



# Information Quality of a Nursing Information System depends on the nurses: A combined quantitative and qualitative evaluation

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## ABSTRACT

**Purpose:** Providing access to patient information is the key factor in nurses' adoption of a Nursing Information System (NIS). In this study the requirements for information quality and the perceived quality of information are investigated. A teaching hospital in the Netherlands has developed a NIS as a module of the Hospital Information System. After the NIS was implemented in six wards in March 2009, the NIS was evaluated.

**Methods:** A paper questionnaire was distributed among all 195 nurses, who used the system. Included in the research were 93 (48%) respondents. Also twelve NIS-users were interviewed, using the USE IT-model.

**Results:** Nurses express a broad need for information of each patient. Although the history is essential, the information needs are not very specified. They expect complete, correct, up-to-date and accessible information of each patient. The information quality of the NIS is satisfactory, but needs improvement. Since the achieved quality of information depends largely on the data-entry by the nurses themselves, a controversy exists between the required information quality and the effort needed to accomplish this.

**Conclusions:** The aspect of data-entry by the user of the information is not included in Information Quality-literature. To further increase the quality of information, a redesign of both process and system seems necessary, which reduces the information needs of nurses and rewards the nurse for accurate data-entry.

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## 1. Introduction

### 1.1. Rationale for the study

The use of the Nursing Information System (NIS) is mandatory for the nurses in a Dutch teaching hospital, so one could say that the adoption of the innovation is 100%. But adoption is not a dichotomous phenomenon: using the innovation, does not

automatically mean optimal use and correct use, nor user satisfaction. Evaluation of the NIS reveals what aspects are used and appreciated by the nurses and contributes to knowledge on aspects which enhance adoption. The evaluation is based on the USE IT-model, which theorizes that user characteristics determine adoption. User characteristics are described by four determinants: relevance, requirements, resources and resistance [1].

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The four determinants are located on two axes: the innovation axis, and the domain axis to demonstrate that adoption is always affected by the innovation process and the innovation product, and on the same time always affects both the user domain and the IT domain. The determinants help to identify what characteristics of the user and aspects of the innovation are dominant in a specific case.

Previous research on the relevance of the NIS learned, that the NIS is micro-relevant, because it solves the information problem of the nurse; the NIS can be regarded as an improved version of the paper record. Information quality seems more micro-relevant than relieving time pressure [2]. The NIS in the present study does not solve the problem of time-pressure, on the contrary: using the NIS is perceived as taking more time. But users expect that experience will reduce time spent on the NIS [2]. This implicates a challenge for the implementation of the NIS, because reducing time spent on documentation was one of the objectives the hospital management wanted to achieve by introducing the NIS. The predictions of shortage of nursing and medical staff in the near future are the incentives to make care processes more efficient. In order to understand why information quality is more micro-relevant than reducing time pressure, information quality is further explored in this article. The expectation that a NIS improves the quality of information and documentation is met in several studies [3–6], but not always [7]. To be able to improve the quality of information in the nursing documentation, it is necessary to know what factors determine this quality, and to know what information quality is required by the users of the information.

## 1.2. Scientific background

In their review of research dealing with IS-success DeLone and McLean define Information Quality as a the category of IS Success factors on the semantic or product level [8]. Since information is the product or output of an Information System (IS), the concept of output quality in the Technology Acceptance Model applies to the quality of information produced by an IS. Venkatesh and Davis define output quality as the degree to which an individual believes that the system performs its tasks well [9]. Output quality defined this way is part of the requirements determinant of the USE IT-model, see Fig. 1 [1]. The main quality criteria of the innovation are: timeliness (accessibility), accuracy (informativeness) and ability to integrate [1]. Also English defines information quality as the fulfillment of a requirement: information quality is “Consistently meeting knowledge worker and end-customer expectations” [10].

To accomplish the required information quality, information must be: the information the user needs, complete, accurate (reliable), understandable, accessible when and where the user needs it, in the format the user can use it easily, and fit the purpose [11]. According to Delen and Rijsenbrij the Information dimension of quality of Information Systems has five attributes: (1) correctness, (2) completeness, (3) up-to-dateness, (4) accuracy (degree of detail), and (5) verifiability [12]. In the above cited definitions the term accuracy is used in three meanings: (1) informative, (2) reliable, and (3) degree of detail. The common element in those three meanings is whether the information is usable and useful for a specific

	User Domain	Information Technology Domain
Product	<b>Relevance</b>  Macro-relevance Definition: The degree to which the user expects that the IT-system will solve his problems or help to realize his actually relevant goals.  Micro-relevance: Definition: The degree to which IT-use helps to solve the here-and-now problem of the user in his working process	<b>Requirements</b>  Definition: the degree to which the user needs are satisfied with the product quality of the innovation.  Macro-requirements Strategic general requirements and tactical approach is the degree in which the users agree with the objectives and methods used.  Micro-requirements Functional and performance requirements specify what the content of the innovation should be.
	<b>Resistance</b>  Macro-resistance Definition: The degree to which the surroundings an locality negatively influence the users of IT  Micro-resistance Definition: The degree to which IT-users themselves are opposing or postponing the IT-change	<b>Resources</b>  Material resources Definition: The degree to which material goods are available to design, operate and maintain the system.  Immaterial resources Definition: The degree to which immaterial goods are available to design, operate and maintain the system.

Fig. 1 – The USE IT-model.

task the user wants to accomplish. Accuracy is therefore interpreted as ‘fit for purpose’ in this study. Since patient information includes objective information (e.g. lab results), as well as subjective information (e.g. reporting), objective verification of data is not always possible. This means that reliability or trustworthiness is an important feature. Analysis of the definitions and attributes described above leads to the concept of Information Quality used in this study: Information Quality is defined as meeting the user’s information needs and being complete, correct, up-to-date, accurate, reliable and accessible anywhere and anytime the user needs the information.

## 1.3. Objectives of the study

To evaluate the quality of information in the NIS, the opinion and needs of the users on the quality of information are investigated by performing a further analysis of the study results. The central research question is:

*Does the Nursing Information System meet the information quality requirements of the users and what aspects determine this?*

To better understand the perception of information quality by the users, it is worthwhile to know their information needs. That is why the research question is further detailed in:

- (1) What are the information needs of the users?
- (2) To what extent are the information needs met?
- (3) What are the information quality requirements of users?
- (4) To what extent are the information quality requirements met?
- (5) What aspects of the NIS determine information quality?

The answers to these questions will result in the answering of the main research question.

**Table 1 – Study flow with participating departments and number of participants.**

Department	Implementation of NIS	Evaluation NIS March 2009% (n)	Interviews March 2009
Internal medicine			3
Orthopedic surgery			3
Geriatry	June 2007	39% (12)	3
Traumatology	January 2008	54% (26)	
Surgery	June 2008	43% (26)	3
Neurology	November 2008	51% (28)	
Planning office		1	
Total participants		48% (93)	12

The percentages represent the responses per ward.

## 2. Study context

### 2.1. Organizational setting

The study is performed in a Dutch teaching hospital, which provides tertiary medical and referral care. In 2005 the development and implementation of the NIS, as part of the Hospital Information System (HIS) has started. The project was split in two stages. In the first stage the patient history and the care transfer were developed and implemented. In the second stage the other functionalities were completed. The objectives of the hospital were to reduce time spent on administrative tasks by nurses, to reduce time spent on searching for patient information, to accelerate recording and reporting, to improve the quality of care by making more time available for providing care, and to enhance continuity of care by improving the information processes. The project manager and the members of the project group were all nurses, most working as team-managers. They consulted the nurses in their team during the development of the NIS. Before implementation the users received formal training of several hours. After the training the users could practice with computers in the department. During the implementation period a member of the project-team was present for instruction and consultation. In addition short trainings were given in the department when new functionalities were released.

The geriatrics, neurology and traumatology departments participated in the pilot in 2007. After the pilot, the care transfer and patient history functionality were implemented in the entire hospital, and by that the use of a computer in

documentation was introduced. Starting mid 2007 the complete Nursing Information System is implemented in the geriatrics, traumatology, surgery, and neurology departments. The evaluation is performed eight months after the last implementation (see Table 1). A department has 36 beds and approximately 40 nurses and 10 non-medical employees.

### 2.2. System details and system in use

Before the implementation of the NIS, the nursing process – including the paper nursing record, the nursing patient history and the nursing care transfer – was standardized. Based on these standardized stages of the nursing process, the NIS is developed by the hospital as a module on the Hospital Information System (HIS). The NIS can be considered as an improved version of the paper nursing record [2]. However, the structure of a computerized record is never exactly the same as in a paper document.

To open the NIS the nurse needs to log-on to the HIS, using a personal account and password, and to choose the tab NIS. The NIS is divided in categories, divided by tabs with underlying functionalities (see Figs. 2 and 3). All use is logged and the authorization is role-based.

## 3. Methods

### 3.1. Study design

To answer the study questions a multi-method socio-technical approach is used, combining both quantitative and qualitative methods. In March 2009 a paper questionnaire with

**Fig. 2 – Screenshot of the NIS with Tab Care plan selected.**

Fig. 3 – Screenshot of NIS. In Tab Care plan, the Tab reporting is opened.

closed and open questions, is used to evaluate the implementation of the NIS. Complementary interviews are held for evaluation purposes in the NIS-using wards, and in non-using wards for baseline measurement. Qualitative data retrieved from open questions in the questionnaire and interviews add expectations, additional aspects, arguments, feelings and motivations in order to explain and explicate the quantitative results.

### 3.2. Theoretical background of methods

Since filling out a questionnaire is less time-consuming than interviewing, more nurses can be interrogated with the questionnaire. In this section the construction of the questionnaire is justified. The used methodology is based on Babbie [13] and Cooper and Schindler [14]. The questionnaire was first constructed to measure the adoption of an EPR by medical specialists in 2003 [15], and adjusted for the evaluation of an EPR in a nursing home in 2007 [16]. For the evaluation of the NIS, questions of an evaluation of the paper patient record (unpublished work) are added and questions on use of the NIS are adapted for the specific system.

The questionnaire consisted of the sections: general (ward, experience with the NIS, job, job size, year of birth, sex), computer literacy, NIS use, support of providing care, ease of use, support of use, user satisfaction, patient focus (closed questions), and advantages, disadvantages and suggestions for change of the NIS (open questions). In this article only those results related to Information Quality will be reported. Since lack of ease of use can be an obstacle for using the NIS to fulfill the user's information needs, and for entering data accurately, especially in the early phases of using an Information System [17], results on perceived ease of use are also reported.

The items in the questionnaire are partially based on the research of Garrity and Sanders [18] and TAM3 [19] and are reformulated to fit the case of nurses using a NIS. The operationalization of the aspects of Information Quality is visible in Table 5: completeness is measured by item 6 and 7, correctness by item 4 and 5, whether the information is up-to-date by item 8, accuracy by item 1 and 2, reliability by item 3, accessibility by item 9 and 10, and the overall perception of Information Quality by item 11. In this way a questionnaire is constructed with more detailed and more specific questions than usually

applied for evaluation research. Instead of adding statements about the satisfaction with specific functions of the NIS, open questions were added at the end of the section about advantages, disadvantages and suggestions for change of the NIS. The language used complies with the language familiar to nurses. The questionnaire was in Dutch, the reported items are translated for this article. All items are intended to be one-dimensional, i.e. measuring one dimension. The time it takes to fill out the questionnaire is estimated at 10–20 min.

In addition to the questionnaire twelve nurses were interviewed, six NIS-users, and six nurses from wards where the NIS was not implemented yet. In both groups three nurses worked in a surgical department and three nurses in a non-surgical department. In this way four different case study settings are created with a sufficient number of both literal replications as chances to discover rival explanations [20]. To prevent bias, the criteria for being interviewed were not related to the objective of the research. The inclusion criteria were: availability and being able and willing to express one's opinion and thoughts on the topics. The interview candidates were ad hoc asked to co-operate by the team-manager at the start of the research. The participants were informed about the purpose of the research and were guaranteed full anonymity. They had the liberty to refuse co-operation without any consequences for their position. The semi-structured interviews were based on the USE IT-model, which comprises five sections: working process, relevance, requirements (information quality), resources and resistance [21]. The USE IT-model is suitable for baseline measurement and evaluation [22].

### 3.3. Study flow and participants

The participants in the evaluation research were all 195 nurses using the NIS. All participants received an envelop with the questionnaire, a return-envelop and an accompanying letter with information about the research, and in which full anonymity was guaranteed. The questionnaires were sent directly to the researcher by mail. Ninety-five nurses returned the questionnaire, of which 93 (48%) were included in the research. The participating departments and the responses per department are listed in Table 1.



### 3.4. Outcome measures and evaluation criteria

The actual use of the NIS and its specific functions can be regarded as an indication for the information needs of the users. Daily and weekly use are considered as frequent use and reflect the use of at least once during a shift. The answers to the closed questions constituted of five ordinal categories: fully agree, partially agree, neutral, partially disagree, and fully disagree. The results were analyzed using non-parametrical tests, because the data were not normally distributed. When the median was in the fully or partially agree, or when the sum of percentages of fully agree and partially agree was higher than the percentage of partially disagree added to the percentage of fully disagree, the result was considered to be positive.

### 3.5. Methods for data analysis

The quantitative data were analyzed using non-parametric tests, because the data were not normally distributed, the answering categories for frequencies of use were ordinal. For the same reason the median is marked, instead of the mean. For each question a  $\chi^2$ -test was performed to test whether the distribution of scores (fully agree, partially agree, neutral, partially disagree, fully disagree) differed significantly from an equal distribution of scores. The proposition is that by filling out at random the distribution would be equal. To test whether differences between departments were significant, the Kruskal–Wallis Test is used. Correlations between questionnaire items and the experience with the NIS (measured as length of using the NIS in months) the Spearman's rho is calculated. For all statistical tests the confidence interval is 95% ( $p < .050$ ).

The answers to the open questions consisted of short statements. In several iterations these were analyzed per question by splitting them in one-topic-statements. Statements which expressed a similar opinion were grouped, labeled, and counted. The transcripts of the interviews were analyzed by isolating topics and opinions. Answers to questions were compared to find shared, contrasting and additional opinions. The resulting statements were analyzed in a similar way as the answers to the open questions. Because of the limited number of interviews, frequencies are not reported.

## 4. Results

### 4.1. Demographic and other study coverage data

Seven (8%) nurses were also working as a team-manager. Three (3%) nurses were students. Three (3%) respondents are male. Few nurses work in small part-time jobs (<24 h/week), most common job size is 32 h/week. A full-timer works 36 h/week. Age shows a large range, see Table 2.

### 4.2. Study findings and outcome data

#### 4.2.1. Use of the Nursing Information System

The self-reported use of specific functions of the NIS is listed in Table 3. The use of the NIS is mandatory, and no paper nursing record was available. Each day a 'work-note' was printed with

a summary of planned actions. The doctor's orders were registered by hand at special paper forms. Those functions that did not apply to all nurses every day – like information and transfer at discharge – are not reported.

The low response on some items (e.g. Tab Care plan) can be explained in two ways: (1) Tabs were probably considered as headings in the questionnaire, and (2) previous research learned that respondents skip the items they do not use. Analysis of the results shows, that the NIS is used intensively for making care or nursing plans. However, supporting functions, such as the nursing plan example and the option to start a multi-disciplinary problem, are used by a limited number of nurses. In reporting categories are used, but linking to health problems, multi-disciplinary problems or nursing plans occurs less frequently. For several parts of the NIS the frequency of use significantly differs between departments. Table 3 also demonstrates that no correlation with the experience with using the NIS exists. It seems that nurses limit the use of the NIS to the mandatory and necessary functions, and decline the use of additional functions, this use behavior does not change over time. Whether the nurses do not need the function or consider it too much work is unclear. Comparison to the answers to the open question makes the last option probable. In the answers to the open questions complains can be read about the many actions one has to perform in the use of the NIS.

In the interviews the nurses report to use the NIS (and the paper nursing record) many times through the day. They start their shift reading the record in order to know what patients are in and how they are, and to know what care must be provided. The nurses report to enter measurements and write reports throughout the day. They also register doctor's orders at paper forms and less frequently mutations in action or nursing plans are mentioned. The interviewed nurses express three motivations for entering information: (1) As a message to their colleagues (they want their colleagues to know some specific information about the patient), (2) to record their actions and (3) to complete their tasks. In the first case they trust their colleagues to read it, or they tell their colleagues about the information. They do not seem to check whether the message is received (this is not asked).

#### 4.2.2. Ease of use

Although training is needed and the lay-out does not fit exactly to what the users want, the NIS is in general considered to be easy to use. The automatic filling with data saves time.

The scores on retrieving data and entering data are very similar both are considered to be easy, but going not faster, using the NIS (Table 4, item 1, 2, 9, and 10). The last column of Table 4 demonstrates the learning effect. For many items a positive correlation exists with experience with using the NIS. The results per department differ significantly from each other. Since the NIS is implemented department-by-department (see Table 1), the difference in experience is the most likely explanation for this. In the answers to the open questions complains can be read about the many actions one has to perform in the use of the NIS. No questions were asked in the interviews about ease of use. The remarks on learnability match with the results of the questionnaire (Table 4, item 13 and 14).

**Table 2 – Working hours per week, age and length of NIS-use.**

Variable	M	SD	n
Working hours per week	29.14	5.87	93
Age	36.55	11.21	93
NIS-use in months	9.24	5.18	93

Part-time jobs are correlated to younger age (Spearman's  $\rho = -.467$ ,  $p < .01$ ) and with a shorter experience in using the NIS (Spearman's  $\rho = -.253$ ,  $p < .05$ ).

#### 4.2.3. Information needs

The information needs can be derived from the open questions and the interviews. The questionnaire did not question this topic. The answers to the open question about advantages of the NIS, give some clues on information needs. The possibility to copy data from previous admissions and the patient history is mentioned by 19% and 4% mentions the access to information of other disciplines. In the interviews specific questions are asked on the information needs [21]. Nurses want to know everything about the patient: especially the medical history, the actual situation of the patient, medication, treatments and planned investigations, but also information on the social system and family relations of elderly patients. Also the actual nursing interventions like infusions and e.g. whether the patient is allowed to walk are needed. “The more information you have about the patient, the better you can act. You can better deal with and act upon certain behavior and remarks of the patient, than when you would not know this information.” Only two of the twelve interviewed nurses mention the care plan as information needed to provide care. Another two nurses mention the ‘work note’, on which planned interventions are written. No difference in answers is found between nurses using the NIS and nurses using a paper record. Nurses use the patient record (electronic or paper) throughout the day.

For all nurses the patient record is the main source of information according to the interviewed. Additional oral information is given and received by nurses, physicians, and other disciplines both no matter whether the NIS was used, or the paper record. The tradition of ‘oral transfer’ of patient information between nurses at changing shifts has been continued after introduction of the NIS. The results of the interviews suggest that the NIS meets the information needs better than the paper record, because of its higher availability. In the open questions about disadvantages, lacking information is not mentioned. The interviews show no specific items missing in the NIS. Most remarks are on the quality of information. “In the NIS things are often not reported, which should be in it”.

#### 4.2.4. Quality of information

Item 1 and 2 (Table 5) of the questionnaire show that the information in the NIS is considered to be accurate by a majority of users, but further improvement is possible. NIS-users are less satisfied about the correctness of the information. Although 70% agrees that no contradiction between oral and written information exists (item 4), a high percentage of users disagree that data of patients are not entered in the wrong record (item 5). Also a small percentage of nurses agrees that every colleague enters data in the same way (item 3). This suggests

that the NIS is not used consistently. The results for completeness of the patient data (item 7) in the NIS match the results for accuracy (item 1 and 2). The results for accessibility (item 9 and 10) show that about 50% agrees with the statements on accessibility anywhere, anytime, but 20–25% disagrees. This is probably due to technical problems of the computer-on-wheels (COW's). The wireless network was not always available, and batteries were sometimes flat. At rush hours a shortage of computers hindered access. The computers fixed to the wall in the patient rooms, were seldom used, for privacy and ergonomic reasons. Table 5 shows that a majority seems satisfied with the quality of information of the NIS, and thinks the NIS has a positive effect on the quality of recording (item 11). For only a few items the results correlate to the department and to the experience with the NIS. On those items more experienced nurses judge more positively.

According to the interviewees the medical history is often incomplete, and visiting disciplines do not always enter their findings or interventions in the record, according to both NIS-users and paper record users. The interviews suggest that especially the latest information is missing in the patient record. In the interviews also complaints are uttered that records are not always kept accurately, equally by users of the NIS and users of the paper record. This contradicts to the results of the questionnaire, 75% of the NIS-users agree that records are kept regular and are up-to-date. An interviewed NIS-user mentions that in the paper record some information was recorded several times at different pages in order to be sure that the information was noticed. She blames the inconclusive structure of the paper record for this. In the interviews the expectation is expressed that the NIS supplies better information than the paper record, because the NIS stimulates to keep the record up-to-date, e.g. because care planning is automatically generated. “I think that with reporting in the paper record a lot was forgotten, or funny handwritings that were not readable. And that is all gone now. Now you just have your fixed items and everybody reports about those.” On the other hand nurses tend to postpone entering data and create small paper buffers, because computers are not always available and logging on takes too much time for entering a single item (interviews) “You have to log on each time and that takes a lot of time. . . That is why you save it up for a while”.

## 5. Discussion

### 5.1. Answers to study questions

#### 5.1.1. What are the information needs of the users?

The interviewed nurses express a broad range of patient information they consider necessary to provide good care (Section

**Table 3 – Frequency of use of functions in the NIS.**

How often do you use the part of the Nursing Information System mentioned below?	Daily	Weekly	Monthly	Rarely	Never	n	Department <sup>a</sup> p	Experience <sup>b</sup> p
Tab History	82% <sup>Mdn</sup>	17%	0%	1%	0%	81	n.s.	n.s.
Copy data from previous record to anamnesis	34%	42% <sup>Mdn</sup>	10%	5%	9%	92	.005	.004
Open guideline from Tab History <sup>c</sup>	18%	27%	14% <sup>Mdn</sup>	22%	19%	90	n.s.	n.s.
Tab Care plan	90% <sup>Mdn</sup>	7%	0%	2%	0%	41	n.s.	n.s.
Copy data from anamnesis to care plan	50% <sup>Mdn</sup>	36%	3%	5%	7%	93	.005	n.s.
Interventions – agenda	87% <sup>Mdn</sup>	11%	1%	0%	1%	93	n.s.	n.s.
Nursing plan	60% <sup>Mdn</sup>	19%	2%	8%	11%	91	n.s.	n.s.
Use Nursing plan example	4%	6%	9%	16%	65% <sup>Mdn</sup>	69	n.s.	n.s.
Make Multi-disciplinary problem in care plan	8%	21%	9%	30% <sup>Mdn</sup>	32%	87	.000	n.s.
Report on Category	50% <sup>Mdn</sup>	13%	3%	18%	16%	90	n.s.	n.s.
Report on Health pattern	35%	9%	3%	24% <sup>Mdn</sup>	29%	89	.000	n.s.
Report on Multi-disciplinary problem or nursing plan	29%	22% <sup>Mdn</sup>	7%	24%	18%	90	.000	n.s.
Tab Measurements	91% <sup>Mdn</sup>	8%	0%	1%	0%	79	n.s.	n.s.
Tab Intake – output	85% <sup>Mdn</sup>	14%	0%	1%	0%	78	n.s.	n.s.
Total balance	58% <sup>Mdn</sup>	30%	8%	3%	1%	92	.003	n.s.
Per os (oral intake)	62% <sup>Mdn</sup>	33%	2%	1%	1%	93	.006	n.s.
Infusion – list	85% <sup>Mdn</sup>	13%	1%	1%	0%	93	n.s.	n.s.
Tube	51% <sup>Mdn</sup>	32%	8%	7%	3%	89	.000	n.s.
Fluids list	63% <sup>Mdn</sup>	31%	3%	0%	2%	90	.001	n.s.
Help NIS	2%	2%	5%	41% <sup>Mdn</sup>	50%	88	n.s.	n.s.

The highest level of the NIS consists of tabs. *Mdn*, category contains median; n.s., not significant.

<sup>a</sup> Kruskal–Wallis Test.

<sup>b</sup> Spearman's rho.

<sup>c</sup> The  $\chi^2$ -test on the null-hypothesis of an equal distribution was not rejected.

**Table 4 – Ease of use.**

To what extent do you agree?	Fully agree	Partially agree	Neutral	Partially disagree	Fully disagree	n	Department <sup>a</sup> p	Experience <sup>b</sup> p
1. Retrieving information is faster <sup>c</sup>	22%	18%	22% <sup>Mdn</sup>	17%	22%	88	.000	.000
2. Entering information is faster <sup>c</sup>	19%	23%	23% <sup>Mdn</sup>	18%	17%	88	.000	.001
3. Automatic filling with data saves time	24%	41% <sup>Mdn</sup>	10%	11%	14%	88	.002	.021
4. Lay-out fits with my way of working	22%	35% <sup>Mdn</sup>	26%	10%	7%	88	.005	.040
5. I can easily find the right window	35%	42% <sup>Mdn</sup>	13%	7%	3%	88	n.s.	n.s.
6. I can read the information well	43%	41% <sup>Mdn</sup>	8%	5%	3%	88	.038	n.s.
7. I consider the screen format logical	28%	44% <sup>Mdn</sup>	17%	9%	1%	86	.007	n.s.
8. I like colors and lay-out	31%	40% <sup>Mdn</sup>	16%	6%	8%	88	.012	n.s.
9. It is easy to enter data correctly	20%	45% <sup>Mdn</sup>	20%	10%	65	87	.019	n.s.
10. It is easy to retrieve data	23%	41% <sup>Mdn</sup>	18%	15%	3%	88	.002	.008
11. Data-presentation is exactly as I need	15%	33%	28% <sup>Mdn</sup>	19%	5%	88	.000	.008
12. I can enter data exactly the way I want	10%	36%	21% <sup>Mdn</sup>	26%	8%	88	.000	.002
13. You become skilled automatically	47%	42% <sup>Mdn</sup>	9%	1%	1%	88	.004	n.s.
14. Little or no training is needed	5%	17%	19%	31% <sup>Mdn</sup>	28%	88	n.s.	.029
15. Meaning of a button is clear right away	13%	23%	32% <sup>Mdn</sup>	25%	8%	88	.024	n.s.
16. Use of a button is clear right away	11%	24%	30% <sup>Mdn</sup>	26%	9%	88	.011	.021

Mdn, category contains median; n.s., not significant.

<sup>a</sup> Kruskal–Wallis Test.

<sup>b</sup> Spearman's rho.

<sup>c</sup> The  $\chi^2$ -test on the null-hypothesis of an equal distribution was not rejected.

**Table 5 – Quality of information.**

To what extent do you agree?	Fully agree	Partially agree	Neutral	Partially disagree	Fully disagree	n	Department <sup>a</sup> p	Experience <sup>b</sup> p
1. Precisely provides the information I need	11%	33%	34% <sup>Mdn</sup>	14%	9%	86	.003	.004
2. No superfluous information	22%	38% <sup>Mdn</sup>	32%	6%	2%	87	n.s.	n.s.
3. Everyone enters data in the same way	8%	18%	27% <sup>Mdn</sup>	30%	18%	90	n.s.	.011
4. Oral and written reports do not contradict	25%	48% <sup>Mdn</sup>	19%	7%	1%	89	n.s.	n.s.
5. Patient data are not entered in wrong record	7%	24%	19%	30% <sup>Mdn</sup>	20%	90	.035	.042
6. Can enter all information	18%	44% <sup>Mdn</sup>	17%	15%	6%	87	n.s.	n.s.
7. Contains all information I need	12%	39% <sup>Mdn</sup>	25%	15%	9%	87	n.s.	n.s.
8. Reports are kept up-to-date	34%	43% <sup>Mdn</sup>	13%	7%	2%	90	n.s.	n.s.
9. Access to all information anytime	13%	41% <sup>Mdn</sup>	23%	20%	3%	87	n.s.	n.s.
10. Access to all information anywhere	15%	35%	23% <sup>Mdn</sup>	23%	5%	87	.000	.006
11. Quality of recording increases	22%	39% <sup>Mdn</sup>	23%	8%	8%	87	n.s.	.045

The  $\chi^2$ -test on the null-hypothesis of an equal distribution was rejected for all items. Mdn, category contains median; n.s., not significant.

<sup>a</sup> Kruskal–Wallis Test.

<sup>b</sup> Spearman's rho.



4.2.3). Especially the history of the patient is thought essential. Although the care plan is not mentioned in the interviews as an information need, the results of the investigation on use of specific items of the NIS show that the care plan and patient history are used by all nurses during their shifts (Table 3). In the methodic nursing process the patient history serves as input for composing the care plan, which constitutes of problems, goals and nursing interventions. As far as the use of specific functions of the NIS represents the information needs, the results indicate that information needs depend on what department one is working, but do not change over time. Experienced users do not use more or other functions than less experienced users. From the study can be learned that information on the interventions themselves does not suffice for executing the interventions. The nurses need to know the history of the patient as a motivation and explanation why the intervention is necessary and they also need background information on the patient to know how to approach (care for) the patient. This broad need for information can be partly be explained by the professional character of the nursing profession, but it is important to know whether more reasons exist. E.g. is the care plan inconclusive, is the care needed by the patient too unpredictable to be contained or defined in the care plan, or does the nurse not dare to trust the provided care plan?

#### 5.1.2. *To what extent are the information needs met?*

The reported broad need for information requires quite an effort for data entry, and increases the risk that the information is considered incomplete. This is also shown by the results: nurses do not miss specific items, but the scores for agreement with ‘contains all information I need’ and ‘provides precisely the information I need’ are 45% and 40%, respectively, although 75% of the respondents agrees that records are kept up-to-date. This finding suggests that the respondents find it hard to specify what information they really need. One reason why the respondents are not able to specify their information needs, may be caused by the fact that the need for information depends on the specific situation and the specific patient, and alters with the situation and the patient. When medication has to be administered to a patient, other information is needed, than when a patient has to be transferred to the operation room. It is likely that the respondents ‘summoned’ their information needs. It is interesting to investigate whether the information needs can be specified and related to specific tasks. In this way nurses can be provided with exactly that information they need at that moment, and the time spent by the nurses for searching or selecting information can be reduced.

#### 5.1.3. *What are the information quality requirements of users?*

From the interviews can be learned that nurses want information to be complete, correct, up-to-date, and accessible. In a previous research we also found that physicians rank the availability of all complete, correct and relevant patient data anywhere, anytime, and compatibility with the working process as very important requirements for the Electronic Patient Record [15]. Although reliability is not mentioned as a specific requirement, doubts about the reliability of the information

exist. Verifying presented information could be an explanation for the broad information needs. The score for records to be up-to-date, is high (Table 5, 77% agrees with item 8) but improvement is still possible. To reduce postponing of data entry with the chance entering data is later forgotten, the ease of entering data should be improved. E.g. by structuring and tailoring the data-entry, but also ‘automatic’ recording or reporting can help. Accessibility seems to be improved, because the structure of the NIS improves ease of retrieval of data. Technical problems on the other hand, sometimes reduce accessibility in the patient rooms.

#### 5.1.4. *To what extent are the information quality requirements met?*

Overall the perception of information quality is positive, except for entering data in the wrong record (Table 5). Some respondents doubt whether the data entered are always correct, especially in case of the infusion lists (open questions and interviews), but users of the paper record also report mistakes on this topic. It is not known whether the number of mistakes in the NIS is higher or lower than in the paper record. However, maybe other mistakes are made, mistakes might be more visible or recognized, and correcting mistakes is more complicated. Since the nature of the NIS is quite different from a paper record, it is possible that mechanisms to deal with errors in the paper record fall short of dealing with errors in the NIS. An interesting finding is that the perception of quality of information correlates positively on several items to experience with the NIS. This suggests that the quality of recording increases with experience.

The research of Pirnejad et al. shows that when the IS does not support the process and collaboration between nurses and physicians, workarounds create inconsistencies between paper, oral and digital information. This caused data in the IS to be unreliable and patient safety was violated [23]. The present research did not include the check whether inconsistency exists, except for reporting doubts by the respondents. The respondents perceive little inconsistencies, but do experience that records are not complete.

#### 5.1.5. *What aspects of the Nursing Information System determine information quality?*

Nurses expressed their need of complete, correct, accessible, and up-to-date information. This information must be entered by the nurses and their colleagues. In order to fulfill the information needs and to meet the information quality requirements, nurses have to keep the records up-to-date, enter information without making mistakes, and enter the patient data in a consistent manner. The quality of information is by that determined by the users themselves. Item 3 and 5 of the Quality of Information (Table 5) show, that the respondents think these quality requirements are violated. Experience helps, but does not solve the problem. The results clearly demonstrate the dilemma of the user: she depends on the quality of data entry of others, but does not benefit from her own effort to enter data accurately. To improve data entry the design of the NIS should encourage and facilitate entering information in a correct and consistent way. Meanwhile the time and effort needed for entering information should decrease. This means that the NIS needs to be designed in such

a way that nurses directly experience the benefits of accurate and consistent data-entry.

#### 5.1.6. Does the Nursing Information System meet the information quality requirements of the users and what aspects determine this?

Table 3 shows that mainly those functions of the NIS were used, that were mandatory or essential for providing care. Further analysis reveals that the provided level of information quality depends on the data entry by the users. The Information Systems Success Model indicates that use, user satisfaction and net benefits enforce each other [24]. In the case of the NIS this loop is not closed, because in the daily nursing process the user does not retrieve the data she entered herself, but uses the data a colleague entered. All previous cited authors view the quality of information from the output perspective: the information system processes or produces information (see Section 1.2). The quality of the input of information, and its effect on the quality of the output is not taken into account. The main purpose of the NIS is to share and transfer data between nurses in order to facilitate them to provide care and to help them make decisions for the benefit of patients. This implies that *entering* data is less micro-relevant to the user, than *retrieving* data. Raising the micro-relevance of entering data is one approach to raise the level of perceived information quality, e.g. stopping the ‘oral transfer’ at changing shifts, may encourage the nurses to keep the records better, because they will depend more on the information in the NIS. Another approach would be to reduce the workload on data entry by ‘reducing’ the information needs. Nurses now express a high need for information, but seem to need the care plan much less. It appears as if nurses are not satisfied with the care plan alone, but want to be able to ‘reconstruct’ the motivation for the care plan, and want to be able to justify the provided care, using the patient information. This can be explained by the professional character of the nursing profession, and the sometimes unpredictable nature of patients’ needs, but it does not mean that tailoring or a redesign is not possible. A redesign of the NIS, which presents the care plan as key information source, and which presents the care plan as key access to additional patient information, reporting functions, and to entry of vital values, might reduce the need for information and by that reduce the data entry workload, and finally create more time for providing care to the patients. Prerequisite for the redesign of the NIS in this way, is that the information is trusted by the nurses. The study of Dahm and Wadensten [25] showed that nurses expect standardized care plans in the Electronic Health Record (EHR) to improve the quality of care, and to decrease documentation time. In these hospitals the introduction of standardized care plans preceded the introduction of the EHR. Törnvall et al. found that using an electronic standardized wound record improved the quality of documentation [6]. This supports the result that the implementation of a NIS can improve the quality of reporting. It also shows that it is worthwhile to make an effort to improve the quality of use of the NIS. A third approach to facilitate data entry is to tailor the system in such a way, that data entry is not considered to be an effort. Standardizing and structuring forms can contribute to this.

## 5.2. Strengths and weaknesses of the study

The socio-technical approach which combined quantitative and qualitative research methods proved to be a strong research policy, in which outcomes of interviews supported and explained the results of the questionnaire. Using a questionnaire carries the risk of unfaithful answers. This was anticipated by guaranteeing the respondents full anonymity. Despite the use of non-parametric tests, like the Kruskal–Wallis, which produce weaker statistical evidence than parametric tests, meaningful results were achieved. By including the whole targeted population, the internal validity of the study became high. Comparing the quantitative and qualitative data increased the reliability of the outcomes. Both quantitative and qualitative instruments measured the perceived information quality; objective measurements like loggings are not used. Since adoption is all about perception, subjective measurements are very meaningful. However, objective data about use and error can add value to the outcomes. The variance in experience of the nurses in using the NIS ( $M=9.24$  months,  $SD=5.18$  months), can affect the results of the research, although the participants used the NIS intensely from the start.

## 5.3. Meaning and generalization of the study

The purpose of introducing a NIS or Electronic Patient Record is often to make care delivery more efficient by reducing time spent by care providers on retrieving data and reporting. This study shows that the nurses appreciate the NIS for providing better and more information, although nurses do not perceive to save time by using the NIS [2]. The participants in this study express a broad desire for information about the patient, which the NIS satisfies better than the paper record. However, in order to achieve efficiency computerizing the patient record is not enough. If the information needs can be specified, e.g. for specific tasks, the NIS may be redesigned in a way that the nursing process becomes more efficient. This study demonstrates that Information Quality is more than output quality: it also includes input quality. Information Quality is not just determined by the IS, but depends on the data entry by the user. Departments of several surgical and medical specialties were included in the research, which makes it possible to generalize the results for most specialties. The hospital is a typical Dutch teaching hospital. There is no reason to assume that the results will not apply to outer Dutch hospitals.

## 5.4. Unanswered and new questions

In their article “Drowning in information, but thirsty for knowledge” Janowitz and Königer described the information paradox, of people complaining about information overload on the one hand, but also complaining about lack of information on the other hand. According to Janowitz and Königer the solution lies in structuring information, and by creating an ‘information profile’, i.e. information over the information [26]. The structure of information has four dimensions: selection, time, hierarchy and sequence [26]. The NIS provides the end-user with a selection of patient information in a hierarchical, orderly structure, and nurses can easily assess the

timeliness of information. However, the selection is broad, as nurses request, but the nurses seem not to trust themselves to make a further selection or to trust the selection their colleagues made. They feel the need to redo some phases in the information and nursing process. The care plan or work note itself is not enough: nurses desire the information on which the care plan is based in order to check whether the care plan is correct. This costs extra time, which should be spent on patients. Even though the nursing professional is expected to be critical to the information she retrieves, and is expected to make her own decisions, an effort should be made to make the use of the NIS more efficient. Structuring and labeling data is not enough, tailoring is as important. Tailoring means further selecting information in such a way that exactly that information is presented that is needed for that specific task. A NIS constructed this way is perceived as anticipating on the use by the nurse.

Respondents in the research show a lack of trust in the quality of information entered by their colleagues. To make the information process more efficient, the information must be trusted. Investigation is needed to reveal how this can be achieved. Research should be done to investigate the influence of the quality of entering information, especially in the case of professionals entering data that are not well defined or standardized.

## 6. Conclusion

The design of the NIS is based on the standardized paper record and the nursing process at that time. No fundamental business process redesign has taken place. The study shows that the NIS is an adequate computerized replacement of the previous paper record, and at least equals, and maybe improves the information quality of the recording and documentation of patient data. The broad information need expressed by the end-users requires a substantial effort for data entry by the end-users. However, the micro-relevance of entering data is low, because the nurse mainly retrieves the patient information her colleagues entered. To make full benefit of the possibilities of a Nursing Information System a redesign of the nursing process with reconsidering the purpose and function of documentation, is entitled. Adoption has proved to be not a dichotomous variable in two aspects: not only the frequency of use matters, but also the way of using (correct, as intended) does.

## Author contribution

The research, including design, data collection – except for the interviews – data analysis and presentation of the results is performed by the author.

## Conflicts of interest

The author has and had no formal or informal relation with the hospital, other than to conduct the research. The author was neither involved in the development, nor in the implementation of the NIS.

## Summary points

What was already known on the topic?

- Information Quality attributes are: complete, correct, accurate, reliable, up-to-date, meeting the information needs
- Information Quality is more micro-relevant for nurses than relieving the time pressure
- A Nursing Information System can increase the quality of documentation

What this study added to our knowledge?

- Redesign of the Nursing Information System is necessary to increase the information quality
- Entering data is less micro-relevant than retrieving data, which has a negative influence on information quality
- Information quality depends on the users

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