Electronic Data Interchange in Medical Care: An Evaluation Study

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Abstract

This paper describes the evaluation of the first phase of the Communication Project Apeldoorn (COPA). The aim of COPA was to investigate the contribution of Electronic Data Interchange (EDI) to quality of care and practice efficiency. In this project over 33 general practitioners (GPs), 12 pharmacists and two hospitals (with one management) participated. In order to limit the number of variables for the evaluation study a limited number of messages was implemented:. free-text messages between GPs; admission/discharge reports from hospitals to GPs, laboratory test reports from hospital to GP. The goal of the evaluation of the first phase of the project was to study message flow, the effect of integration with the Electronic Medical Record and the use of those data for patient care. In order to compare the use of EDI with the original situation (i.e. regular mail) a baseline study was performed. In this study the procedure for handling laboratory test reports and admission/discharge reports was also investigated. The results of the baseline study were compared with the evaluation of the use of EDI.

1. Introduction

In the Dutch city of Apeldoorn the Communication Project Apeldoorn (COPA) was started in 1988, with the participation of 33 GPs, 12 retail pharmacists and two hospitals, the Juliana Hospital and the Lukas Hospital, each with a clinical laboratory. This project deals with the implementation and evaluation of Electronic Data Interchange (EDI) in health care.

In Apeldoorn the hospital clinical laboratories and patient administration have used computer systems for data processing for many years. In 1986 the GPs of Apeldoorn decided for a common strategy for practice automation and expressed the aim to establish EDI between GPs, hospitals, pharmacies, specialists and other health care providers. They decided to mutually select one information system, on the assumption that homogeneity of information systems would greatly facilitate the set-up of a communication project. Eventually the ELIAS system was selected and the supplier expressed willingness to support a communication project. ELIAS is a modular system and can be used as a paperless medical office system (including Electronic Medical Records) or for administration only [1].

The first phase of the project included the implementation of three types of electronic messages: free-text messages between GPs; admission/discharge reports (a/d reports) from hospitals to GPs, laboratory test reports from hospital to GP [2]. Data exchange is done using a commercially available communication system, based on E-mail principles. A/d reports and laboratory test reports are transmitted as standardized messages using the EDIFACT protocol [3], thus enabling fully integrated data exchange. Information from the *a/d reports* is used to automatically create and update an overview of hospitalized and discharged patients in the GP's information system. The GP can obtain a print-out of this overview, optionally combined with relevant data from the Electronic Medical Record (EMR) to be used as a memo for home visits. Data from *laboratory reports* can be stored directly into and integrated with the EMR of the patient concerned.

At the beginning of COPA the aim was defined as *to investigate the contribution of EDI to quality of care and practice efficiency*. Three specific fields of interest can be extracted from this aim: message flow; practice efficiency; patient care.

2. Method

The evaluation study consisted of three major parts: a baseline study; measurements on EDI message flow; recording GPs experiences with EDI. The baseline study was performed *before* GPs received the communication software. With the first version only exchange of free-text messages was possible: at a later stage the ELIAS EDI-handler was added. The evaluation of EDI took place *after* installation of the EDI-handler. After a period of ten weeks, during which the EDI message flow measurements took place, GPs were asked about their experiences with EDI.

Privacy protection. Protecting privacy of both physicians and patients is an important aspect of health care, and of growing importance when information systems and EDI are used. Ideally, all data are made anonymous in an evaluation study. While gathering data it is necessary to distinguish between the sources of the data, and additional information might be required from a certain source. In this evaluation study two important measures were taken to protect privacy

0195-4210/91/$5.00

of GPs and their patients and yet to permit the acquisition of additional data. 1) a so-called Gate-Keeper, representing the GPs in the Steering Committee, was appointed. The Gate-Keeper randomly allocated a three-digit number to all participating GPs, the final codes being known only by the Gate-Keeper. The code numbers were used throughout the evaluation study and all data from GPs were collected under code. On the other hand, the Gate-Keeper had no access to "raw" data. 2) Because part of the data from GPs was collected using the E-mail system itself, the coding of physicians and patient was not sufficient as the senders' E-mail address could negate the privacy protection. Therefore a special electronic mailbox (the "evaluation mailbox") was installed, which could receive incoming mail like any other mailbox. Its only function was to forward E-mail to the department's mailbox, overwriting the E-mail address of the original sender, thus making it impossible to trace the original sender.

The Baseline Study. The baseline study was performed before EDI was implemented, by means of a questionnaire consisting of multiple choice and open-end questions. Space was left for the GP's own comments. A first draft was discussed with three of the GPs and with a member of the Department of Biomedical Statistics of the Erasmus University. The final version consisted of four sections: GP characteristics (age, gender); practice characteristics (use of the EMR, number of years experience with it); a/d reports (sources of communication, time aspects, importance of reports); laboratory test reports (time aspects, processing of information). Time aspects of the delivery of a/d reports were investigated by asking GPs to estimate how many days after the actual admission/discharge of a patient the information became available through the reports.
Similarly, for laboratory test reports GPs were asked to estimate the average time needed for a laboratory test report to reach the GP's office. This is done by comparing the date/time the report was printed at the laboratory (available from the heading of the report) and the moment it arrived at the GP's office.The results of the baseline study were to be compared with the evaluation of the use of EDI.

EDI message flow measurements.. During a period of ten weeks laboratory and a/d reports were followed on their way from senders (hospitals) to receivers (GPs). Time intervals were measured and actions taken by GPs as a result of the information were evaluated. The following time stamps were made: T1: Generation of the message; T2: Availability of the message as E-mail; T3: Use of the message by the GP. These time stamps were measured automatically and sent to this department with an anonymous copy of the original message (a so-called *evaluation message*), using a customized EDIFACT lay-out enabling automatic processing of the material. All messages were sent to this department through the special "evaluation mailbox" described previously.

User experiences with EDI. After completion of the EDI evaluation a questionnaire was sent to those GPs also involved in the baseline study. The mode of operation was the same as for the questionnaire used for the baseline study. GPs were asked for their experiences with EDI, focusing on the following aspects: use of free-text E-mail messages for exchange of patient data, and the benefits of E-mail for this type of message; benefits of E-mail for a/d reports; benefits of E-mail for laboratory test reports, with regard to speed of delivery and integration of data into the EMR.

3. Results

At the beginning of the project 27 GPs participated. Baseline study questionnaires were completed and returned to by 24 GPs (23 males and one female, average age 41 years), together with a total of approximately 50,000 patients. Of all GPs, 13 used the EMR, 11 used the administration and finance modules only. Of these 11 non-users 8 participated in the EDI message flow measurements.
The use of E-mail for reporting a/d reports and laboratory test reports started by end December 1989. During the period 15-jan-1990 to 26-mar-1990 (10 weeks) the message flow for these types of messages was evaluated. The previously described method provided a total number of 2784 evaluation messages: 1388 a/d reports and 1396 laboratory test reports. In this section we describe the results of EDI measurements and user experiences with EDI. When relevant, comparisons will be made with the baseline study

3.1 EDI :Time Aspects

A /d reports. The creation and transmission of a/d reports is done twice every working day, at 11.00 a.m. and 4.00 p.m. The EDI measurements have shown that within one hour of creation more than 90% of all reports are available to the GP, reaching 100% after three hours. In the baseline study the GPs indicated that the average time needed for an a/d report to reach their office was two days for reports from the Lukas Hospital and four days from the Juliana Hospital. Comparing these results with those from the EDI measurements it is obvious that, for these type of messages, E-mail is much faster than reporting via the original structure. It should be noted, however, that the method for obtaining data during the baseline study (the questionnaire) is less reliable than the measurements of EDI message flow.

Laboratory test reports. Both hospitals use the same mode of operation for reporting laboratory test results to GPs. Sample taking and sample analysis continue throughout the day, whereas generation of paper reports occurs once per day (at about 4.00 p.m.) to be distributed in the afternoon mail round. While the paper reports are being printed, E-mail

reports are generated and transferred to the E-mail box of the GP. Using E-mail it is of course far more efficient to generate a report and send it to the GP the moment the test results are available. Because of organizational reasons (e.g. verification of reports, which is still done by hand) and technical limitations, changing the old routine will take considerable time.

Unlike the a/d reports, the exact moment of the creation of laboratory test reports is not available. Each laboratory report contains the time/date the patient arrived at the laboratory, had samples taken (T1), and the time/date data became available to the GP as E-mail (T2).

Measurements show that 30% of laboratory test results from the Lukas hospital and 55% from the Juliana hospital arrived at the GP's E-mail box the same day the samples were collected. Apparently, the laboratories managed to analyse and report these tests on the day the sample was obtained. The advantage of E-mail, with respect to speed, diminishes when the laboratory test takes longer than one working day . Some tests take more than three days to become available on E-mail. Three reasons exist for this delay: 1) The test is not performed every day, but e.g. only once a week. This is, for instance, the case for TSH and free T_4; 2)The sample is obtained shortly before the weekend, reporting is done no sooner than Monday afternoon, causing a delay of up to 72 hours. 3) The laboratory test is done in a specialized laboratory, on a different location (e.g., Amsterdam).

In all cases, time is saved by bypassing the normal paper mail delivery. For that reason, in the baseline study the GPs were asked to estimate the time interval between the time/date of printing the report (available on the form itself) and the moment the laboratory report arrived in the office. The GPs indicated that the average time for a laboratory test report to reach their office was three days from the Lukas Hospital and two days from the Juliana Hospital.

3.2 EDI: Use of information

The previous section described communication characteristics of the delivery of reports to GPs E-mail box. This section focuses the next link of the chain: the time interval between availability of the messages and use of its contents by the GP. The baseline study showed that not all GPs use the EMR. The communication module provides integration between electronic messages and ELIAS. On the assumption that the mode of operation for GPs using the EMR in daily practice differs from that of those who do not, GPs were divided into two groups: EMR users (n=13) and non-users (n=8). For both groups two aspects of the use of messages were investigated: the time of day messages were processed; the time interval between availability in the E-mail box (T2) and processing of the message (T3).

Message Processing: Time of Day. As mentioned earlier, delivery of messages peaks at 11.00 a.m. (a/d reports only) and 4:00 p.m. (a/d reports and laboratory reports). The EDI measurements showed that GPs who use the EMR respond more adequately to this fact than the non-users. Within the first four hours after 4:00 p.m. the EMR-users processed 55% of the laboratory reports, whereas GPs not using the EMR processed only 25% in the same period.

Message Processing: Time Delay. The time intervals between delivery of messages in the E-mail box of GPs (T2) and processing of these messages (T3) are depicted in Figure 1.

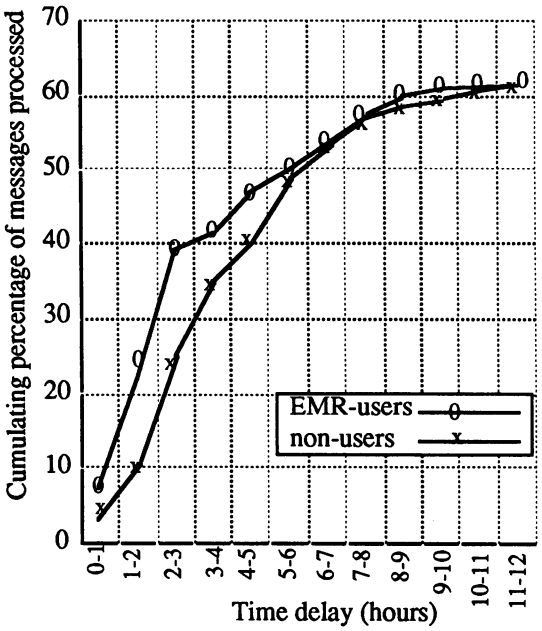

Figure 1. Time interval between message availability (a/d reports and laboratory test reports on E-mail and processing by the GPs, truncated at 12 hours: for both groups processing of the remaining 40% was identical. Total number of messages: 562 (EMR-users) and 228 (non-users)

The EMR-users processed more messages within the first four hours of the messages becoming available (42% of the total) than the non-users (35%). The median for EMR-users falls within hour 6 and for non-users within hour 7. Both groups also have a number of messages processed after a longer period. This may be because the measurements are not adjusted for vacations/weekend shifts: GPs do not normally process messages during off-duty periods. The link between the GP code numbers, weekend shifts and vacation schedules was not available for privacy protection reasons.

3.3 GPs experiences with EDI

After completing the measurements of EDI message flow, GPs were asked about their experiences with EDI. A questionnaire was sent to those GPs also involved in the baseline study: of these 27 GPs, 23 returned the questionnaire (13 EMR-users and 10 non-users).

Free-Text Messages. During the baseline study and the evaluation of EDI focus was on laboratory reports and a/d reports. However, informal conversations with a number of GPs learned that the use of free-text messages was very popular; therefore questions regarding this message type were also included.
It appeared that, with one exception, all GPs used free-text E-mail for exchange of patient information. When asked to indicate the benefits of E-mail for this type of information, GPs placed it at a premium.

A/d reports. Measurement of EDI message flow has shown that reporting of admission/discharge of patients with EDI is much faster than with traditional mail services. Furthermore, use of EDI has led to an improved structure of reporting, giving GPs an overview of their patients that is constantly updated by the a/d reports from the hospital administration. GPs were asked whether their insight as to the whereabouts of their patients had increased with the introduction of EDI. Fifteen of the 23 GPs judged that their insight had increased. GPs were also asked to indicate the benefits of EDI for a/d reports. Although the overall appreciation was positive, on a scale of 0 (useless) to 5 (very useful) EMR-users were clearly more positive about the benefits than the non-users (4 times a score of 5 and 4 times a score of 4 vs. 0 times a 5 and 4 times a 4).

Laboratory reports. Use of EDI for transmission of laboratory test results has two major aspects: 1) Increased speed of reporting; 2) the integration of laboratory test results in the EMR.
GPs were asked to indicate the benefits of EDI with regard to these two aspects. GPs using EMR valued the increased speed of delivery somewhat higher than GPs not using the EMR (on the scale mentioned above 5 times a score of 5 and 2 times a score of 4 vs. 1 score of 5 and one of 4). Integration of data into the EMR, however, was more highly valued much higher by both groups. On the scale mentioned above all GPs indicated a 4 or a 5.
In 10 instances automated processing of laboratory data led to an overall reduction in workload in the GP's office. One GP explicitly reported a shift in laboratory data processing: more data is now processed by the GP himself instead of the practice assistant and the overall time needed has decreased. One GP reported an increased workload, blaming it on the user interface of the EDI-handler.

4. Discussion

At the start of the project the GPs were asked which benefits they expected from the project. Three issues were mentioned by a majority of GPs: the possibility for exchanging free-text messages (GP to GP, describing patient encounters during weekends and night shifts); faster reporting of a/d reports and laboratory test reports; integration of laboratory test results into the EMR.
At the end of the first phase of COPA, it is concluded that all three goals have been achieved. The overall appreciation of EDI by GPs was very positive.
Measurements were performed during a 10-week period. This period is relatively short, because during this time GPs also had to acquaint themselves with EDI. During the evaluation, emphasis focused on investigation of message flow and use of data, rather than the contents of the messages. It is concluded that EDI has proven to influence message reporting and GPs usage of messages on several fields:

Speed of reporting. Measurements have shown that, compared with conventional mail, EDI increases speed of reporting (i.e. reports arrive within hours instead of days).
Regarding gain in speed, overall appreciation by GPs is positive, but not over-enthusiastic. There may be several reasons for this somewhat weak response: 1) For the reporting of emergency tests the telephone is faster; 2) When unexpectedly an alarming test result occurs, the GP is usually phoned by the laboratory anyhow; 3) A number of lab tests, requested by the GP, are of a non-urgent nature.

Integration. Integration of laboratory test results into the EMR was highly valued by GPs. Even after only ten weeks a decrease in workload was reported by 10 out of 23 GPs: EDI leads to improved efficiency with regard to processing of laboratory test results.
Automatic storage generally tends to diminish transcription errors and might lead to an increased number of test results being stored by the GP. These matters are being studied and will be presented at the conference.

Quality of reporting. Use of EDI for transmission of a/d reports has led to improved reporting. With the introduction of EDI a systematic error in reporting between the hospital and GPs was discovered and corrected (this error probably existed for many years). In this case EDI proved to be a valuable instrument for getting feedback about the internal organization of patient administration.
Use of EDI for a/d reports, combined with maintaining within ELIAS an overview of hospitalized patients has led to an improved structure of reporting: most GPs judged that their insight in this matter has increased. EDI supports the GP in achieving continuity of care for admitted and discharged patients.

With one exception, all participating GPs used free-text E-mail messages for exchanging patient information, especially for describing patient encounters during weekends and night shifts. Use of E-mail for exchanging this type of message was very highly valued.
It is concluded that for GPs the increased quality of communication offered by EDI, and not the gain in speed as such, constitutes the most important factor.

EDI and EMR. Especially those GPs who use the EMR in daily practice appreciate the use of EDI. Results of the evaluation of EDI have shown that GPs using EMR worked more efficiently with EDI than their colleagues not using EMR (see section 3.2). Also, relatively more EMR-users (9 of 13) experienced a reduced workload with regard to storage of lab test results in the EMR than non-users (1 of 10) and, finally, relatively more EMR-users noticed increased insight regarding the a/d of their patients (9 of 13 vs. 6 of 10). The above might be due to by the fact that EDI and EMR together form a "perfect couple", but it could also be the result of a pre-selection: GPs that are willing to go through the arduous phase of converting from paper records to electronic records might have a special attitude.

Research. The structure of COPA has proven to be an efficient set-up for research. The "Gate-Keeper" enables to evaluate use of information without threatening the privacy of either physician or patient. EDI facilitates research and enables the collection of quantitative data for scientific projects in primary care. The first phase of COPA has shown the feasibility to develop a method to evaluate the continuity of care.

The initial results of COPA demonstrate that the effects of EDI on health care are very promising: the following issues remain to be investigated:

* EDI has the potential to improve quality of care: to what extent is not yet clear. This is one of the most important aspects of the use of EDI.
* More participants and more message types are necessary to further increase the acceptance and efficiency of using EDI. The benefits of EDI can only be optimal if all communication is made using this concept.
*An organizational structure is needed to guarantee widespread use of EDI, financial regulations and standardization.
*E-mail might lower total costs of communication [4]. However, GPs previously accustomed to receiving 'free' mail via the letterbox now have to pay for receiving that same information. New structures have to be developed for financing the use of E-mail.
*Specially structured communication between GPs and specialists might greatly improve the continuity of care, preventing the possibility of conflicting medication and duplication of diagnostic tests.
*Privacy aspects are an important issue in the handling of medical data, not only with EDI, but as an issue of ongoing concern.

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