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Quality indicators from laboratory and radiology information systems

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Abstract

Consequences of the computerization of laboratory and radiology information system (LIS and RIS) are not well documented. The aim of this study was to evaluate the impact of computerization of LIS and RIS of four hospitals on performance and quality of care. The study was divided into three phases. First, the subprocesses and information flows of LIS and RIS were described. Then, a literature review was performed in order to identify the indicators used to assess the impact of computerization. Finally, comparisons were made between 2 hospitals. Using the initial framework, each partner described its process mapping concerning LIS and RIS. The review identified a wide panel of indicators. Only 41 were useful to assess the impact of information systems. For each two by two comparison, lists of relevant indicators have been selected from the identified indicators and according to the process mapping comparison. Two by two comparisons have to be completed. Eventually, these indicators may be integrated in the quality process of hospital information systems.

Keywords:

Hospital information systems; process assessment (health care); quality indicators, health care

Introduction

Health information systems (HIS) have been widely studied in order to evaluate their effectiveness [1-4]. Benefits of HIS have been shown on the improvement of hospital productivity, coordination of care and quality of care [5]. The use of HIS also has a positive impact on the prevention of medication errors and the reduction of adverse effects [6]. However, most published studies are descriptive ones, and are performed in a monodisciplinary context. They do not provide the analysis of the consequences of the computerization implementation in a system involving multiple participants in the care process [7].

One important part of HIS is the computerization of laboratory and radiology services, from the prescription to the report of the exam results to the health professional. The computerization of laboratory and radiology services started many years ago [8], but still varies widely between health establishments [9].

The aim of this study was to: 1) describe the computerization of the subprocesses of a laboratory information system (LIS) and a radiology information system (RIS) of four hospitals; 2) identify indicators of the impact of computerization on performance and quality of care; 3) evaluate the impact of computerization on performance and quality of care using the pre-defined indicators.The same methodolody was applied to the three steps of this study, for LIS and RIS.

Methods

This study is part of the EVALSI project, led by a multidisciplinary consortium including four departments of biomedical informatics (Rouen, Paris, Lille and Nice), an engineer school (Mines ParisTech Graduate School) and a social sciences research centre (Research centre for the study and observation of life conditions).

The great variety of computerization between hospitals allowed us to build a global methodology based on comparisons between hospitals. This methodology was chosen in order to limit the risk of bias of before and after studies, following the advice of the scientific committee of the DHSO.

The study was divided into 3 phases. To date, phases 1 and 2 have been completed.

Phase 1: Process mapping

For each hospital, a detailed description of processes and information flow in the HIS of medical biological and imaging services was performed. For each process or sub process, the computerization level, the inter-step data flow, and the data that could be used for the measures of indicators were described. An initial framework was originally built from two hospitals (Lille and Rouen), and then used to obtain the final process mapping.

Phase 2: Identification of performance and quality of care indicators

In order to identify the indicators used to evaluate the subprocesses of medical biological and imaging systems, a literature review was performed. We used systematic search processes to identify all published studies concerning our topic. We searched the PubMed database, and selected articles in English and French. Detailed queries are available at: http://www.chu-rouen.fr/cismef/papers/Detailed_queries_used_for_the_literature_review.pdf. Inclusion criteria were studies performed in hospitals, concerning performance and quality indicators, used to evaluate the impact of HIS. The selection of articles was performed by two authors (JP and CP) and controlled by three others (MS, NG and SJD). We also systematically searched the reference lists of all the included studies and relevant reviews. Disagreements were resolved by consensus.

Phase 3: Evaluation of the impact of computerization on performance and quality of care

A list of performance and quality indicators was extracted from the literature review. Indicators that will be used for evaluation have been selected by five physicians (PM, MBJ, MS, NG, SJD), using 3 criteria: their applicability disregarding the level of computerization of subprocesses, their measurability disregarding the hospital and their relevance. Disagreements were resolved by consensus. Some data will be directly extracted from the HIS. Other data will be manually collected in laboratory and radiology services and in clinical wards (medicine and surgery). Comparisons will be made between 2 hospitals, process mapping of which showed a difference in the level of computerization in one subprocess.

Results

Phase 1: Process mapping

This phase has already been completed, and the results have been published. The result of the description of processes and subprocesses, using the previously developed framework, is a process mapping that allows for comparison between all the involved hospitals. Indeed, all participating hospitals described the same list of processes and subprocesses.

The following subprocesses have been described for the LIS: ordering, request filling, sample labelling, transmission of the request, sample delivery to the laboratory, registration of the request in the LIS, reconciliation of the request and the sample, technical validation, biological validation, report of the result, result awareness.

The following subprocesses have been described for the RIS: ordering, request filling, transmission of the request, appointment scheduling, organisation of the transport of the patient, registration of the patient in the RIS, production of the images, recording of the report, redaction of the report, transmission of the report, result awareness.

This process mapping allowed us to identify the steps where methods or levels of computerization were different between hospitals, and for which we may be able, using the indicators, to assess the impact of computerization (e.g presence of a ScanBack in hospital A vs. none in hospital B). The interested reader may refer to the publication for more information [10].

Phase 2: Identification of performance and quality of care indicators

Respectively, 446 and 986 articles were retrieved by the bibliographic queries for biology and radiology. Respectively, after reading the titles and abstracts (and the full texts in case of a doubt), 109 and 64 papers met our inclusion criteria (see figure 1).

Indicators for biological systems

The literature review included 109 articles. Examples of indicators reported in the literature are listed below by type.

- Delay indicators
  - Turnaround time and associated measures
  - Time between report of the result and reading of the result
  - Time between report of the result and consequential therapeutic change
  - Length of stay
- Quality indicators
  - Quality of the exam request filling
  - Proportion of samples that cannot be analyzed
  - Error rate in exam result reports
- Management indicators
  - Workload of the staff
  - Satisfaction of the staff, feeling of efficiency
  - Utilization rate of the machines
- Cost indicators

Indicators for imaging systems

This literature review included 64 articles. Examples of indicators reported in the literature are listed below by type.

- Delay indicators
  - Turnaround time and associated measures
  - Time between report of the result and reading of the result
  - Time between report of the result and consequential therapeutic change
  - Length of stay
  - Length of stay in medical imaging ward
- Quality indicators
  - Irradiation dose
  - False diagnostic rate
  - Rate of unread reports
  - Rate of lost reports
- Management indicators
  - Satisfaction of the staff, feeling of efficiency
  - Compliance rate with guidelines
  - Enhanced patient flow
- Cost indicators

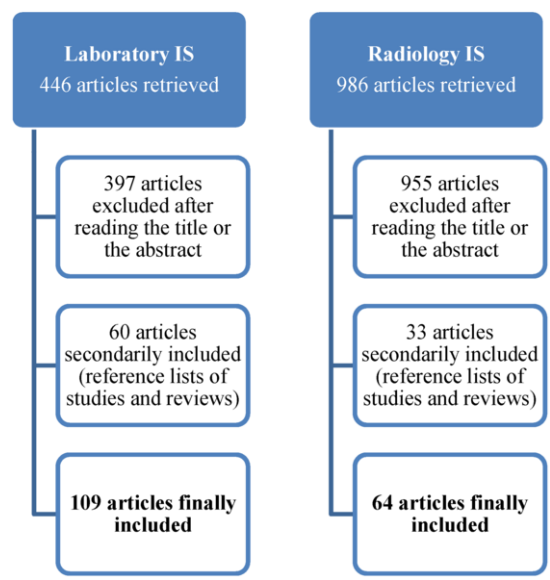

Figure 1 – Inclusion flow-chart

Phase 3: Evaluation of the impact of computerization on performance and quality of care

From the wild list of performance and quality indicators extracted from the literature review, two short lists of indicators for laboratory information and radiology

information systems were selected. Some activity indicators were also included in this selection. As a global indicator, turnaround time (TAT), which has been recognized in the literature as a key indicator [11], was impacted by all the subprocesses. Therefore, it has been decided to divide TAT into several sub-indicators. All the selected indicators are listed in tables 1 for biology and 2 for medical imaging.

Table 1 – Indicators selected for laboratory information systems (n=17)

Indicator type	Indicators
Activity indicators	Number of analyses over a given period
	Mean number of analyses per patient and per day
	Mean number of analyses per physician and per day
	Mean number of blood samples per hospital stay
	Mean number of blood samples per day of hospitalization
	Number of analyses per patient and per hospital stay
Performance indicators	Rate of cancelled analyses over a given period
	Rate of analyses rejected as non-compliant over a given period
	Time between sample collection and report of the result (TAT)
	Time between sample collection and arrival in the lab
	Time between arrival in the lab and start of analysis
	Time between start of analysis and technical validation
	Time between technical validation and biological validation
	Time between start of analysis and report of the result
	Time between the report of a drug dosage result and the consequential therapeutic change
	Time between the report of a hyperkalemia and the consequential therapeutic change
	Time between report of the result and reading of the result

Each indicator was precisely described, including all the data necessary to measure it. For each subprocess, indicators potentially impacted were identified. This allowed us to define the relevant indicators to perform each two by two comparison for LIS and RIS. Partial examples of the obtained matrixes are summarised in Tables 3 and 4, respectively.

In most cases, indicators were impacted by several subprocesses. The selection of indicators for each two by two comparison was automatically deducted from:

- the process differences between hospitals
- the potential impact of the computerization of subprocesses on the indicators.

The computerization of some subprocesses could be similar between two hospitals, for example, in Table 3, the ordering and sample labelling. The indicators only impacted by these subprocesses (eg: the rate of cancelled analyses over a given period) should be used as controls. Therefore, there should be no difference for these indicators between these two hospitals.

Table 2 – Indicators selected for imaging services information systems (n=24)

Indicator type	Indicators
Activity indicators	Number of exams over a given period
	Number of exams per patient and per stay relative to the length of stay
	Number of exams relative to the number of physicians
	Number of exams relative to the number of radiologists
	Number of exams relative to the number of available machines
Performance indicators	Number of redundant exams per hospital stay
	Compliance rate of exam requests with guidelines
	Proportion of exams requests modified by radiologists
	Proportion of images viewed by requesting physicians
	Proportion of reports read by requesting physicians
	Proportion of lost exams in patients files
	Absorbed radiation dose per patient
	Time between prescription and report of the result (TAT)
	Time between prescription and receipt of the request in the radiology service
	Time between receipt of the request and appointment schedulling
	Time between appointment schedulling and execution of the exam
	Timer between the scheduled time of the exam and the actual time of the exam
	Exam length
	Time between the end of the exam and the availability of the images for the requesting physician
	Time between the end of the exam and the availability of a first report for the requesting physician
	Time between the availability of the report and taking into account the results of the exam
	Time between the end of the exam and the availability of the final report for the requesting physician
	Patients waiting time in the radiology services
	Report writing time by the radiologist

In the case that one indicator was impacted by several subprocesses, and the difference in the computerization between two hospitals concerned only one of theses subprocesses, the above mentioned indicator should be considered as relevant to assess the impact of computerization of this subprocess. For example, in Table 4, the time between ordering and reception of the request in the medical imaging ward was potentially impacted by ordering, request filling and

Table 3 – Examples of computerization differences of several LIS subprocesses between Rouen and Paris hospitals, and their respective impacted indicators

Subprocesses	Rouen Hospital	Paris Hospital	Impacted indicators
Ordering	Computerized step (use of the LIS test catalogue)	Computerized step (use of the LIS test catalogue)	Number of analyses over a given period, mean number of analyses per patient and per day, number of cancelled analyses over a given period, number of analyses rejected as non-compliant over a given period, time between sample collection and report of the result, time between sample collection and arrival in the lab
Request filling	Paper application form	Computerized step	Time between sample collection and report of the result, time between sample collection and arrival in the lab
Sample labelling	Label identifying the patient	Label identifying the patient	Number of cancelled analyses over a given period, number of analyses rejected as non-compliant over a given period, time between sample collection and report of the result, time between sample collection and arrival in the lab
Transmission of the request	Physical transmission	Electronic transmission after validation	Time between sample collection and report of the result, time between sample collection and arrival in the lab

Table 4 – Examples of computerization differences of several RIS subprocesses between Rouen and Lille hospitals, and their respective impacted indicators

Sub processes	Rouen Hospital	Lille Hospital	Impacted indicators
Ordering	Computerized step (use of the RIS exams catalogue)	Paper prescription	Number of exams over a given period, number of exams per patient and per stay relative to the length of stay, number of exams relative to the number of physicians, number of exams relative to the number of radiologists, number of exams relative to the number of available machines, number of redundant exams per hospital stay, compliance rate of exam requests with guidelines, time between prescription and report of the result, time between prescription and receipt of the request in the radiology service
Request filling	Paper application form	Paper application form	Compliance rate of exam requests with guidelines, time between prescription and report of the result, time between prescription and receipt of the request in the radiology service
Transmission of the request	Physical transmission	Physical transmission	Compliance rate of exam requests with guidelines, time between prescription and report of the result, time between prescription and receipt of the request in the radiology service
Appointment scheduling	Partially computerized step	Manual registration	Number of exams over a given period, compliance rate of exam requests with guidelines, rate of exams requests modified by radiologists, time between prescription and report of the result, time between receipt of the request and appointment schedulling, time between appointment schedulling and execution of the exam

transmission of the request. Ordering is the only subprocess that differs between Rouen and Lille hospitals. Therefore, for the Rouen vs. Lille comparison, the time between ordering and reception of the request in the medical imaging ward was relevant to asses the impact of ordering computerization. Nevertheless, and still considering one indicator impacted by several subprocesses, if the difference in the computerization between two hospitals concerned more than one subprocess, the measures of the indicator should be hard to interpret, and could be useless.

Discussion

Using the initial framework, each partner described its process mapping concerning laboratory and imagery information systems. The literature review allowed us to identify a wide panel of indicators. Most of them were relevant to assess the quality of biological and medical imaging exam processes, but only few of them were useful to assess the impact of IS in our context. From the indicators identified and the process mapping, lists of relevant indicators have been defined to perform two by two comparisons.

TAT, and its subindicators, seemed to be well fitted to assess the impact of IS [11], and were considered quality indicators, especially in the biological domain.

Our study has several limitation.The standardized framework was quite basic. On the one hand, two quite different processes can be described in the same way. Therefore, it was necessary to have good knowledge of the process in order to avoid a false comparison. On the other hand, the framework facilitated the description of processes in hospitals as it did not require advanced skills for the description process. Moreover, the resulting process mapping was easy to compare as they shared the same format. The framework was adopted well by the four hospitals. Furthermore, only university hospitals were included in this study. This might be a possible concern for external validity. Nevertheless, their HIS profiles were quite different and many interesting comparisons could be made. A few subprocesses were similarly computerized. Obviously, this prevented the evaluation of the computerization of such processes, however, as indicators were impacted by multiple subprocesses, this strengthened the interpretation of indicators. The consortium validation of each step is a strength of this study: the validity of the overall process should be considered as strong.

These indicators will be integrated in the quality process of the Rouen LIS and RIS, and more generally in the Rouen computerized provider order entry and other involved applications of the HIS. Several other steps are already planned, in particular the extension of this quality process evaluation framework in other types of health facilities, eg: proprietary hospitals and nursing homes.

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