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Elderly Surgical Patients: Automated Computation of Healthcare Quality Indicators by Data Reuse of EHR

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Abstract. The objective of the work is to implement and evaluate the automated computation of 9 healthcare quality indicators, by data reuse of electronic health records, in the field of elderly surgical patients. Methods: Data are extracted from EHR, including administrative data, ICD10 diagnoses, laboratory results, procedures, administered drugs, and free-text letters. The indicators are implemented by a medical data reuse specialist. The conformity rate is automatically computed (3.5 minutes for 15,000 inpatient stays and 9 indicators). A medical expert reviews 45 stays per indicator. The precision is the proportion of non-conform inpatient stays among the cases detected as non-conform by the algorithms. Results: the paper describes the implemented algorithms, the conformity rates and the precisions. Two indicators have a precision of 0%, 3 indicators have a precision of 40 to 60%, and four indicators have a precision from 80 to 100% (for 2 of them, the conformity rate is lower than 2.5%!). This demonstrates that automated quality screening is possible and enables to detect threatening situations. The implementation of the indicators requires special skills in medicine, medical information sciences, and algorithmics. Failures of precision are mainly due to defaults of information quality (missing codes), and could benefit from text analysis.

Keywords. Quality Indicators, Process Assessment, Guideline Adherence, Data reuse, Electronic Health Records, Geriatrics

Introduction

The first step to improve the quality of care is to measure it by mean of quality indicators. Among them are process indicators, which measure the percentage of adherence to a guideline. They are widely used in healthcare. Contrary to input indicators, they are closer to patients' outcome [1]. Contrary to outcome indicators, they are not impacted by the initial severity of the patients [2–6], and are then easier to interpret [7,8]. Finally, they directly enable to identify areas of improvement [2,3].

In a previous work, a systematic literature review [9] was performed. It enabled to identify 8,744 papers, among which 126 papers described 440 process indicators. Some

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of those indicators (22.3%) could be automatically computed using a minimal dataset including diagnoses, drug administrations, medical procedures, administrative data, laboratory results, free-text reports with basic keyword research, linkage with the patient's previous stays, and dependence assessment.

The objective of this work is to implement and evaluate process indicators. To provide the reader with a consistent set of indicators, 9 indicators about surgery on elderly are selected from a unique scientific paper published by McGory et al. [10].

1. Methods

A database of 15,000 randomly-selected and de-identified inpatient hospital stays is extracted from a French community hospital. It notably contains administrative data (patient flow, age, gender, etc.), diagnoses (ICD10 codes without date), procedures (French CCAM codes with dates), administered drugs (ATC codes with dates, routes and doses), laboratory results (with dates, values and units), and free-text letters.

The indicators published by McGory et al. [10] are available as free-text. A physician, with a personal background of computer scientist, implements them as a set of PHP code in command line interpreter mode. Each indicator is defined as a function, composed of inclusion criteria, and conformity criteria. For each stay, the function returns "NA" if the stay is not included, "1" if the stay complies with the guideline, and "0" in other cases (Figure 1). The conformity rate is the average of the return values.

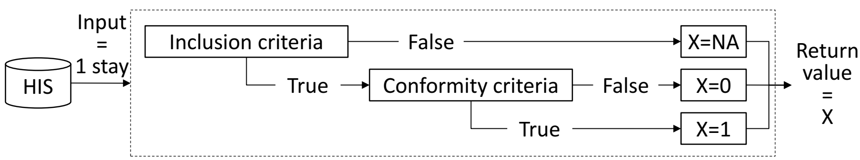

Figure 1. Each function is composed of inclusion criteria, and conformity criteria.

The implementation process takes into account the available data, and aims at increasing the precision of the detection of non-compliant cases. Over-alerting is decreased by relaxing the conformity criteria, or by tightening the inclusion criteria (respectively arrows (1) and (2) on Figure 2). The purpose is to identify fields requiring a priority intervention of a quality management team, without demotivating caregivers.

Finally, for each rule, an expert reviews randomly-selected cases: 15 excluded cases (but with interesting keywords in the discharge letter), 15 non-conform cases, and 15 conform cases (if possible). The expert reads completely the free-text documents.

Automated output \ Expert advice	Compliant	Not compl.	Excluded
Compliant	a	b	c
Not compl.	d (1)	e	f (2)
Excluded	g	h	i

Automated computation:

$$Conformity = \frac{a}{a+d}$$

Expert review (detection of non-compliance):

$$Precision = \frac{e}{d+e}$$

Figure 2. Contingency table of the automated output and the expert advice: conformity rate and precision.

2. Results

The total processing time is 3.5 minutes for 9 indicators and 15,000 inpatient stays using a personal computer. This section is composed of one subsection for each indicator. "*n*" denotes the number of included stays, "*conformity*" is the automatically computed conformity rate, and "*precision*" is the ability of the program to detect non-conform cases according to the experts. Important changes in criteria are commented, as well as the lack of precision. From this point, "*If (...)*" stands for "*If an elderly patient is undergoing surgery*". Original formulations of indicators are given in [10].

Indicator #01: creatinine clearance dosage

Formulation: If (…), then creatinine clearance should be estimated.

Inclusion criteria: [age≥75 & surgical stay & emergency admission]. As it is not possible to screen ambulatory laboratory exams in case of pre-planned admission, only emergency admissions are analysed.

Conformity criteria: [creatinine clearance or creatinine dosage before surgery]. We assumed some physicians were able to compute the creatinine clearance by hand from the creatinine dosage.

Results: n=238, conformity=86.6% [81.6-90.7], **precision=86.7%** [59.5-98.3]. Some dosages could be absent from databases but cited in the discharge letter.

Indicator #02: confusion

Formulation: If (…) and has a new diagnosis of delirium, then an evaluation should be undertaken for: infection, electrolyte abnormalities, hypoxia, uncontrolled pain, urinary retention or faecal impaction, use of sedative-hypnotic drugs.

Inclusion criteria: [age≥75 & surgical stay & ICD code (F05* | R410*)]. It was not possible to analyse the date of diagnosis.

Conformity criteria: [postoperative dosage of Na^+ & K^+ & Creat. & Uremia & Glycemia]. It was not possible to automatically detect whether the physicians had searched for other clinical factors or drugs administrations.

Results: n=8, conformity=75 % [34.9-96.8], **precision=0%.** Capillary blood glucose had been measured from patient bedside but not traced in the databases. In 2 cases there was a post-operative confusion, without ICD10 code.

Indicator #03: Beta-blockers

Formulation: If (…) and takes a beta blocker as an outpatient, then beta blocker therapy should be continued postoperatively.

Inclusion criteria: [age≥75 & surgical stay & ATC code C07* at d0 or d1 & no death]. The outpatient treatment was not available. The contraindications could not be traced using ICD10 codes. Dead patients were excluded.

Conformity criteria: [ATC code C07* administered from d2 to day prior discharge]

Results: n=18, conformity=27.8% [9.7-53.5], **precision=46.2%** [19.2-74.9]. All false positives were due to some missing ATC codes in the database.

Indicator #04: intravenous antibiotic prophylaxis (onset)

Formulation: If (…), then intravenous antibiotic prophylaxis should be started within 1h of skin incision.

Inclusion criteria: [age≥75 & surgical stay & no ICD code of (bacterial infection, unprecise infection, or open fracture)]. We excluded cases were an oral antibiotic treatment was already indicated.

Conformity criteria: [intravenous administration of antibiotic the day of surgery]

Results: n=607, conformity=2.4% [1.5-4.2], **precision=93.3%** [68.1-99.8]. All false positives were due to the absence of ICD10 codes despite an active infection, for which the oral antibiotic treatment was appropriate.

Indicator #05: oral antibiotic prophylaxis (continuation)
Formulation: If (…), intravenous antibiotic prophylaxis should be discontinued within 24h after surgery (48h for cardiac surgery).
Inclusion criteria: [age≥75 & surgical stay & no ICD code of (bacterial infection, unprecise infection, or open fracture)]. We excluded cases were an antibiotic treatment was necessary.
Conformity criteria: [no ATC code J01* at d3 of surgery]. The type of surgery was not taken into account, and a permissive delay was used.
Results: n=607, conformity=2.3% [1.3-3.9], **precision=93.3% [68.1-99.8].** All false positives were due to the absence of ICD10 codes despite an active infection.

Indicator #06: deep venous thrombosis prevention
Formulation: If (…), then deep venous thrombosis prophylaxis should be provided (unfractionated or low molecular weight heparin) or document why not appropriate. For cancer or previous thromboembolism, mechanical prophylaxis should be added.
Inclusion criteria: [age≥75 & surgical stay & CCAM code of (major surgery of lower limbs | major digestive surgery) & no ICD10 code of heparin contra-indication]. It was not possible to trace mechanical prophylaxis. Therefore, we traced heparin administration, only for high risk surgeries. We searched for contra-indication.
Conformity criteria: [ATC code B01AB*]
Results: n=314, conformity=70.0% [65.6-76.0], **precision=53.3% [26.6-78.7].** False positives are mainly due to the inclusion of non-surgical inpatient stays.

Indicator #07: anemia treatment
Formulation: If (…) and has anemia, then the following should be set up prior to surgery: iron, vitamin C, erythropoietin, blood transfusion if hemoglobin < 7 g/dl.
Inclusion criteria: [age≥75 & surgical stay & hemoglobin value<10]. The threshold was not specified. The severity of anemia is handled in indicator #08.
Conformity criteria: [ATC code B03A* or B05AX01 | ICD10 code Z5130 | transfusion]
Results: n=217, conformity=60.4% [53.5-66.9], **precision=86.7% [59.5-98.3].** False positives are due to the absence of administered drugs from the databases.

Indicator #08: anemia transfusion
Formulation: If (…), unless otherwise contraindicated or refused by the patient, then he/she should receive blood transfusion at the following hemoglobin/hematocrit threshold: 8/24 (man), 7/21 (woman).
Inclusion criteria: [age≥75 & surgical stay & ((man & (hemoglobin<8 | hematocrit<24)) | (woman & (hemoglobin<7 | hematocrit<21)))]
Conformity criteria: [ATC code B05AX01 | ICD10 code Z5130 | CCAM transfusion]
Results: n=19, conformity=73.7% [48.8-90.9], **precision=60.0% [14.7-94.7].** False positives are mainly due to the absence of transfusion encoding.

Indicator #09: postoperative fever
Formulation: If (…) and has a new fever, the following should be performed: urinalysis and urine culture, wound examination, blood cultures of central venous line or catheter, chest radiograph, blood culture.

Inclusion criteria: [age≥75 & surgical stay & ICD10 code (R50* | R65*)]. Note that if the etiology of a fever is found, then it is encoded and the fever is not encoded.

Conformity criteria: [CCAM code of chest radiograph]. Clinical exams and some laboratory exams were not available.

Results: n=4, conformity=75% [19.4-99.4], **precision=0.0%.** The inflammatory syndrome was present before the surgery (no precise date).

3. Discussion

The automated computation of process quality indicators is feasible, and enables to quickly identify threatening situations due to failures in guideline adherence. However, even indicators that have been published require a medical interpretation of free-text, and deep modifications of their algorithms. Those modifications, as well as the implementation, require special skills in medicine, medical information sciences, and algorithmics in the same time. To our knowledge, rule management systems would bring no help for that important and expert-based task. In addition, the algorithms are complex, polymorphic and would however require hard code writing.

However, some indicators suffer from problems in data quality, such as missing codes. Their lack of precision could be improved by free-text analysis. If such indicators are deployed, their precision should be re-evaluated in each new setting, because quality failures may be hospital-dependent. Finally, those indicators could be used to identify clinical cases to support morbidity and mortality reviews.

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