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Process assessment by automated computation of healthcare quality indicators in hospital electronic health records: a systematic review of indicators

Emmanuel CHAZARD[a,1], Djaber BABAOUSMAIL[a], Aurélien SCHAFFAR[b], Grégoire FICHEUR[a], Régis BEUSCART[a]
[a] *Department of Public Health; UDSL EA 2694, University of Lille; Lille, France*
[b] *Department of Medical Information; St Philibert Hospital, GHICL; Lille, France*

Abstract. The objective of the work is to extract healthcare process quality indicators from the literature, and to evaluate which of them could be automatically computed using routinely collected data from electronic health records (EHRs). A minimal set of data commonly available in EHRs is first defined. The initial bibliographic query enables to identify 8,744 papers, among which 126 papers describe 440 process indicators. 22.3% of indicators can be automatically computed. The computation of the indicators mostly require diagnoses (99%), drug prescriptions (59%), medical procedures (48%), administrative data (30%), laboratory results (20%), free-text reports with basic keyword research (19%), linkage with the patient's previous stays (11%) and dependence assessment (3%). 77.7% of indicators cannot be automatically computed, mostly because they require a linkage with outpatient data (61%), structured data that are usually not available (43%), unstructured data (26%) or the trace of an information that was given to the patient (8%).

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

Introduction

Quality of care has a complex definition [1]. The Institute of Medicine defines it as "the degree to which health care services for individuals and populations increase the likelihood of desired outcomes and are consistent with current professional knowledge" [2]. The assessment of quality of care is a mandatory step in quality of care improvement. It can be supported by the use of quality indicators, which can sometimes be used to modulate hospital payment [3–5].

Indicators can be classified into 3 groups [6]. Input indicators measure the amount of resources consumed or healthcare. Their main drawback is that they do not reflect the outcome on patients' health [7]. At the opposite, output indicators reflect the results of the process. Their main drawback is that the outcome is mainly in relation with the

[1] Corresponding Author: Emmanuel Chazard, Public Health Department, CHRU Lille, 2 av Oscar Lambret, F-59000 Lille, France; E-mail: emmanuel.chazard@univ-lille2.fr

initial severity of the patients [8–12]: for this reason, they can hardly be interpreted [13,14]. Process indicators occupy a middle ground: they can notably evaluate the adherence to guidelines. They do not have the drawbacks of the previous ones, and immediately enable to identify areas of improvement [8,9]. Indeed, improving the processes is commonly described as the best way to improve outcomes [15].

Several qualities are expected from quality of care indicators [16,17]. Among the qualities defined by the Agency for Healthcare Research and Quality (AHRQ), this work attempts to address two important ones: the scientific soundness, which includes reliability and validity, and the feasibility, which includes the explicit specification of numerator and denominator, and data availability. Based on the above, our future project is to build a set of process indicators for quality of care evaluation in hospitals. We intend to use only indicators published in peer-reviewed journals (to address "reliability" and "validity") that could automatically be computed by reusing routinely collected data from hospital electronic health records (to address "explicit specification" and "data availability").

The objective of this work is to obtain such indicators by a literature review.

1. Methods

1.1. Systematic literature review

A systematic literature review is performed using the Pubmed database, using the following keywords: "Quality indicator(s)", "Process indicator(s)", "Quality of care AND indicator(s)", "Care quality AND indicator(s)", "Health care AND indicator(s)", "Healthcare AND indicator(s)", "Assessing AND quality of care". Only papers written in English and published between 01/01/2000 and 12/31/2012, and dealing with process indicators are retained. The title and abstract are read. If necessary, the full-text is then obtained through the web (Pubmed Central, Google Scholar, Google), or using the subscription of the Lille University, or by contacting personally the authors of the papers. The papers that contain at least one documented process indicator are kept. As the review only relies on international peer-reviewed papers, the scientific validity of the papers is not questioned.

1.2. Classification of the indicators

All the indicators described in the remaining papers are classified with respect to their medical specialty. They are then classified as implementable or not by a committee of 3 experts (the first 3 authors of this paper). This decision relies on the hypothesis that the following data are available in a hospital database. To our knowledge, they are a common core set of available data:

- Administrative data: dates of venue, entry and discharge mode, age, gender, and a patient identifier that enables to access previous inpatient stays,
- Diagnoses encoded in ICD10 [18], without precise date,
- Diagnostic and therapeutic procedures with a precise date,
- Dependence of the patient evaluated using the Activities of Daily Living,
- Administered drugs with name encoded in ATC [19], date, route and dose,

- Laboratory results with parameter name, date, result and unit (by convention those data may include the patient's weight),
- And free-text procedure reports and discharge letters, with a simple keyword research feature, but no advanced natural language processing available.

Non-implementable indicators are the ones that cannot be automatically implemented using routinely-collected EHR data. The reason is classified as follows:

- Missing outpatient data: the indicators requires to access data that might be available in another database. E.g. if a radiology exam has to be performed before a programmed surgery, searching for this exam in the hospital database only would lead to falsely decrease the compliance rate.
- Missing structured data: the indicator requires accessing a structured data which is usually not available when parts of the patient records are in paper form, e.g. patient's temperature, pain score, etc.
- Missing unstructured data: this refers to data that are usually expressed in free-text, e.g. the clinical severity of a disease.
- Information given to the patient: some indicators might require that information is systematically given to the patient (therapeutic alternatives, benefits and risks of a procedure, etc.). Such traces are not always available.

For the implementable indicators, the data that are required are documented.

2. Results

2.1. Systematic literature review

The keywords are present in the title or abstract of 8,744 papers. After reading of the title, the abstract and if necessary the full-text paper, 126 papers are selected.

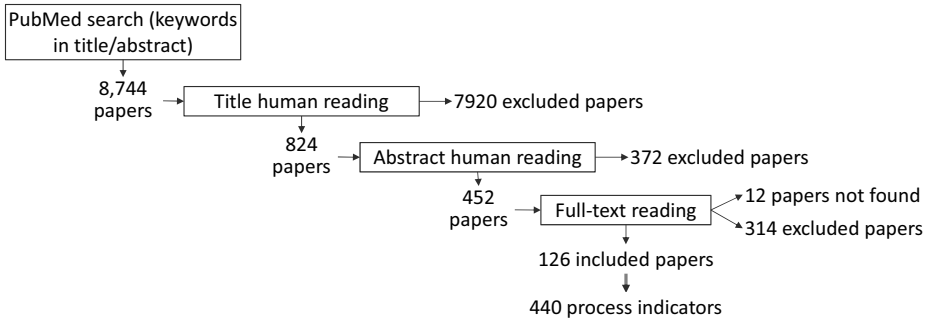

Figure 1. Process and quantitative results of the bibliographic research

2.2. Classification of the indicators

In total 440 process indicators are found in the selected papers, among which 98 (22%) are implementable for an automated computation in the EHR. The medical specialties with the highest numbers are oncology (n=135), geriatrics (n=105), rheumatology and internal medicine (n=77). Details are available in Table 1.

Table 1. Classification of the process indicators extracted from the scientific papers

Specialty	Domains	Total number of indicators	Implementable indicators
Cardiology	Angina, myocardial infarction	24	18 (75%)
Endocrinology	Diabetes	13	7 (54%)
Gastroenterology and Hepatology	Cirrhosis	5	4 (80%)
Geriatrics	Arthrosis, general, surgery	105	18 (17%)
Neurology	Dementia, Parkinson disease, stroke, transient ischemic attack	25	7 (28%)
Obstetrics	Pregnancy monitoring	2	0 (0%)
Oncology	Colon and rectum, esophagus, general, liver, lung, pancreas, prostate, skin, testicles	124	25 (20%)
Pediatrics	Sickle cell	38	6 (16%)
Psychiatry	General	9	0 (0%)
Pulmonology	Asthma, chronic obstructive pulmonary disease	13	4 (31%)
Rheumatology, internal medicine	Lupus, rheumatoid arthritis, sclerosis	77	8 (10%)
Traumatology	General	5	1 (20%)
TOTAL		**440**	**98 (22%)**

Most of the indicators (n=343, 77.7%) are classified as non-implementable for the following reasons (total greater than 100%):

- Missing outpatient data: 209 indicators (61.1%),
- Missing structured data: 147 indicators (43.0%),
- Missing unstructured data: 90 indicators (26.3%),
- And information given to the patient: 29 indicators (8.5%)

A substantial number of indicators (n=98, 22.3%) are classified as implementable. Those indicators require the following data (total greater than 100%):

- Diagnoses (without date): 97 indicators (99.0%),
- Drug prescriptions (with date): 58 indicators (59.2%),
- Medical procedures (with date): 47 indicators (48.0%),
- Basic administrative data: 29 indicators (29.6%),
- Laboratory results (with date): 20 indicators (20.4%),
- Free-text documents with basic keyword research: 19 indicators (19.4%),
- Ability to link the patient's previous stays: 11 indicators (11.2%),
- And dependence scale: 3 indicators (3.1%).

3. Discussion

In this study, a bibliographic research is performed to extract validated healthcare process indicators. From 126 selected papers, 440 indicators are selected, from which 98 (22%) could be computed fully automatically by reusing data that are commonly available in EHRs. This proportion is quite high considering the criterion used to define an "implementable" indicator. However, 61% of non-implementable indicators require a linkage with outpatient data, underlining the need for a more comprehensive analysis of quality of care. The next step of this work is to implement each of those 98 indicators as a precise algorithm, and to test them on a hospital database. This will require choosing a syntactic interoperability standard, and making some strong

interpretation choices, which will have to be discussed. Then, a review of randomly selected patient records will enable to validate the automated use of those indicators.

Such process indicators could be automatically computed in a few time using the historic database of a hospital, and then enable to measure quality of care and support quality improvement. We could then obtain a temporal trend immediately. As those indicators would rely on a simple common dataset, they would enable to compare medical units or hospitals together. Finally, statistical procedures would enable to discover risk factors of low guideline adherence.

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