INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS 80 (2011) 669–679

journal homepage: www.ijmijournal.com

A logic programming approach to medical errors in imaging

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ARTICLE INFO

Article history:
Received 15 March 2010
Received in revised form
17 June 2011
Accepted 17 June 2011

Keywords:
Medical error
Classification system
Medical imaging
Knowledge representation

ABSTRACT

Background: In 2000, the Institute of Medicine reported disturbing numbers on the scope it covers and the impact of medical error in the process of health delivery. Nevertheless, a solution to this problem may lie on the adoption of adverse event reporting and learning systems that can help to identify hazards and risks. It is crucial to apply models to identify the adverse events root causes, enhance the sharing of knowledge and experience. The efficiency of the efforts to improve patient safety has been frustratingly slow. Some of this insufficiency of progress may be assigned to the lack of systems that take into account the characteristic of the information about the real world. In our daily lives, we formulate most of our decisions normally based on incomplete, uncertain and even forbidden or contradictory information. One's knowledge is less based on exact facts and more on hypothesis, perceptions or indications.

Purpose: From the data collected on our adverse event treatment and learning system on medical imaging, and through the use of Extended Logic Programming to knowledge representation and reasoning, and the exploitation of new methodologies for problem solving, namely those based on the perception of what is an agent and/or multi-agent systems, we intend to generate reports that identify the most relevant causes of error and define improvement strategies, concluding about the impact, place of occurrence, form or type of event recorded in the healthcare institutions.

Results and conclusions: The Eindhoven Classification Model was extended and adapted to the medical imaging field and used to classify adverse events root causes. Extended Logic Programming was used for knowledge representation with defective information, allowing for the modelling of the universe of discourse in terms of data and knowledge default. A systematization of the evolution of the body of knowledge about Quality of Information embedded in the Root Cause Analysis was accomplished. An adverse event reporting and learning system was developed based on the presented approach to medical errors in imaging. This system was deployed in two Portuguese healthcare institutions, with an appealing outcome. The system enabled to verify that the majority of occurrences were concentrated in a few events that could be avoided. The developed system allowed automatic knowledge extraction, enabling report generation with strategies for the improvement of quality-of-care.

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doi:10.1016/j.ijmedinf.2011.06.005

1. Introduction

Currently, there is a growing awareness regarding the problem of medical error and how it affects both the service and the healthcare institution's quality or, in other words, the patient safety. According to a study undertaken by the European Commission in 2005 and published in the following year, about 78% of the inquired citizens classified medical errors as a major problem in their countries [1].

The Institute of Medicine's 2000 report, "To Err Is Human: Building a Safer Health System", focused attention sharply on medical error and patient safety. The conclusion that more people may die as a result of medical errors in hospitals than from injuries sustained in motor vehicle accidents is alarming. The report documented that medical errors cause between 44,000 and 98,000 deaths annually in the United States. In addition, medical errors result in annual costs of $17–$29 billion [2,3].

It is widely recognized that we may learn more from our mistakes than from our successes. However, there is an apparent failure of healthcare systems to learn from mistakes. Too often healthcare providers do not advise others when a mishap does occur, nor do they share what they have learnt. As a consequence, the same mistakes occur repeatedly and patients continue to be harmed by preventable errors. One solution to this problem is reporting. At least, reporting can help to identify hazards and risks, and to provide information on the aspects that should be improved [4].

The main purpose of reporting systems is learning from experience. However, it is important to note that only the registration of errors is not sufficient to ensure patient safety. It is the response to errors that leads to change. The accumulation of potentially relevant data in databases contributes little to the improvement of healthcare. A technical specialized analysis of the data is required to identify trends and patterns [4–6].

An error can be defined as the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim, and includes problems in practice, products, procedures, and systems [7].

It is important to note that classification systems work best when restricted to a specific medical field (e.g. medication errors, events of inadequate dialysis, transfusions) [4]. Although our approach has broad application in the medical field, we intended to focus the system on the adverse events happening in the medical imaging department. The medical imaging is a high-risk field for the occurrence of errors, especially due to the multiplicity of techniques, to the several stakeholders and to the complexity of the whole circuit that involves the conduct of studies. In modern Medicine, imaging studies play an important role in clinical practice. Most of the issues identified in studies on quality and safety in healthcare apply to Diagnostic Imaging. In the last two decades the greater sophistication and complexity of medical technology has led to an increase of errors. Communication, interpretation and perceptual errors, are some of the most common errors in medical diagnostic imaging that can lead to e.g., misdiagnosis, wrong-side examinations, wrong-name errors and delivering delay. The long learning curves of the new techniques, the inappropriate training, reliance on automated systems and confusing software features, are some of the relevant issues behind these problems [8,9].

In daily life, we make most of our decisions, if not all of them, based on incomplete, not precise, uncertain and even forbidden information. Knowledge is crucial to the problems of modern economy and society. In the scope of patient safety, medical error and adverse event reporting and learning systems there are several situations where information is insufficient or incomplete.

Unfortunately, most of information systems just ignore this characteristic of the information about the real world and build upon models where some idealisation expunges the inherent uncertainty [10]. The result is a system that never provides the expected answers, due to its inability to model the world. Instead, one should deal with the uncertainty in the model itself. Indeed, to implement useful information systems, namely knowledge based ones, it is necessary to represent and reason with defective information. Several approaches to the representation of imperfect knowledge may be found in literature. Many of them link logic with the theory of probabilities, combining Bayesian reasoning, Certainty Factors, Dempster-Shafer theory, Fuzzy Logic or non-standard logics [11–13].

The most effective way to prevent adverse events is to attack directly their causes [8]. It is common that one cause is also, somehow, a cause of various accidents. Preventing the adverse events' root causes improves significantly the patient safety [14]. Thus, our system focuses sharply on preventing the adverse events' root causes by applying a model that we've developed specifically for the medical imaging field. The model served as the formal foundation to our adverse event reporting and learning system, which is now deployed in two Portuguese healthcare institutions. The system makes possible to build on judgements about the impact, place of occurrence, type of form and type of event recorded in the healthcare institutions. It was possible to detect the adverse events that need immediate attention, identify its causes and generate recommendations to improvements.

In the next section, the classification system developed specifically for the medical imaging field and the clinical and theoretical concepts behind the system are presented. Based on the formal approach presented in this section, an adverse event reporting and learning system was developed. Section 3 presents the system, as well as the results obtained in the two Portuguese healthcare institutions where it was implemented. Finally, in the last section, conclusions are presented.

2. Methods

A medical version of the Eindhoven Classification Model (ECM) followed by the extensions and adaptations to the ECM for the medical imaging field and its causal tree that is used to classify the adverse events' root causes is presented. The theoretical foundation based on an extension to Logic Programming, in terms of a revision of its knowledge representation and reasoning system is described. By the introduction of explicit negation, leading to a process of on-the-fly quantification of the Quality of Information (QoI) of the predicates extensions