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Concept and implementation of a computer-based reminder system to increase completeness in clinical documentation

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ABSTRACT

Purpose: Medical documentation is often incomplete. Missing information may impede or bias analysis of study data and can cause delays. In a single source information system, clinical routine documentation and electronic data capture (EDC) systems are connected in the hospital information system (HIS). In this setting, both clinical routine and research would benefit from a higher rate of complete documentation.

Methods: We designed a HIS-based reminder system which identifies not yet finalized forms and sends reminder e-mails to responsible physicians depending on escalation level. The generic concept to create reminder e-mail messages consists in database queries on not-finalized forms and generation of e-mail messages based on this output via the communication server. We compared completeness of electronic HIS forms before and after introduction of the reminder system three months each.

Results: Completeness increased highly significantly ($p < 0.0001$) for each form type (medical history form 93% (145 of 156 forms) vs 100% (206 forms), stress injection protocol 90% (142 of 157 forms) vs 100% (198 forms) and rest injection protocol 31% (45 of 147 forms) vs 100% (208 forms)). Forty-six reminder e-mails to the responsible study physician and 53 reminder e-mails to the principal investigator were sent to finish 2 medical history forms, 8 stress and 20 rest injection protocols. These 2 medical history forms were completed after 1 and 56 days. The median processing time of the stress injection protocols in the post-implementation phase was 18 days (range from 1 to 60 days). The median processing time of the rest injection protocols was 26 days (range from 5 to 37 days).

Conclusion: A computer-based reminder system to identify incomplete documentation forms with a notification and escalation mechanism can improve completeness of finalized forms significantly. It is technically feasible and effective in the clinical setting.

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1. Introduction

Completeness of medical documentation is a relevant issue and there is evidence for data completeness problems in hospital information systems (HISs) [1]. Possible reasons of incomplete documentation are for instance working under time pressure [2], errors at data entry [3] and not available information.

Usually, clinical routine documentation takes place in a HIS which is separated from electronic data capture (EDC) systems in clinical studies. El Emam et al. state that “Electronic data capture (EDC) tools provide automated support for data collection, reporting, query resolution, randomization, and validation, among other features, for clinical trials” [4]. Case report forms (CRFs) are entered into the research database and are not available in the HIS. This documentation approach is called dual source [5]. In a single source information system, collection of medical data is united in the HIS and used for clinical routine as well as studies. According to Dugas et al., routine and research data are collected within HIS, research data are exported into the research database [5]. Monitoring handles incomplete or incorrect data elements. Completeness of documentation is particularly relevant in a single source setting because “... missing data are hard to interpret” [6] and “The problem of missing data is even more serious than is that of data-entry-errors” [7].

Recently, we reported about a single source information system in nuclear medicine which connects patient care and clinical research for studies on cardiovascular diseases [8]. Medical history, stress and rest injection protocols of myocardial scintigraphy on single photon emission computer tomography combined with two-slice computer tomography (SPECT/CT) are documented within the HIS and exported into a research database for analysis. Thereby, we emphasized correctness and completeness of documentation by using ranges and plausibility check functions in order to provide high-quality data for analysis in research. A form which fails the plausibility checks cannot be finalized by electronic signature and consequently, it is incompletely documented. In the clinical setting, incomplete documentation can be saved and closed any time in draft state. In this case, a link to this form is enqueued in a work list for physician’s review. In an initial assessment of data quality, we found that the mean rate of completeness was only 72%.

Completeness of medical documentation is a generic problem, therefore we focus on the following objectives:

1. Is it feasible to design and implement a generic reminder system in a setting with a commercial HIS?
2. Can an automatic reminder system which identifies incomplete documentation increase the rate of completion?

2. Methods

A HIS-based reminder system should satisfy the following requirements:

1. Identification of incompletely documented forms as configured.
2. A large number of parallel studies are performed simultaneously. The documentation of each study typically consists of several forms; the reminder system should allow to set up different configurations with regard to the start date and limits of the queries for each form type of each study and have the potential to send ‘summary e-mails’ by study.
3. An escalation mechanism in order to notify different groups of people about incomplete documentation should be provided.

Orbis® from Agfa Healthcare [9] is used as the clinical information system (CIS) at our university hospital. Furthermore, a communication server e*gate from ORACLE [10] is used to transfer data between departmental systems, CIS, laboratory information systems (LIS) and the radiological information system/picture archiving and communication system (RIS/PACS) within the HIS.

Fig. 1 shows a flow chart from the user’s point of view about the reminder system. In case of an incomplete form, the responsible study physician will be notified after expiration of the defined grace period in order to catch up finalization. If a second grace period is expired and the form is still incomplete, the principal investigator will be notified.

To implement the generic workflow of Fig. 1, we designed the following data model (Fig. 2).

2.1. Technical approach

Five tables in the relational database management system ORACLE [10] of our CIS were defined. The first table (qms_def) contains the definitions of queries by form type, the second table (qms_schedule) provides the schedule and the third (qms_data) is needed for data export. Two further tables are used for providing mailing lists and e-mail addresses. This data model is presented in Fig. 2. Then, we created a database package using procedural language/structured query language (PL/SQL) which interacts with those tables. The flow chart in Fig. 3 presents the database processing of generating a reminder e-mail event which takes place as follows: The procedure is started periodically by job control. It checks whether the schedule contains a due record and stores the related set. In this case, a prepared query is started for each definition table’s due record which is a member of this set. This query delivers the incomplete forms’ creation date and the patients’ case ID for a defined time interval. After calculating the age of each incomplete form, the escalation level can be determined. Subsequently, the resulting data are transferred into a table for export. To improve performance, each subsequent search starts with the oldest identified incomplete form for each form type. The schedule table stores for each form type the time of the last and next run. When due records are identified, a dedicated procedure identifies the receiving person depending on the reached escalation level. Then, a message based on unfinished records of the export table and the relating transaction ID is created. This message is pasted into a table fetched by the communication server which translates it into a standardized extended markup language (XML) message and transfers it to

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