tasks are not completely documented?	<input type="radio"/> this question does not apply to me	<input type="radio"/> paper-based <input type="radio"/> IT				
3.	How adequate do you consider the time needed to complete the necessary documentation?	<input type="radio"/> this question does not apply to me	<input type="radio"/> paper-based <input type="radio"/> IT	--	-	+	++

Fig. 3 – Translated extract from the HIS-monitor questionnaire.

4.1. Demographic data

Overall, we obtained 179 questionnaires in the first survey and 130 questionnaires in the second survey. Only registered nurses filled out the questionnaires. The return rate of the first survey can be estimated near 100%, as all the nurses underwent training sessions and, within the training session, nearly all the nurses filled out the questionnaire. As the number of registered nurses did not change much during the study time, the return rate of the second survey can be estimated as 67% (130 of 179).

Ninety-four nurses filled out both surveys, only those were included in the further analysis. These nurses came from 13 different wards. From the 94 respondents, 43 worked in nursing for up to 5 years, and 45 for more than 5 years (6 did not answer this question). Seven respondents were head nurses, and the remaining were ward nurses.

In the first survey, 75% (69 of 94) of the respondents stated that they were quite or very comfortable when working with computers in general. In the second survey, this number increased to 93% (87 of 94) ($p = 0.001$).

4.2. Significance and support of nursing documentation

In both surveys, most of the respondents found patient documentation to be very important (see Table 1). In the first survey, a large minority did not feel well supported by the available tools. This number significantly declined in the second survey. In both surveys, most nurses were familiar with computer use.

4.3. Time for computer usage

Before IT introduction, the nurses stated that they spent around 1/4 of their time on documentation. After IT introduction, this significantly increased to 41% of their time ($p = 0.00$) (Table 2).

4.4. Expected and realized impact of computer-based nursing documentation

Table 3 shows the expectations before IT introduction, and the experienced benefits and problems after introduction, as stated in the open-ended questions. All open-ended answers were aggregated into 15 categories (C1–C15).

Before IT introduction, nurses expected time savings, a better overview on patient-related information, and better readability of the documentation. They, however, feared reduced efficiency especially shortly after the introduction of the new system, more time needed for documentation, and less time for the patient.

After introduction, they found that indeed planning and documentation were faster, that the overview on patient information was better, and that documentation was more readable. In addition, they stated that documentation was more complete and comprehensive. On the negative side, they complained about technical problems during the introduction period. With regard to the time needed especially for care planning, the statements were contradictory, with some nurses seeing time savings, other seeing larger time becoming necessary. Some argued that they had even less time for the patients due to increased time at the computer.

4.5. Quality of information processing in nursing as measured by the HIS-monitor

Detailed results on how the quality of the information processing in nursing changed after IT introduction are shown in Appendix A. The data shows a significant change in the responses for 25 of the 41 questions. A strong increase of quality could especially be observed concerning: faster information access; readability of all the parts of the documentation; easier updating or changing in care plans; avoidance of double documentation; easier re-usage of already documented data; easier usage of checklists and guidelines; better work support by getting information on open tasks; clearer documentation of “who did what”; and better fulfillment of the legal regulations.

Table 1 – Answers to three general questions on IT support, before and one year after the introduction of a nursing information system.

		Not at all	Rather no	Rather yes	Very much	N (valid)
G1 How important is a complete, correct, readable and on-time documentation for the quality of care for your?	Before PDS	0	2	11	78	91
			2.2%	12.1%	85.7%	100%
G2 How much do you feel familiar with the computer used at your working place?*	After PDS	0	1	16	74	91
			1.1%	17.6%	81.3%	100%
G3 How well do you feel supported during nursing documentation by the tools used?*	Before PDS	0	16	50	25	91
			17.6%	54.9%	27.5%	100%
	After PDS	0	6	40	45	91
			6.6%	44%	49.5%	100%
	Before PDS	7	27	43	11	88
		8%	30.7%	48.8%	12.5%	100%
	After PDS	1	7	55	25	88
		1.1%	8%	62.5%	28.4%	100%

* $p < 0.01$.

Aspects that did not improve comprise the support of the communication with the physician, the access to medical reports and images, the support for prescriptions, the support of information handover during ward rounds or shift changes related to organization of patient care (e.g. appointments, new findings), the readability of medical findings and prescriptions, and the avoidance of double examinations.

4.6. Synthesis of the results

We will now synthesize the results from the closed and open questions. Ongoing problems with the quality of paper-based documentation were the motivation for this overall project, as explained before. In fact, more than 1/3 of the nurses felt insufficiently supported in nursing documentation by the paper-based tools used (Table 2, questions G3). In the second survey, already around 80% felt well supported by the tools. This indicates that the support for the nursing process and its documentation has improved by the nursing information system.

The general IT knowledge of the nurses seemed to be good (Table 1, G2), as the majority of nurses felt familiar with computers, this number even rose in the second survey. The time nurses felt to be spending using IT increased from 25% to 41% (Table 1), which may correspond to the larger number of tasks now being performed at the computer. The large standard deviation points to the fact that, depending on the role of the nurse and the department, the amount of documentation can vary largely. In addition, some nurses might have expressed their general dissatisfaction with IT usage by stating a higher time effort for IT usage than the time effort that objectively could have been measured.

The standardized HIS-monitor survey questions (Appendix A) showed significant improvements in those areas that are directly affected by the nursing information system. This includes, among others, the improved support during patient

anamnesis and during developing and maintaining a care plan, higher availability and completeness of nursing documentation, better readability of nursing documentation, reduction of duplicate documentation, better workflow support with task lists and checklists, and better fulfillment of the legal regulations. In all of those areas, a significant improvement of the quality of information processing could be observed by the HIS-monitor instrument.

No changes in the quality of information processing were visible in those areas where IT support did not change during the study. These are, for example, activities related to order entry, access of new findings, or other patient information (questions 1.1.4, 2.1.1, 2.1.2, 2.1.3, 2.1.5, 2.1.6, 2.1.7, 2.1.8, and 2.1.9) that has not changed by the new nursing information system, readability of information provided by other professional groups (questions 2.1.12, 2.1.13, 2.1.14, 2.1.16), or the transmission of information to other institutions (question 4.1.12).

Before IT introduction, nurses saw several general benefits of computerized nursing documentation. Some of them were realized after IT introduction, others not. For example, more than 60% of nurses expected time savings, while 1/3 expected time loss (Table 2, C5). After IT introduction, 50% saw time savings, while 1/3 found time loss. This different interpretation may originate in the different personal usage of the system: for example, while care planning is certainly much faster when using pre-defined care plans, it will take much longer when these pre-defined care plans are individually adapted to a patient. Altogether, the number of nurses who found the time invested in nursing documentation adequate (Appendix A, question 3.2.3) increased significantly from around 50% to around two-thirds.

Another benefit expected was a better overview on patient information, and in fact nurses commented that this benefit could be realized (Table 2, C6), as for exam-

Table 2 – Answers to the question “How much time of your daily work do you spend using IT”, before and one year after the introduction of a nursing information system (n = 94).

	N	Mean	Std. dev.	Range
Time using IT—before the introduction of a nursing information system	88	25.5%	20.1%	1–80
Time using IT—one year after the nursing information system	85	41.1%	20.9%	9–90

Table 3 – Expected and realized impact of computer-based nursing documentation (n = 94 nurses). The numbers give the number of nurses that uttered a related statement in the open questions. For each category, a typical example for a comment is given. Those categories with more than 20 comments are highlighted in gray.

Category	Expectations (before introduction)		Realization (one year after introduction)	
	Each cell gives the number of nurses who issued a comment in this category, and an example of a comment			
	“What do you expect as benefits?”	“What do you expect as problems?”	“Which benefits do you see?”	“Which problems do you see?”
C1. General usability and flexibility of the software		1 (“need to get used to the interface”)		16 (“system too complex”)
C2. Performance and stability of the overall system (e.g. breakdowns)		13 (“breakdown of the system”)		45 (“Laptops are SO slow”)
C3. Support and updates of the system				10 (“too many changes disturb”)
C4. Problems during introduction period (e.g. chaos, frustration)		24 (“chaos during introduction”)	5 (“learning by doing works”)	3 (“some users are overburdened”)
C5. Time needed for nursing documentation	60 (“time savings”)	28 (“more time needed”)	47 (“care planning is faster”)	28 (“often very time consuming care planning”)
C6. Overview on the information on a patient	38 (“better overview on open tasks”)	9 (“too much information”)	35 (“care plan is much clearer arranged”)	5 (“overview not good, most important information should be highlighted”)
C7. Readability of patient information	44 (“documentation readable for everybody”)		22 (“no problem anymore to read the handwriting of coworkers”)	
C8. Precision of documented information	13 (“more precise care planning”)		11 (“all documentation is much more exact”)	
C9. Completeness and reproducibility of documentation	15 (“complete description of patient care”)		27 (“continuous, complete documentation”)	6 (“nursing process not always reproducible”)
C10. Uniformity and standardization of documentation	7 (“uniform documentation for our house”)		12 (“standardized care plans, no formulation problems”)	9 (“possibility for free text is missing during care planning”)
C11. Better information access	2 (“access to patient data directly at the bedside”)		8 (“by using the laptop, always informed when being with the patient”)	
C12. Paperwork and double documentation	16 (“reduce multiple documentation”)		11 (“removed paper chaos”)	5 (“double documentation in patient chart and system”)
C13. Professionalism of nursing and effect on the patient	15 (“improve quality of care”)	21 (“too much time at the computer, less time for the patient”)	19 (“tasks lists help not to forget a planned task”)	14 (“quite a lot of time at the computer, less time for the patient”)
C14. Communication with other groups or wards	12 (“better cooperation with other groups”)		5 (“better information transfer to other wards”)	
C15. Legal issues	9 (“documentation conforms to the law”)		2 (“better evidence”)	

Table 4 – Reliability of the HIS-monitor instrument in the first and second survey.

Survey chapter	Number of items	Cronbach Alpha (1st survey)	Cronbach Alpha (2nd survey)
P1 Nursing admission	7	0.75	0.68
P2.1 Access to patient-related information	18	0.62	0.77
P2.2 Nursing care planning	6	0.66	0.67
P3 Execution of nursing care	9	0.63	0.8

ple the care plans and other parts of documentation were much better arranged and structured. Only very few nurses expressed concerns with regard to information overload in their comments. In the survey, a better overview on information was confirmed (questions 2.1.11, 3.1.1, and 3.2.1), supporting nursing workflow by showing for example open tasks.

In the quantitative survey, better and quicker information access could clearly be seen (questions 1.1.1, 1.1.2, 1.1.3, 2.1.4, 2.1.10, 2.1.11, 3.1.1, and 3.2.1). This aspect was mentioned only by a few nurses in the open comments (Table 2, C11), for example related to laptop use at the patient bedside. During the nursing shift change, the computer is typically not used, and the survey did not find improvements in the accessibility of information here (question 2.1.9).

Around half of the nurses mentioned the increased readability as an important benefit (C7), and this obviously could be realized, as the standardized survey showed (questions 1.1.5, 2.1.15, and 2.2.2).

Some nurses expected that the completeness and reproducibility of the documentation would be a benefit, and in fact around 1/3 of the nurses commented on this benefit after IT introduction (C9). This is supported by the standardized survey (question 2.2.3, 3.2.2). In the open comments, the precision of the documentation was also mentioned as a possible benefit, and in fact was seen by some nurses (C8). This was not visible in the standardized survey.

The standardization and uniformity of the documentation was mentioned as a benefit by some nurses after IT introduction (C10). Nearly the same number, however, found this to be a negative effect. The quantitative survey showed that there is good support provided in order to follow the guidelines after IT introduction (question 3.1.2), but that it did not further focus on the standardization of document content.

In the first survey, around 1/3 of nurses expressed concerns with regard to the introduction period, expecting chaos and other introduction problems (C4). After IT introduction, these starting problems were seldom mentioned any more. Indeed, five nurses even expressed that it turned out to be better than expected. In the quantitative survey, these introduction problems were not measured.

Nearly half of the nurses stated severe problems with the performance and stability of the system (C2), especially of the laptops being used. This seems to be a problem still after one year of use, but that is not visible in the quantitative survey. The aspect of usability and too frequent changes in the software were critically mentioned by some nurses (C1, C3). This also was not directly visible in the quantitative survey.

Some nurses expected a reduction in double documentation and duplication of information, and around 10% mentioned a reduction in paper chaos after IT introduction

(C12). A few nurses, however, mentioned that still some nursing information is in the paper-based patient chart (e.g. the vital signs), leading to duplicate information. The quantitative survey showed a reduction of the general duplication of information (question 2.2.4, 3.2.4, and 3.2.5).

With regard to the professionalism of nursing and the quality of care, opinions were mixed (C13). Both before and after IT introduction, the majority said to be aware that high-quality documentation is important for the quality of patient care (Table 2, G1). However, before IT introduction, around 1/4 of the nurses feared that the quality of nursing care would be negatively affected by the system, for example by having less time for the patients, while 15% expected an improvement of care (C13). After introduction, around 15% of the nurses in fact mentioned that they had less time for the patient, but another group saw benefits for patient care, as e.g. planned tasks are not forgotten as easily as before.

In the qualitative survey, no special comments on risks for data protection by IT have been made, and also the quantitative survey did not show rising concerns in this area (question 2.1.18). With regard to legal issues, the quantitative survey showed a better fulfillment of those laws concerning nursing documentation (question 3.2.6), which had been expected by some nurses (C15).

Overall, we found a significant increase in the perceived quality of information processing with regard to 25 (out of 41) questions, an unchanged quality in 16 questions, and no question with a significant decrease in the perceived quality. Thus, interestingly, despite the discussed specific technical and other problems, the overall perceived quality of information processing has clearly improved.

4.7. Reliability of the HIS-monitor instrument

Cronbach Alpha is a standard measure to describe the reliability of an instrument [21]. It reflects the internal consistency of a group of items. Table 4 shows the Cronbach Alpha values for those parts of the HIS-monitor instrument with more than two items. Values of 0.7 and higher are generally considered sufficient [21]. The results show that certain chapters show a satisfactory Cronbach Alpha, while others are not completely satisfactory.

5. Discussion

5.1. Answers to the study questions

By using a standardized survey instrument, we found a strong increase of quality of nursing documentation in areas that are related to efficiency, readability, information access, legal issues, and the re-usage of data; aspects that did not

improve comprise communication with physicians, prescriptions, information handover during ward rounds or shift changes, and the avoidance of double examinations.

These results mostly correspond to the open-ended questions on the expectations and fears of the nurses. Before IT introduction, nurses expected several benefits such as time savings, better overview on patient-related information, and better readability of documentation. After the introduction, they found an increased efficiency of planning and documentation, a better overview on patient information, and a better readability and completeness of documentation. With regard to the time needed, especially for care planning, the statements were contradictory, with some nurses seeing time savings, and others seeing more time necessary. Some argued that they had even less time for the patients due to increased time at the computer.

We only included nurses in this survey and were, therefore, unable to detect changes in the work processes of other healthcare professional groups.

5.2. Strengths and weaknesses of the study

We used a combination of a quantitative screening instrument with open-ended questions to analyze the changes in information processing in nursing. The strengths of this study are the usage of a standardized instrument, a high response rate, and the combination of quantitative and qualitative data. We did not conduct further in-depth interviews or objective measurements to validate or further explain the findings, as for example Lee et al. did [22]; this can be seen as a weakness.

The original HIS-monitor instrument comprised 107 + 10 questions, while the sub-set we used for this study comprised only 41 + 10 questions. As this could affect validity of the instrument, we re-calculated Cronbach Alpha. The used sub-set of the HIS-monitor showed partly sufficient reliability, while some parts had a Cronbach Alpha slightly below 0.7. The HIS-monitor was developed based on a matrix of process steps and quality criteria [19]. Each chapter (organized according to the process steps) thus contains items related to different quality criteria—within the chapter “nursing admission”, for example, questions related to time effort, completeness, and readability are combined. These items do not necessarily correlate, and this is reflected by Cronbach Alpha. Further research is needed to identify those items that best reflect the overall quality of information processing in order to reduce the number of questions in the instrument.

We found the HIS-monitoring screening instrument useful to assess general changes in information processing; in fact, many aspects that were mentioned in the open-ended questions were confirmed by the screening instrument. However, aspects that are related to technical issues, project management, or user supports were not covered in the HIS-monitor and were, therefore, not explicitly detectable. In addition, as it is only a screening instrument, some aspects were not assessed in detail (such as changes in the quality of nursing care).

A weakness of the study is the before-after design without applying a control group. Therefore, we cannot exclude that other changes besides for the documentation system may have influenced the quality of information processing. How-

ever, the survey took place in different departments and at different points of time, so this danger seems low.

HIS-monitor was able to detect a general change in the perceived quality of information processing. The reasons for this change, however, were not directly investigated. This can partly be compensated by the open-ended questions that we posed in our study. Overall, we did not find any contradictions between the quantitative and qualitative part.

5.3. Results in relation to other studies

Several evaluation studies have focused on the effects of nursing information systems on different criteria such as the quality of nursing documentation [7–10], time needed for certain tasks [11], user satisfaction [8,12], or patient outcome [13]. The results of those studies have often shown mixed effects, with for example a higher documentation workload, but increased quality of documentation. Only a few studies are comparable to our study and have tried to screen these effects in a more general way.

Lee et al. [12] surveyed around 550 nurses for one month and then again one year after the implementation of a nursing information system of a Medical Center in Taiwan. They used a 30-item survey instrument, asking for effects, training, usability, and usefulness, and combined this with one open-ended question asking for general comments. Comparable to our results, they found increased computer skills over time and increased time spent at the computer. Major problems were hardware shortages, system down times, and reports of the staff not spending enough time with the patients. This confirms our findings that hardware problems can pose severe problems during an IT introduction project. The University Hospitals of Innsbruck – like other hospitals – gradually roll out EMR systems, and this steadily increases the pressure on nurses to use IT functions in their daily work. Hardware or software problems can even increase the resulting feeling of stress and overload. In our study, individual nurses even stated to work more than half of their time at the computer—a value that cannot objectively be confirmed, but can be rather seen as an indication of negative feelings. This is also supported by the findings both by Lee et al. [12] and by our study that nurses complain about having less time for patients because of having to spend more and more time at the computer.

In another study, Kossman [23] used qualitative methods to assess how nurses in two community hospitals perceived the impact in the second year after an EHR introduction. Nurses were found to be comfortable with technology and felt that the EHR increased information access and improved efficiency. However, they also felt that documentation time increased, that interdisciplinary communication decreased, and that critical thinking was impaired through the overuse of standardized documentation. This supports the findings of our study.

Lærum and Faxvaag [24] designed a survey instrument to assess the usage of different IT-based functions in hospitals. The survey contains a list of typical tasks that can be supported by hospital information systems. It asks the respondent how often he/she uses a computer program for each task. In addition, the survey asks on the satisfaction with content, accuracy, format, ease of use, and timeliness of the

EMR system. This approach is different from our survey, as we focused on the perceived quality of information processing for different information-related tasks, and not so much on the frequency of IT usage for each task. In fact, the IT use in our case was mandatory for most functions.

In our study, we compared the quality of information processing in nursing before and one year after IT introduction. This helped us to see changes in the perceived quality of information processing. According to the Lewins change theory, change occurs in three phases: the unfreezing phase, change phase, and freeze phase [25]. With only two measurement points, we cannot be sure in which phase the organization is at the moment. However, the first survey may highlight the unfreezing phase, with a mix of expectations and fears. The second survey may reflect that some nurses are in the change phase, while others are already in the freeze phase: some nurses still seem to be fighting to respond to the new situation while having to conduct their daily work, complaining about hardware and software quality and less time for the patients; others may already be in the freezing phase, having internalized the new situation and seeing the benefits of it. Taking the standardized HIS-monitor survey as a basis, we would carefully estimate that 10–20% nurses are still in the changing phase, given the negative responses to the specific questions.

5.4. Implications of the results

We found that nurses in an Austrian University Hospital stated a clear increase in the quality of information processing after the introduction of a nursing information system. We could also see that hardware and software problems were an ongoing source of frustration. This result corresponds to the results of studies conducted in other healthcare organizations.

For the University Hospitals of Innsbruck, the incoming results of this evaluation study served as input to improve the implementation project. For example, user training was extended, the system documentation was improved, and more information and tips were presented via the intranet to the users. This all should help the users to work more efficiently with the system. User support during the first weeks was also intensified, and re-training sessions were offered to nurses who felt the need for it.

What was interesting and potentially new was that our screening instrument allowed the quantifying of the improvements of the quality of information processing, and to detect significant changes pre- and post-implementation. We have now the possibility to quantify the changes in information processing, which is a step forward compared to more qualitative investigations.

In addition, the numbers that we have generated can serve as benchmark data for other hospitals that decide to use the same survey instrument. In the future, this will allow for the comparing of the quality of information processing at different hospitals in a comprehensive, quantitative way.

To our knowledge, our survey instrument is one of the first attempts to allow the survey-based quantitative measurement of the information quality within a healthcare institution. It is unique in its very comprehensive approach, covering different processes and activities. Further research

Summary points

What was known before:

- Computer-based nursing information system can have mixed effects on nursing care.

What the study has added:

- A nursing information system was found to clearly improve the quality of information processing in many areas.
- The perception of the nurses with regard to time savings or time losses was mixed.
- The HIS-monitor screening instrument was useful to measure the quality of information processing.

is needed to refine and optimize the instrument. In addition, it would be helpful to develop shortened versions (for example, one version for each professional group). These shortened versions should then be further validated.

Furthermore, it would be helpful to use the numbers generated by the HIS-monitor to assess whether an institution is still in the “change phase” or already in the “freeze phase” [25]. The HIS-monitor instrument could then be used to identify the different phases of an IT adoption in an institution. For this, however, further research is also needed.

6. Conclusion

We used a combination of a quantitative screening instrument with open-ended questions to analyze changes in the information processing in nursing. In general, we found a significant improvement of information processing in many areas. Hardware and software problems as well as the feeling of increased documentation load were reported by many respondents, but seem to not affect the overall feeling of better IT support for nursing care. The used HIS-monitor instrument seems applicable to measure changes in quality of information processing.

Authors contributions

EA, FR and BH developed the HIS-monitor instrument. EA designed the study. FR and CS organized the study, collected the data and prepared data analysis. EA analysed the data and wrote a first draft of the manuscript. All authors contributed to the final version of the manuscript.

Conflict of interest

No conflict of interest stated.

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Appendix A.

Answers to the 41 HIS-monitor questions ($n=94$, before and one year after introduction of a nursing information system).

		-- Bad, infrequently, inadequate	-	+	++ Good, fre- quently, adequate	p-value
P1.1 Nursing admission						
1.1.1 How well (easy and quickly) can you access information of earlier stays/examinations of the patient ... of your department?	Before PDS	13	20	43	18	0.000
	1 year after PDS	1	6	36	49	
1.1.2 How well (easy and quickly) can you access information of earlier stays/examinations of the patient ... of other departments?	Before PDS	22	30	27	7	0.002
	1 year after PDS	4	20	44	19	
1.1.3 How well do you feel supported while collecting all the relevant earlier patient information for the physician ... Information from your department?	Before PDS	10	28	36	7	0.129
	1 year after PDS	3	15	40	15	
1.1.4 How well do you feel supported while collecting all the relevant earlier patient information for the physician ... Information from other departments?	Before PDS	16	36	25	2	0.003
	1 year after PDS	3	26	32	10	
1.1.5 How often is anamnesis data not readable or unclear?	Before PDS	14	41	28	8	0.000
	1 year after PDS	36	19	14	11	
1.1.6 How well do you feel supported by the available tools while documenting the patient history?	Before PDS	2	24	54	14	a
	1 year after PDS	0	9	40	43	
1.1.7 How well do you feel supported by the available tools during the documentation of risk factors and allergies?	Before PDS	12	29	44	7	0.063
	1 year after PDS	8	19	47	18	
P2.1 Access to available patient-related information						
2.1.1 How well (easy and quickly) can you access recent lab values?	Before PDS	1	1	26	66	a
	1 year after PDS	0	0	18	75	
2.1.2 How well (easy and quickly) can you access radiological findings?	Before PDS	2	9	28	44	0.176
	1 year after PDS	1	6	25	50	
2.1.3 How well (easy and quickly) can you access the physician consultation letter?	Before PDS	8	22	31	24	0.489
	1 year after PDS	6	18	34	25	
2.1.4 How well (easy and quickly) can you access nursing care plans and nursing documentation?	Before PDS	6	23	31	32	0.001
	1 year after PDS	2	6	23	60	
2.1.5 How well (easy and quickly) can you access prescription information?	Before PDS	13	27	39	14	0.679
	1 year after PDS	17	31	27	10	
2.1.6 How well (easy and quickly) can you access images (such as X-rays)?	Before PDS	10	13	30	12	0.063
	1 year after PDS	9	8	22	25	

Appendix A (Continued)

		-- Bad, infrequently, inadequate	-	+	++ Good, fre- quently, adequate	p-value
2.1.7 How well (easy and quickly) can you access patient-related appointments?	Before PDS	6	27	34	17	0.559
	1 year after PDS	7	18	34	16	
2.1.8 How well (easy and quickly) can you access medical and nursing information (such as open orders, appointments, new findings) during your ward round?	Before PDS	9	30	34	17	0.226
	1 year after PDS	7	22	35	23	
2.1.9 How well (easy and quickly) can you access medical and nursing information (such as open orders, appointments, new findings) during the nursing shift change?	Before PDS	7	19	42	23	0.996
	1 year after PDS	6	19	37	28	
2.1.10 How well (easy and quickly) can you access medical and nursing information (such as open orders, appointments, new findings) during nursing care?	Before PDS	12	34	36	10	0.012
	1 year after PDS	1	21	44	19	
2.1.11 How well (easy and quickly) can you obtain an overview on the changes in patient-related data that require immediate actions (e.g. new lab findings)?	Before PDS	1	23	36	31	a
	1 year after PDS	1	7	34	42	
2.1.12 How often are lab findings unreadable or unclear?	Before PDS	56	11	7	17	0.402
	1 year after PDS	56	7	9	12	
2.1.13 How often are X-ray reports unreadable or unclear?	Before PDS	52	9	7	9	a
	1 year after PDS	43	16	9	10	
2.1.14 How often are consultation letters unreadable or unclear?	Before PDS	12	13	25	37	0.772
	1 year after PDS	8	12	34	30	
2.1.15 How often is nursing documentation unreadable or unclear?	Before PDS	19	36	31	7	0.000
	1 year after PDS	46	15	12	15	
2.1.16 How often are prescriptions unreadable or unclear?	Before PDS	10	19	35	29	0.930
	1 year after PDS	10	17	27	34	
2.1.17 How often does it happen that clinical information (such as findings) are attached to the wrong patient?	Before PDS	37	39	9	2	0.231
	1 year after PDS	41	26	11	5	
2.1.18 How well is it prevented that somebody without sufficient rights can access specific clinical data?	Before PDS	19	20	29	14	0.288
	1 year after PDS	15	20	18	22	
P2.2 Creation and update of a nursing care plan						
2.2.1 How well do you feel supported while creating and updating a nursing care plan (for example, using care standards)?	Before PDS	5	23	47	17	0.003
	1 year after PDS	1	11	37	36	
2.2.2 How often are nursing care plans unreadable or unclear?	Before PDS	20	35	29	7	0.000
	1 year after PDS	52	9	9	7	
2.2.3 How often are changes in a nursing care plan documented in an unclear way?	Before PDS	11	30	34	15	0.001
	1 year after PDS	27	34	11	8	

Appendix A (Continued)

		-- Bad, infrequently, inadequate	-	+	++ Good, fre- quently, adequate	p-value
2.2.4 How often does it happen that you have to copy the same data when updating a nursing care plan?	Before PDS 1 year after PDS	14 39	26 11	35 5	17 4	0.000
2.2.5 How well do you feel supported by the information that is provided to prevent medication errors?	Before PDS 1 year after PDS	24 25	27 20	27 19	9 7	0.329
2.2.6 How well do you feel supported by the information that is provided to prevent unnecessary double examinations?	Before PDS 1 year after PDS	14 10	32 18	27 25	5 12	0.116
P3.1 Nursing care						
3.1.1 How well do you feel supported to obtain an overview on the open tasks for your patients (such as to-do lists)?	Before PDS 1 year after PDS	4 4	22 9	44 39	16 34	0.019
3.1.2 How well do you feel supported to follow standards or guidelines for planned tasks (such as by checklists)?	Before PDS 1 year after PDS	5 4	34 10	40 43	10 31	0.001
P3.2 Documentation or nursing care						
3.2.1 How well (easy and quickly) can you obtain an overview on the nursing tasks that have been already done for a patient?	Before PDS 1 year after PDS	6 3	18 5	46 34	24 51	0.001
3.2.2 How often are tasks documented in an unclear or incomplete way (such as who has done what, why not)?	Before PDS 1 year after PDS	16 30	39 31	29 22	8 7	0.021
3.2.3 How adequate do you find the time effort for nursing documentation?	Before PDS 1 year after PDS	18 6	34 21	37 47	4 16	0.005
3.2.4 How often does it happen that you have to copy the same data when documenting nursing care?	Before PDS 1 year after PDS	15 16	24 39	35 26	20 11	0.006
3.2.5 How well do you feel supported in reusing the available information for nursing documentation (such as observation results)?	Before PDS 1 year after PDS	13 5	40 24	31 45	8 18	0.023
3.2.6 How well do you feel supported in developing nursing documentation that corresponds to the legal requirements (such as complete documentation or the nursing care process)?	Before PDS 1 year after PDS	14 4	38 18	36 37	5 32	0.000
P4.1 Patient discharge						
4.1.1 How well do you feel supported in detecting incomplete nursing documentation during patient discharge?	Before PDS 1 year after PDS	18 7	24 15	30 34	13 29	0.030
4.1.2 How well are you supported in collecting and transmitting nursing-related information for other healthcare providers?	Before PDS 1 year after PDS	7 10	34 19	40 35	9 19	0.153

Median values are highlighted in bold.

^a McNemar–Bowker could not be conducted as some cells were empty.

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