Evaluation of the Electronic Transmission of Medical Findings from Hospitals to Practitioners by Triangulation

C. Machan, E. Ammenwerth, T. Schabetsberger
Institute for Health Information Systems, UMIT – University for Health Sciences, Medical Informatics and Technology, Hall i. T., Austria

Summary

Objectives: The need for regional, cross-institutional electronic networks in health care is steadily growing to support seamless, cooperative health care. The aim of this study is to evaluate the impact of electronic transmission between hospitals and practitioners in a Tyrolean health care network, and to derive technical and organizational points for improvement.

Methods: Between March and August 2004 we carried out a triangulation-based cross-sectional study, combining a qualitative study based on semi-structured, problem-centric interviews with selected practitioners, with a quantitative study based on a standardized questionnaire survey of all the Tyrolean practitioners that receive electronic messages. The survey was designed to confirm the hypotheses which have been systematically derived from the interviews.

Results and Conclusions: The results show high satisfaction and positive impact of electronic communication. The triangulation of quantitative and qualitative methods was found to be useful in order to make the definition and confirmation of the hypotheses more transparent.

Keywords

Health informatics, evaluation studies, hospital information systems, triangulation, electronic transmission of findings, regional networks

Methods Inf Med 2005; 44: 225–33

1. Introduction

Due to the increasing importance of comprehensive cooperation and communication in health care, the need for regional, cross-institutional electronic networks in health care is steadily growing [1-3].

While computer-based information and communication tools have been used in health care facilities for several years, and the use of electronic medical records (EMR) within health care enterprises is increasing [4], cross-institutional information exchange between different health care providers is still in the beginning stages [5].

Seamless sharing of multi-clinical information is a fundamental requirement for achieving continuity of care [2, 6] Patient-centered shared care, supported by regional networks, has been recommended for more than 30 years to support high-quality and efficient health care, e.g. by reducing waiting times, avoiding unnecessary examinations, and improving quality of decisions. The paper-based information exchange (e.g. sending a discharge letter by mail to a general practitioner) is seen as too slow, incomplete, inefficient, and erroneous, possibly leading to negative effects on quality of patient care [7, 8]. There seems to be a need to advocate for the creation of electronic cross-institutional communication.

In the year 2002, the Tiroler Landeskrankenanstalten (TILAK), the corporation responsible for most of the hospitals in Tyrol [9], launched a project with the goal of building such a regional network between hospitals and general practitioners in Tyrol. The goal was to replace paper-based communication with electronic transmission in a standardized and secure way.

Since 2003, this project called "health@net" makes it possible to transmit discharge letters and medical findings from hospitals to general practitioners [10]. Physicians can receive discharge summaries, other medical findings as well as images from TILAK hospitals in a form of cryptographically signed S/MIME e-mail messages that can be automatically integrated into the practitioner's computer system. Between June 2003 and October 2004, about 40,200 medical documents were distributed via health@net. Initial feedback on user acceptance is good; however, it is unclear if health@net brings the desired advantages hoped for, such as improvements in care efficiency, cost reductions or quality of care.

An evaluation of the effects of this regional network on practitioners and on patient care was conducted to obtain feedback for continuous improvement of the technical and organizational aspects of the network. These issues are not only of concern to the health@net project, but to all projects dealing with such regional networks. The evaluation can comprise both objective measurements as well as subjective assessments.

Evaluation research in medical informatics still seems to be dominated by a mainly quantitative, objectivist research tradition. Forsythe and Buchanan state that – influenced by drug trials and evaluations of other therapeutic interventions – evaluation researchers tend to use the method of controlled clinical trials (CCTs) as the model of choice [11]. Kaplan indicates that – according to evaluation literature – randomized controlled clinical trails (RCTs) are the "gold standard" in evaluation and assessment studies [12]. However, the acknowledgement for the qualitative,

subjectivist paradigm in contrast to the quantitative one is existent and steadily increasing amongst evaluation researchers in medical informatics [11-13].

The increasing number of examples of qualitative studies also shows this in medical informatics. Some examples: Stavri and Ash use narrative analysis for the assessment of computerized provider order entry [13]. Gagnon et al. describe the adaptation of the theory of interpersonal behavior to the study of telemedicine adoption by physicians [14] and Greatbatch et al. examine ethnomethodological and interactionist approaches in the evaluation of medical information systems [15].

Which of the two approaches, quantitative or qualitative, is better suited for use in an evaluation study is mainly dependent on the research question and situation [16]. In their "Declaration of Innsbruck" a European working group on evaluation recommends a selection of evaluation methods "with an open mind". They see a lack in collaboration between various research traditions and call for a combination of methods in evaluation to make use of the synergies between them [17].

A term strongly associated with the combination of methods is triangulation, first described by N. Denzin in 1970 [18]. In brief, it means the examination of the object of research from two (or more) different perspectives. We selected this approach for the evaluation of the electronic transmission of medical findings within the regional network between hospitals and general practitioners in Tyrol.

2. Aim of this Paper

This paper presents a study carried out in the region of Tyrol (Austria) to evaluate the practitioners' acceptance of the electronic transmission of clinical findings from Tyrolean hospitals to their offices. We will present and discuss the most important results and findings of this study.

In addition, the aim of this paper is the presentation and discussion of the triangulative, multi-methodical study design we employed to explore the effects of regional networks (supporting the transmission of medical findings), especially from the practitioner's point of view.

3. Methods

3.1 Overall Study Design

Between March and August 2004 we conducted a cross-sectional observational study to investigate the practitioners' acceptance of the electronic transmission of clinical findings from Tyrolean hospitals to their offices. We used methods triangulation as described by Denzin [18]. In particular, our study consisted of two main parts: at first, a qualitative study based on semi-structured, problem-centric interviews; and second, a quantitative study using a standardized questionnaire that was based on the hypotheses derived from the results of the interviews.

There were two objectives to be achieved by employing the triangulative study design: Based on the literature (e.g. [16, 19]) we expected to be able to validate the results of the qualitative component by carrying out a quantitative study (*validation of results*). Furthermore, we planned to add to the results of the qualitative component by the quantitative study (*completeness of results*). The link between both parts were the hypotheses resulting from the first, qualitative part (see below).

The *detailed study questions* addressed if and how the electronic transmission of medical findings has an impact on extramural patient care and on the practitioner's workflow, and how electronic transmission can be improved from the practitioners' point of view.

Both parts of the study consisted of four steps that are summarized in Figure 1. Figure 1 explains our approach by using the triangle, which gave the term "triangulation" its name. The following paragraphs provide a detailed description of the study steps.

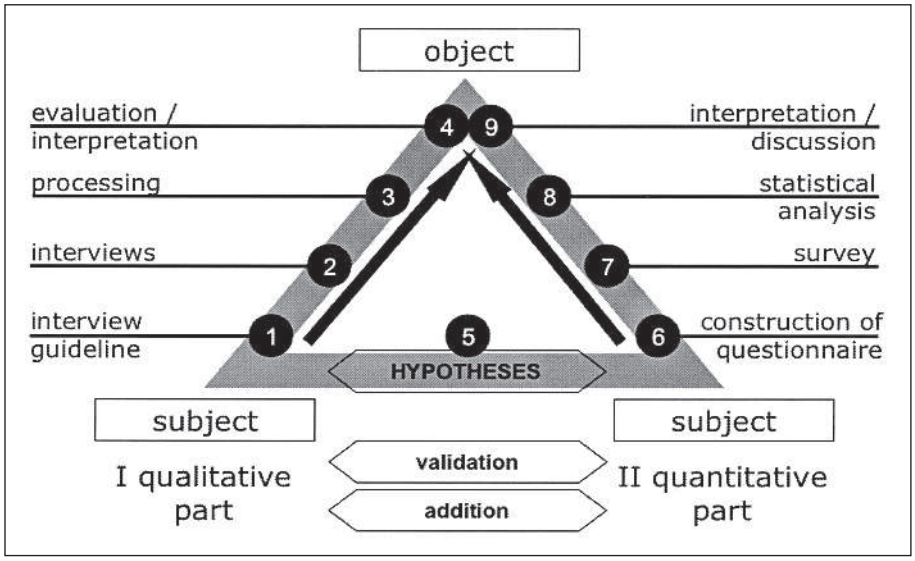

Fig. 1 Study design of the triangulative evaluation of health@net – overview of the qualitative and quantitative part (numbers indicate the order of evaluation steps in our study, further explained in the text)

3.1.1 Part I: Qualitative-exploratory Study

1) *Interview guideline:* After the analysis of available studies on the effects of regional networks, an interview guideline was designed, focusing on the impact of the electronic transmission of medical findings, and on ways to improve it.
2) *Interviews:* We performed semi-structured, problem-centric interviews [20] with selected practitioners, based on the guidelines developed in step 1. The interview participants were a convenience sample from a list of the top ten receivers of electronic medical findings in Tyrol

(analyzed based on log-files). The number of interview partners was based on the approach of theoretical saturation [19], i.e. after each interview it was decided on the basis of the results whether the last interview brought forth new information or not. When no new information was found, and therefore through further interviews no new findings could be expected, further interviews were not carried out.

3) *Processing:* A summarizing report ("Zusammenfassendes Protokoll" according to Mayring [20]) as well as a graphical depiction of business processes was carried out based on the results of each interview. Interviews were not transcribed word for word, but summarized.
4) *Evaluation/interpretation:* Based on the interview reports of step 3, the main results were summarized. It was then decided which findings deserved further examination in the following quantitative study.
5) *Hypotheses:* From the results of step 4, after a content analysis and comparison of the results, hypotheses were deduced which dealt with the impact of electronic transmission of medical findings on extramural patient care and on the practitioner's workflow. Strengths and weaknesses of the system were examined, and how it can be improved. The practitioner's answers were transferred into hypotheses if they could be considered as either important or at least worth further examination by the researchers. The hypotheses formed the foundation for the subsequent quantitative study.

To better illustrate the research process, all steps are explained in the following by taking one aspect from the interview guideline as an example:

"Which advantages and disadvantages of electronic transmission of medical findings do you see compared to paper-based transmission of findings?" (Interview guideline, question 4)

Three of the interview partners gave comparable answers as indicated in the excerpts of the interview transcript below:

Practitioner 1: "… one weakness he sees was the structure of medical reports received electronically. It did not satisfy his needs at all …"

Practitioner 2: "… The practitioner mainly criticizes the length of electronic reports in combination with an – often – confusing structure …"

Practitioner 3: "… a main problem was seen in the fact that electronic reports were difficult to read …"

Based on these statements the following hypothesis was created as a result of part I of the study:

"Often, electronic reports do not fulfill the practitioner's needs concerning their structure. As a consequence, reading and analyzing findings may take more time than necessary." (Hypothesis no. 12)

3.1.2 Part II: Quantitative-explanatory Study

6) *Construction of questionnaire:* To validate the hypotheses from step 5 and to add to a deeper understanding of the object of research, a standardized, closed questionnaire was developed. Each hypothesis was represented by one or more questions. In addition, the practitioners were asked for overall satisfaction and demographic data such as age group, specialization, district, and previous knowledge of how to use a computer. An open question on personal remarks was also provided.
7) *Survey:* The questionnaire was sent by mail to all Tyrolean practitioners registered in the health@net project and therefore receiving electronic findings from TILAK. They were given about four weeks (between the middle of July and the middle of August 2004) to send the questionnaires back by fax or mail.
8) *Statistical analysis:* The results were analyzed by means of descriptive and explorative statistics. The personal remarks were evaluated by content analysis, an approach that is also derived from social sciences [20]. Through this step the results of step 7 were made anonymous.
9) *Interpretation/discussion:* A final report summarizing the most important results and findings with regard to the impact of electronic transmission, and recommendations to improve it, was prepared.

Continuing the example from above, the following questionnaire item in the form of a statement was constructed from hypothesis 12:

"A major weakness of electronic medical reports is that their structure often does not fulfill the practitioner's needs." (Questionnaire item no. 16)

3.2 Study Process

3.2.1 Part I: Course of Qualitative-explorative Study

After the development of the study plan and the interview guideline, interviews were carried out in May 2004. Four interviews with three general practitioners and one specialist, chosen from the top ten list of receivers in Tyrol, were carried out before we reached sufficient theoretical saturation. Each interview took about 30-45 minutes and was recorded on cassette tape. The interviews took place in the practitioners' offices.

Table 1 Main questions from the interview guidelines to interview Tyrolean practitioners on electronic transmission (qualitative-explorative part of the study)

Interview guideline (Qualitative-explorative part of study)
• What is the workflow in your office when receiving electronic findings? Where, when and how often do you use the system?
• What is your experience with computers in general, and with the system to receive findings in particular?
• What impact has the electronic transmission of findings had on your workflow, and on patient care?
• What advantages and disadvantages do you see compared to paper-based transmission of findings?
• What aspects of electronic transmission should be improved (e.g. organizational, technical changes)?
• Have you been sufficiently informed and trained on the electronic transmission system? Which aspects should be improved in the future?

After each interview the guideline was reviewed again, and minor corrections were made (e.g. order and formulation of questions). A question on technical aspects was taken out because the practitioners turned out to not be the target persons for technical questions. Table 1 indicates the main questions from the interview guidelines. Altogether, from the results of these interviews, 19 hypotheses were deduced.

3.2.2 Part II: Course of Quantitative-explanative Study

Based on the 19 hypotheses, a standardized questionnaire consisting of 26 questions was developed and pre-tested with two medical doctors from our university. As planned, it was mailed to 242 Tyrolean practitioners on July 15, 2004. By the deadline on August 15, 2004, 102 questionnaires were returned; two more were received during the following week, for a total of 104 = 43% returned questionnaires. Three practitioners called to indicate that – due to the low number of electronic documents they received – they could not fill in the questionnaire.

Table 2 Nineteen hypotheses deduced from interviews with Tyrolean practitioners on electronic transmission (result of qualitative-explorative part of the study)

No.	Hypothesis
1	Comparing electronic and conventional transmission of medical reports, the amount of work in terms of filing and archiving is remarkably higher for the conventionally transmitted report.
2	Comparing electronic and conventional transmission of medical reports, the amount of work in terms of retrieving a patient's report is remarkably higher for the conventionally transmitted report.
3	It would be desirable for the practitioner to receive all reports electronically. (Note: At present – depending on the department – medical reports are either transmitted electronically, conventionally or both)
4	With the aid of electronic transmission of medical reports, time can be saved.
5	Time saved is beneficial for the patient. For the practitioner more time is left for listening to the patient and for treatment.
6	Electronic transmission of medical reports reduces the amount of work in terms of filing and archiving.
7	Electronic transmission of medical reports reduces the amount of work in terms of retrieving a patient's report.
8	A major strength of electronic transmission is the short period of time a medical report is received in.
9	Partly, the legibility of electronic medical reports is unsatisfying. Special characters that occur during the process of transmission cause this.
10	Partly, the legibility of electronic medical reports is unsatisfying. Issues of formatting and displaying of the documents cause this.
11	Often electronic medical reports do not fulfill the practitioner's needs concerning their length. As a consequence, reading and reasoning partly takes more time than necessary.
12	Often electronic medical reports do not fulfill the practitioner's needs concerning their structure. As a consequence, reading and reasoning partly takes more time than necessary.
13	Sometimes it occurs that the admitting practitioner does not automatically receive an electronic medical report about his or her patient. As a consequence, the report must be asked for in other ways than electronic means.
14	As writing of medical reports in hospitals often takes too much time, a short electronic report about the findings sent as soon as possible would be desirable.
15	An adjustment of contents and layout to the practitioner's needs would be desirable.
16	The practitioner does not feel to be well informed about the electronic transmission by the TILAK.
17	Letters and information meetings about the electronic transmission of medical reports did not achieve their aim of sufficiently informing the practitioners.
18	The practitioner does not know whom to contact in case of problems with the electronic transmission.
19	Information events and/or workshops where the practitioner can contribute would be desirable in a certain timeframe.

4. Results

4.1 Part I: Results of Qualitative-explorative Study

Three out of four practitioners interviewed viewed our study as important for them and cooperated well. One out of four practitioners interviewed had rather negative experiences with electronic transmission, which were mainly caused by the GP software used. Three out of four turned out to be quite satisfied with the electronic transmission. They saw a clear positive impact on patient care. However, all four indicated that – regardless of how the medical report was transmitted – they saw organizational problems within the hospitals that cause problems and delays during the transmission of reports (e.g. due to delays for writing a report, or the need to ask for reports that were not transmitted). In addition, three out of four were not satisfied with the layout and structure of the transmitted reports (a problem originating from the used EDIFACT standard). A major issue was also the request to receive all reports electronically. (Note: At present – depending on the department – medical reports are either transmitted electronically, conventionally or both.)

According to the procedure described, 19 hypotheses resulted from the four interviews. The resulting hypotheses are indicated in Table 2.

4.2 Part II: Results of Quantitative-explanative Study

Most of the practitioners in the sample of 104 participants were over 50 years old (56.7%), 31.7% were between 41 and 50. 64.5% of the people who returned the questionnaire felt rather confident in handling a PC. Over 70% were general practitioners, the rest were medical specialists.

The results of the survey are shown in Table 3.

The results show that the overall acceptance of electronic transmission is quite high: Accumulated 66.4% either strongly agreed or agreed to this question (Q26). 82.7% strongly

Table 3 Answers of 104 Tyrolean practitioners to questions on electronic transmission of medical findings as a percent of all answers. Mode value is marked in bold. The n-value is sometimes much lower than 104, as some sub-questions (marked with *) should only be answered depending on the preceding master question. In this case, we first planned to calculate the percentage in relation to people that agreed or were undecided to the master question. However, as the sub-questions were frequently answered regardless of the answers to the preceding question, we finally decided to calculate the percentage in relation to all of the people that answered.

Question no.	Question short text	n	Strongly disagree	Disagree	Undecided	Agree	Strongly agree	Missing	Hypothesis
Q1	Transmission of findings quicker than by mail	104	2.9	2.9	11.5	16.4	**65.4**	1.0	X
Q2	Filing and archiving is less work	104	1.0	1.9	6.7	6.7	**82.7**	1.0	H1
Q3	Automatic assignment to patient record in practitioner's database is a key factor	104	0.0	1.9	3.9	10.6	**82.7**	1.0	H4
Q4	Retrieving and reading of reports is less work	104	1.0	5.8	21.2	20.2	**51.0**	1.0	H2
Q5	Electronic transmission helps to save time	104	1.9	2.9	4.8	23.1	**66.4**	1.0	H4
Q6*	If yes: Time saved benefits the patient	99	4.0	6.1	13.1	28.3	**42.4**	6.1	H5
Q7	Electronic transmission helps improve quality of patient care	104	4.8	9.6	5.8	34.6	**44.2**	1.0	X
Q8	All findings should be transmitted electronically	104	1.9	0.0	3.9	8.7	**83.7**	1.9	H3
Q9	Major strength: Filing and archiving is less work	104	1.0	1.0	3.9	12.5	**80.8**	1.0	H6
Q10	Major strength: retrieving and reading is less work	104	1.9	5.8	10.6	19.2	**59.6**	2.9	H7
Q11	Major strength: speed of transmission	104	0.0	1.9	6.7	23.1	**66.4**	1.9	H8
Q12	Major weakness: Legibility of electronic documents	104	13.5	**27.9**	17.3	21.2	17.3	2.9	X
Q13*	If yes: Caused by special characters	69	5.8	10.1	24.6	21.7	**26.1**	11.6	H9
Q14**	If yes: Caused by formatting and display	68	0.0	5.9	13.2	26.5	**42.7**	11.8	H10
Q15	Major weakness: Length of documents does not fulfill practitioner's needs.	104	5.8	**31.7**	24.0	19.2	1.3	1.9	H11
Q16	Major weakness: Structure of documents does not fulfill practitioner's needs.	104	9.6	**30.8**	22.1	22.1	12.5	2.9	H12
Q17	Sometimes findings about a patient are not transmitted	104	2.9	16.4	**26.9**	**26.9**	21.2	5.8	H13
Q18*	If yes: It takes a lot of time to ask for findings about a patient in other ways than electronic means	88	1.1	2.3	4.6	23.9	**58.0**	10.2	X
Q19	A short report about the patient is desirable because writing of complete medical reports can take a long time	104	1.9	9.6	7.7	20.2	**58.7**	1.9	H14
Q20	Adjustment of contents and layout to practitioner's needs desirable	104	2.9	10.6	18.3	17.3	**46.2**	4.8	H15
Q21	Practitioner was informed about electronic transmission in written form	104	6.7	5.8	7.7	10.6	**60.6**	8.7	H17
Q22	Practitioner was informed about information sessions on electronic transmission	104	**39.4**	12.5	7.7	7.7	13.5	19.2	H17
Q23	Practitioner would like to be better informed about electronic transmission	104	9.6	17.3	**26.0**	20.2	15.4	11.5	H16
Q24	Practitioner would like to contribute in workshops	104	23.1	**29.8**	16.4	10.6	8.7	11.5	H19
Q25	Practitioner knows contact person in case of problems	104	**57.7**	13.5	9.6	4.8	9.6	4.8	H18
Q26	In general practitioner is satisfied with electronic transmission	104	0.0	5.8	25.0	**41.4**	25.0	2.9	X

*) Question is dependent on answer to previous one. This explains the lower n.
**) Question is also dependent on Q12
Note: The mode is marked in bold.

agreed that the automatic assignment of electronic reports to the patient record brought an important benefit (Q3), and even 83.7% strongly agreed that it would be desirable to receive all medical reports electronically (Q8). 82.7% strongly agreed that filing and archiving electronic medical reports was less work (Q2). 89.5% agreed, 66.3% strongly that a major strength was the speed of transmission of medical findings achieved now (Q11). Most important: Accumulated 78.8% either agreed or strongly agreed that electronic transmission helps to improve quality in patient care (Q7).

Forty-six respondents (44%) used the free text field of the questionnaire to give additional comments. The content analysis of these statements revealed two important points that also confirmed two of our hypotheses:

- All reports should be sent electronically (n = 16, hypothesis 3).
- Often the layout and structure does not fulfill the practitioner's needs (n = 13, hypothesis 12).

In order to evaluate the combination of methods employed we mapped the results from the questions back to the hypotheses to check whether the hypotheses were confirmed by the survey. To check this, we accumulated the percentages for "strongly agree" (= strongly confirming) and "agree" (= confirming) for each hypothesis. In case a hypothesis was based on more than one question (this is true for hypotheses 4 and 17), the arithmetic mean value between the n questions was calculated. In each of those cases, the differences in percentages were very small, a fact that supported this decision.

Figure 2 shows the confirmation of our 19 hypotheses, ordered by degree of confirmation. One bar represents the accumulation of the values for either a strong confirmation (= strongly agree) or weak confirmation (= agree) of a hypothesis. Please note that a question could be asked using positive wording, while the corresponding hypothesis could be verbalized negatively. In this case the interesting values for confirming the hypothesis were the percentages of "strongly disagree" and "disagree". Figure 3 shows that many of the hypotheses have been supported by the 104 surveyed practitioners.

If we define a limit of 60% confirmation to regard a hypothesis as overall confirmed, 11 of the 19 hypotheses have been confirmed by the survey.

5. Discussion

5.1 Discussion of Results

Systems for the cross-institutional electronic transmission of medical findings can be seen as one example of telemedical applications, and telemedical applications have been evaluated frequently in the last years. A search in the web-based database provided by [21] lists 207 evaluations of teleconsultation systems. However, most of them deal with the patient-centered transmission of individual data, initiated by a physician during the course of patient care (e.g. telepathology, teleradiology, telecardiology), and not with the evaluation of regular electronic information exchange in a regional network. Here, only few studies exist. In a systematic review, van der Kam found 30 publications evaluating electronic communication to and from GPs, also comprising, however, teleconsultation and e-mail services [8].

The available studies have found results comparable to ours. For example, Moorman et al. [5] observed how electronic messaging between a hospital consultant and general practitioners in 15 practices about diabetes patients evolved over a three-year period. They conducted a survey which was answered by 12 (of 15) practices. Their results were quite similar to ours, even though they had a rather small number of practices and concentrated only on diabetes patients. For example, in their survey, 75% (9 of 12) of GPs indicated a desire to continue receiving electronic messaging, in our study, 66% agreed strongly or agreed to this statement (Q26). In their study, 67% found that through electronic messaging, they save time (in our study: 89%, Q5), and 100% said that electronic reports come faster (in our study: 82%, Q1).

This is supported by the review of publications on electronic communication by van der Kam et al. [8] analyzing 30 papers on communication of lab findings, of admission and discharge information, on reports from hospitals such as discharge letters, on teleconsultation, and on e-mail service. Twenty-five of those 30 publications described positive effects such as faster communication (8 of 30 studies), more complete information (10 of 30), and process improvement (e.g. integration of messages into the EPR, reduction of phone calls) on the GPs side (11 of 30).

Based on objective measurements, Branger et al. [22] show that the introduction of electronic data interchange for lab and discharge reports between primary and secondary care providers reduced time intervals between the generation and delivery of messages (from two to four days to one hour). This does not take into account that most of the time is spent on report generation and not on the delivery – the advantages of electronic communication may thus be much less significant. This is supported by the fact that 79% of the practitioners in our study agreed or strongly agreed that a short report about main findings should be sent before the longer report comes (Q19).

Moorman [5] also found during his study that during the three-year period the majority of GPs ceased to copy the communicated data from the electronic messages to their own records. This problem is not relevant for the health@net project, as the electronic messages are automatically integrated in the practitioners' information systems. This automatic integration is very important in order to prevent unnecessary, error-prone data copying. Not surprisingly, 93% of our participants either agreed or strongly agreed that automatic integration is a key-factor for electronic communication (Q3).

In another study, Branger et al. [23] evaluated the effects of electronic communication between physicians co-treating

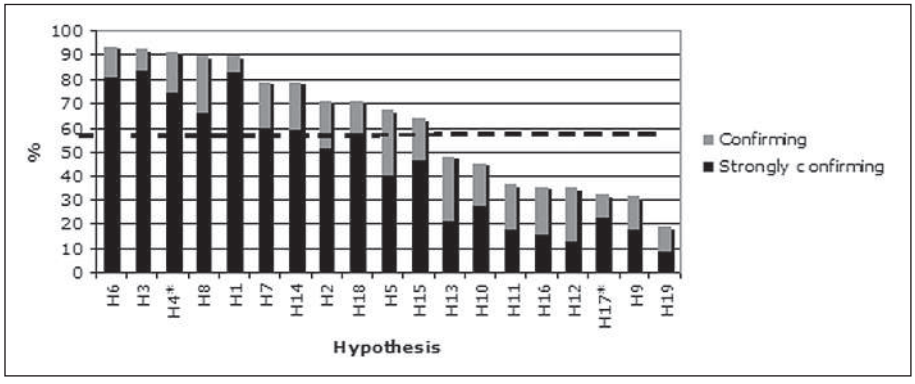

Fig. 2 Confirmation of the 19 hypotheses in the survey study, ordered by degree of confirmation. "Strongly confirming" indicates the percentage of the answer "strongly agree" to the corresponding survey questions, "Confirming" indicates the percentage of the answer "agree". The hypotheses are listed in Table 2, their relationship to the questions is indicated in Table 3. * indicates hypotheses which are based on two questions.

diabetic patients, comparing paper-based transmission with electronic messaging. They used a quantitative approach and found an increase in the frequency of communication after electronic support, a better availability of diabetes-related patient data for the participating 33 physicians, and a positive (but not significant) effect on the quality of care.

Comparably, 75% of the practitioners in the study by Moorman [5] and 79% in our study agreed that patient treatment is improved by electronic communication (Q7). In fact, in the review of the 30 publications on electronic communication by van der Kam et al. [8], 19 of 30 studies stated an increase in quality of patient care as a result of those changes. This supports our findings. However, as van der Kam argues, only one publication (Branger et al. [23]) really *demonstrated* a (non-significant) improvement, the others just claimed it, but did not provide evidence. Van der Kam et al. noted to be "puzzled by the discrepancy between the scarcity of a documented impact on the quality of care and the abundance of electronic communication projects", discussing several reasons for this, e.g. complexity to measure those effects. Due to this complexity of objective measurements of impact, we decided to limit our evaluation to the subjective opinion of the practitioners as the receivers of electronic communication, even when this means that objective data is not available. As our results match the results of other papers, as discussed, we feel that our approach was justified.

Our results show overall high user satisfaction with the electronically received information. For the health@net projects, the results indicate that user support should be improved and some adjustments on structure and layout of the electronic letters were suggested, representing an organizational versus a technical problem.

5.2 Discussion of Methods

The combination of two methods is more time-consuming than just concentrating e.g. on interviews. However, we feel this effort is worthwhile to obtain deeper insight. In addition, the number of time-consuming interviews that are needed in the qualitative part may not necessarily be as high as we found in our study. Though there were only four interviews carried out, 11 out of 19 hypotheses were confirmed with over 60% of respondents agreeing. We decided to terminate after the fourth interview for the following reasons. First, it became obvious after only four interviews that the main issues brought up by the interviewees were quite similar. Indicating the state of theoretical saturation seemed to be reached. Second, the interviews covered rather diverse perspectives on electronic transmission, as three spractitioners interviewed had made rather positive while the other interviewee reported about negative experiences. At last, a rather high return rate for an anonymous written survey of 43% is an indication that the questions of the survey contained important and relevant aspects of electronic transmission. Nevertheless, due to the limited number of interviews it is not surprising that not all interviews could be easily confirmed in the survey.

When talking about qualitative research, one question is how to avoid subjectivity. The researcher is expected to interview persons with as little personal bias as possible and to preferably disregard their own previous knowledge. As we can learn from the literature [20], previous knowledge plays a major role when it comes to interpretation. The solution proposed is not to disregard it – this is described as virtually impossible – but to reveal it from the beginning of the project and to further develop it during the research process. This is what we did by developing an interview guideline on the basis of our research questions that were a formulation of our knowledge based on an intensive literature analysis. During the interview phase we learned about a lot of new aspects and customized the guideline until we were able to deduce the hypotheses from our results.

We feel that we presented a rather general approach to evaluation that can be applied to other studies dealing with user acceptance issues, independent of the type of information system assessed. Methods triangulation as a clean methodical framework can act as the basis for the combination of different methods (e.g. different kinds of interviews, different methods of interpretation, etc.).

Other researchers have already discussed the idea of triangulation in evaluation research in medical informatics. Greene and McClintock [24] differentiate mixed-method triangulation along two dimensions: first, the degree of independence between qualitative and quantitative methods; second, to what extent methods are implemented sequentially or concurrently. They present in their paper an example of concurrent and independent triangulation. In our study, we applied sequential triangulation with a high dependence of both study parts. Greene and McClintock conclude that real triangulation between two research paradigms may be impossible. The reasons for this are seen in the different nature of the findings retrieved by using questionnaires and interviews in parallel, both based on a single conceptual framework. According to the authors, results of both methods could not be integrated on all levels. (They differentiate between specific results, major findings and recommendations.) In contrast to their study we first derived hypotheses from the results of the interviews, which formed the basis for our questionnaire. Mapping each question to one of our hypotheses enabled us to compare the results of the survey to the findings of the interviews.

Another example of sequential and independent triangulation is presented by Hyrkäs et al. [25]. They evaluated patient satisfaction by means of methods triangulation, where questionnaires and interviews were applied sequentially, and the results only compared after both parts of the study had been finished. The authors concluded that triangulation was helpful to "elicit data to which certain methods may be blind" [25]. As a clear disadvantage of the approach they discuss that it is rather expensive and time-consuming. This is not supported by our experience, as we found, as already discussed, the advantages of preparing questionnaires based on qualitative interviews are of much higher importance for the completeness and validity of the study results than the time invested in the interviews.

While those examples show the use of sequential and independent triangulation, other authors recommend the dependent use

of methods as more effective, helping to develop and refine tools of enquiry (e.g. [26]). This was the approach we chose. Barbour discusses how the qualitative approach can contribute to the quantitative paradigm, but argues that the quantitative paradigm might potentially not be flexible enough for such integration [27]. We, however, did not experience these problems in our study.

A partly sequential integration of quantitative and qualitative methods can be found in a study carried out by Ammenwerth et al. at the Heidelberg University hospital. In their evaluation of nursing documentation they used interviews to further explain and analyze results obtained from questionnaires [16], an approach which shows that the other way can be useful (first questionnaires, then interviews). Although there is no clear link between questionnaires and interviews (as for example hypotheses) in this study, they found that results from both methods – be they congruent or divergent – brought new information and helped them to obtain a more comprehensive picture of their object of research.

An approach quite similar to ours can be found in a case study published by Kaplan and Duchon. They also constructed questionnaires on the basis of results from interviews and rated the combination of qualitative and quantitative methods as "especially valuable" to their study. Although there is no doubt that there are other approaches that are less time-consuming, we can – in terms of methods triangulation – only agree with Kaplan's conclusion [28].

6. Conclusion

In this paper we presented a study that showed that the overall satisfaction with electronic communication is rather high. The study also revealed some important points to be improved. One of the most important implications of the electronic transmission of medical findings is seen in the automatic assignment of documents to the patient record. It was revealed that the time that was saved by automatic filing and archiving, as well as the speed of transmission are to be considered major advantages.

Based on our results, adjustments to the layout and structure of the electronic documents, improvements concerning user support as well as quality initiatives to improve the appropriateness of the content and length of discharge letters are just now being discussed in the health@net project and in the TILAK. It will be recommended to expand the electronic transmission of findings to all hospitals and departments.

With regard to the methods we found that triangulation, as a means of integrating qualitative and quantitative methods, was very useful. The sequential application of interviews and questionnaires proved to be a reasonable way to achieve the aims of our study.

The methodical framework of triangulation as we made use of it implies a consistent step-by-step procedure where each step builds on the preceding one. This makes it clear that every single step requires maximum accuracy, which should be ensured by at least two researchers. An accurate documentation of the results of every step is absolutely necessary before continuing with the next step. This is particularly important for the qualitative part because deriving methods are much less standardized than the quantitative.

We believe that triangulation in particular – and qualitative methods in general – can make a valuable contribution to the further improvement of evaluation research in medical informatics.

Acknowledgments
We thank the anonymous reviewers for their helpful comments, as well as the staff of the Institute for Health Information Systems of the UMIT for their valuable contributions and comments.

References

1. WHO. A Health Telematics Policy, Report of the WHO Group Consultation on Health Telematics December 11-16, 1997, Geneva, World Health Organization, Geneva, 1998.
2. Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington: National Academy Press; 2001.
3. Sachverständigenrat für die Konzertierte Aktion im Gesundheitswesen. Finanzierung, Nutzerorientierung und Qualität – Band 2: Qualität und Versorgungsstrukturen. Baden-Baden; 2003.
4. Kuhn K, Guise D. From Hospital Information Systems to Health Information Systems – Problems, Challenges, Perspectives. Methods Inf Med 2000; 40: 275-86.
5. Moorman PW, Branger P, van der Kam W, van der Lei J. Electronic Messaging Between Primary and Secondary Care: A Four-year Case Report. JAMIA 2001; 8 (4): 372-8.
6. Collen MF. General Requirements for a Medical Information System (MIS). Comput Biomed Res 1970; 3 (5): 393-406.
7. Mageean R. Study of "discharge communications" from hospital. Br Med J (Clin Res Ed) 1986; 293 (6557): 1283-4.
8. van der Kam W, Moorman P, Koppejan-Mulder M. Effects of electronic communication in general practice. Int J Med Inf 2000; 60: 59-70.
9. Ammenwerth E, Haux R, Lechleitner G, Pfeiffer K, Triendl C, Vogl R. TILAK IT-Strategie 2003-2007: Informationsverarbeitung im Dienste von Patientenversorgung und medizinischer Forschung, Tiroler Landeskrankenanstalten Ges.m.b.H (TILAK), Innsbruck, 2003. http://iig.umit.at/projekte/itbeirat/itstrategie.htm.
10. Schabetsberger T, Haux R, Hirsch B, Kaloczy C, Lechleitner G, Schindelwig K, et al. A patient-centered telemedicine strategy to support shared care in the Tyrol. In: Baud R, Fieschi M, Le Beux P, Ruch P, editors. The New Navigators: from Professionals to Patients. Proceedings of Medical Informatics Europe (MIE 2003), May 4-7, 2003, St. Malo, France. Amsterdam: IOS Press; 2003. Proceedings available on CD.
11. Forsythe DE, Buchanan BG. Broadening our approach to evaluating medical information systems. In: Clayton P, editor. 15th Annual Symposium on Computer Applications in Medical Care. New York: McGraw-Hill; 1992. pp 8-12.
12. Kaplan B. Evaluating informatics applications – some alternative approaches: theory, social interactionism, and call for methodological pluralism. Int J Med Inform 2001; 64: 39-56.
13. Stavri P, Ash J. Does failure breed success: narrative analysis of stories about computerized provider order entry. Int J Med Inform 2003; 72 (1-3): 9-15.
14. Gagnon M, Godin G, Gagne C, Fortin J, Lamothe L, Reinharz D, et al. An adaptation of the theory of interpersonal behaviour to the study of telemedicine adoption by physicians. Int J Med Inform 2003; 71 (2-3): 103-15.
15. Greatbatch D, Murphy E, Dingwall R. Evaluating medical information systems: ethnomethodological and interactionist approaches. Health Serv Manage Res 2001; 14 (3): 181-91.
16. Ammenwerth E, Mansmann U, Iller C. Can evaluation studies benefit from a triangulation of quantitative and qualitative methods? A case study. Int J Med Inf 2003; 70 (2-3): 237-48.
17. Ammenwerth E, Brender J, Nykänen P, Prokosch H-U, Rigby M, Talmon J. Visions and strategies to improve evaluation of health information systems – reflections and lessons based on the HIS-EVAL workshop in Innsbruck. Int J Med Inf 2004; 73 (6): 479-91.

18. Denzin N. Strategies of multiple triangulation. In: Denzin N, editor. The Research Act. Chicago: Aldine; 1970. pp 297-331.
19. Flick U. Triangulation in der qualitativen Forschung. In: Flick U, Kardoff E, Steinke I, editors. Qualitative Forschung. Ein Handbuch. Reinbek b. Hamburg: Rowohlt Taschenbuch; 2000. pp 309-18.
20. Mayring M. Einführung in die qualitative Sozialforschung. Weinheim: Psychologie-Verlag-Union; 1993.
21. EvalDB. A web-based inventory of evaluation studies in medical informatics 1982-2002, UMIT. http://evaldb.umit.at. Last accessed: Jan. 2005.
22. Branger P, van der Wouden J, Schudel B, Verboog E, Duisterhout J, van der Lei J, et al. Electronic communication between providers of primary and secondary care. BMJ 1992; 305 (6861): 1068-70.
23. Branger P, van't Hooft A, van der Wouden J, Moorman P, van Bemmel J. Shared care for diabetes: supporting communication between primary and secondary care. Int J Med Inform 1999; 53: 133-42.
24. Greene J, McClintock C. Triangulation in evaluation: Design and analysis issues. Evaluation Review 1985; 9 (5): 523-45.
25. Hyrkas K, Paunonen M. Patient satisfaction and research-related problems (Part 2). Is triangulation the answer? J Nurs Manag 2000; 8 (4): 237-45.
26. Begley CM. Using triangulation in nursing research. J Adv Nurs 1996; 24 (1): 122-8.
27. Barbour RS. The case for combining qualitative and quantitative approaches in health services research. J Health Serv Res Policy 1999; 4 (1): 39-43.
28. Kaplan B, Duchon D. Combining qualitative and quantitative approaches in information systems research: a case study. MIS Quarterly 1988; 12 (4): 571-86.

Correspondence to:
Christof Machan
Institute for Health Information Systems
UMIT – University for Health Sciences, Medical Informatics and Technology
Eduard-Wallnöfer-Zentrum 1
6060 Hall in Tirol
Austria
E-mail: christof.machan@umit.at