Ontology Based Organizational Risk Knowledge Creation Support Based on Incident Reports

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Abstract:--Medical workers are quite busy. Risk in the medical workplace is increasing. For those reasons, a framework that can encourage continuous refinement of medical systems, thereby avoiding serious accidents by identifying small risk indicators, must be built using information technology. According to Heinrich's Law, 29 minor injuries and 300 non-injury accidents are implied by a report of a major injury. Consequently, a major injury probably does not occur without a forerunner: it is preceded by minor accidents. We intend to build a framework that can contribute to quality refinement of medical treatments by supporting an organizational knowledge creation based on incident reports. This paper first describes incident-reporting-based organizational risk knowledge creation. Secondly, we overview our ontology-based system, which can guide the analytical processes of incident reports, and which can attach the semantic tags to facilitate semantic retrieval. Finally, we demonstrate our system using a simple scenario.

Key-Words: Incident report, Organizational knowledge, Ontology-based human-computer interaction

1 Introduction

Medical workers are busy. Medical risk is increasing. For those reasons, a framework must be built to encourage continual refinement of medical systems to prevent serious accidents by recording and assessing small risk factors. The system should be built from an information technology perspective.

Although we seek to build such a framework as IT researchers, it is difficult to achieve that goal because many individual factors affect medical situations: patients, nurses, environments, etc. Furthermore, context-dependent factors affect outcomes.

Figure 1 presents Heinrich's Law [1]: 29 minor injuries and 300 non-injury accidents are implied by the report of a single major injury. Based on that conjecture, a major injury probably does not occur without a forerunner: it occurs after many minor accidents. Consequently, we might refine medical treatment processes if we were able to revise medical systems by identifying small precursors of major accidents.

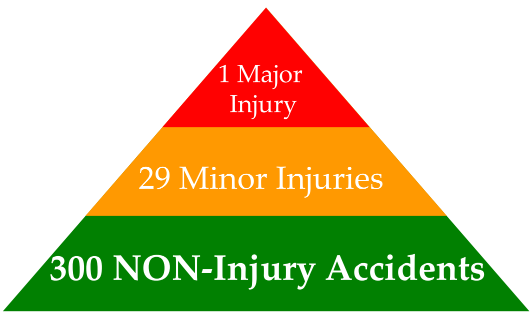

Figure 1: Heinrich's Law [1]

A terrifying experience or event of a mistake is called an incident case. Many efforts have been made to gather and share such information of such incident cases using incident reports. Our research goal is to build a support system of organizational knowledge creation based on the accumulated incident reports.

2 Incident Report Based Organizational Risk Knowledge Creation

The Japan Ministry of Health, Labour and Welfare website includes a database of incident reports to facilitate sharing of individual experiences as valuable resources for medical systems' continual refinement [2].

Advantages of using incident reports are several.

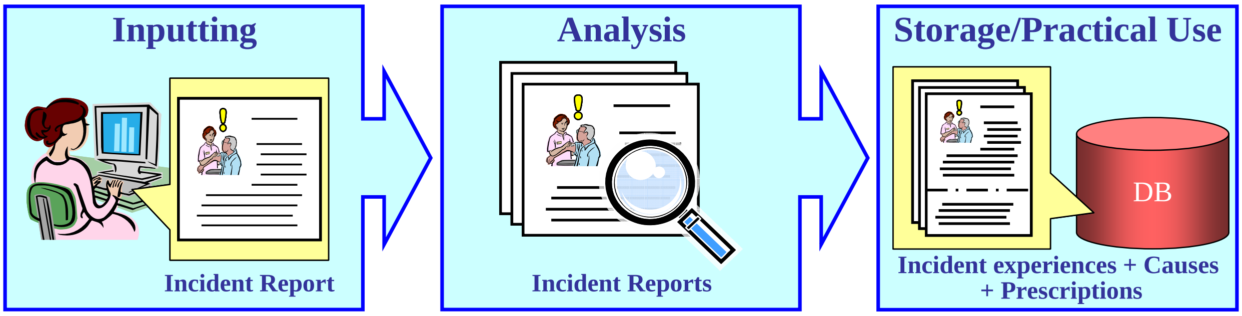

Figure 2: Flow of the Organizational Risk Knowledge Creation Processes

We can collect information about many incident experiences other than major injuries.

Duty of confidentiality pertains less because the incident experiences are not major injury accidents.

Furthermore, meaningful hints for preserving major injuries might be obtained.

Latent risk factors might be discerned through analyses.

We need to build a system that can support the organizational knowledge creation processes shown in Fig. 2 to yield the advantages described above. Time flows from left to right in the figure.

First, a medical worker inputs the incident experiences as incident reports. Then, colleagues simulate and share the experiences by reading the reports and analyzing them collaboratively with the reporter. Finally, they store the analyzed results related to causes and countermeasures with each incident report.

However, we can not say that the flow of input, analysis, and information sharing always form a positive loop: it is time-consuming work for a busy nurse to input incident experiences; it is difficult to maintain motivation without obtaining reasonable outcomes for the necessary efforts. It is also difficult for nurses to analyze collected incident reports because none is an error analysis expert.

Furthermore, data stored in the database cannot be used well for sharing individual experiences and for the refinement of medical systems if analyses can not be done well; even if the analysis can be done well, we cannot form a positive loop if no support exists to distribute adequate information to related persons.

The possibility of forming a negative loop exists, whereby no one inputs, analyzes, or refers, which would prevent organizational knowledge creation.

Therefore, to form a positive loop, we decided to develop a support system that can lighten the users' burdens of input, guide analytical processes, and store individual incident reports in a well organized way.

We particularly emphasize the subjects of adequate analysis and practical use of incident experiences.

For analyses, we intend to build a support system that can guide users' analysis processes by adopting Cognitive Reliability and Analysis Method (CREAM) [3] for the basis of the system. Proposed by Hollnagel, CREAM is a well-known model in the research area of human reliability analysis. It is a model for analyzing the reliability of humans' activities; it systemizes the knowledge acquired in the research area of cognitive psychology. A model characteristic is that, from various viewpoints and in a domain-independent way, it categorizes generic human errors, their causal relations, and the situations in which they occur. For example, categories are defined for "action at the wrong time," "action of the wrong type," "action in the wrong place," "observation," "interpretation," "planning," "equipment failure," "temporary person-related functions," "working conditions," etc.

Using the CREAM model as the theoretical foundation, we can accumulate medical-area-specific erroneous cognitive activities and errors.

For the practical use of incident experiences, we intend to develop a retrieval system that can use keyword and semantic structural matching techniques by referring to semantic tags that are attached during the analysis processes based on CREAM concepts.

3 Overview of the Ontology Based System

In this paper, we describe a support system based on CREAM from the organizational knowledge creation viewpoint (Fig. 3).

Figure 3 depicts two examples of incident reports: both are incident experiences of mistaking an incorrect object for a correct one. Figure 3(a) shows an error in which a druggist mistook "Topsim Spray L" for "Topsim Lotion." The error was caused by lack of unified abbreviation methods of two medicines: actually the doctor wrote only "Topsim l" for "Topsim Lotion" ("Topsim l" might also be short for "Topsim spray L"). Figure 3(b) shows a mistake by which a nurse mistook some "antibiotics" for "Inovan." This is caused by the cognitive overloading of the nurse: she had to perform too many tasks because of understaffing in the early morning.

The respective causes of those two incidents differ entirely, but both are related to similar mistakes.

We seek to build a support system that can clarify the semantic differences of the two incidents, even though both are related to similar mistakes, and which can provide principles of making prescriptions for medical system quality refinement.

Our system can clarify a cause of the incident experiences shown in Fig. 3(a) as "communication failure" and provide a principle of "unifying or standardizing abbreviation methods for confusing names" for medical safety. Furthermore, it can actively inform workers to prepare medicines using standardized briefing rules.

The system can clarify a cause, as shown in Fig. 3(b) as "cognitive overload" and provide a principle of "revising the medical system ("allocating more workers in the early morning" or "re-distribute tasks to times when many people work")."

Furthermore, it stores the incident case with semantic tags to realize semantic matching. Vocabulary defined in the erroneous cognitive activity ontology based on CREAM developed in [4] is used for the semantic tags.

For erroneous cognitive ontology, for instance, the concepts of "communication failure," "wrong identification," and so on are defined as candidate causes of the "wrong object." Furthermore, the concepts of "mislabeling", "missing information", and so on are defined as candidate causes of "wrong identification."

The error analysis activity ontology [4] guides the users' collaborative analysis processes of each incident report: it defines the concepts and their meanings in a machine-understandable way such as "information gathering activity," "identify causes of an error activity," and so on. Figure 4 shows an is-a hierarchy of the error analysis activity ontology.

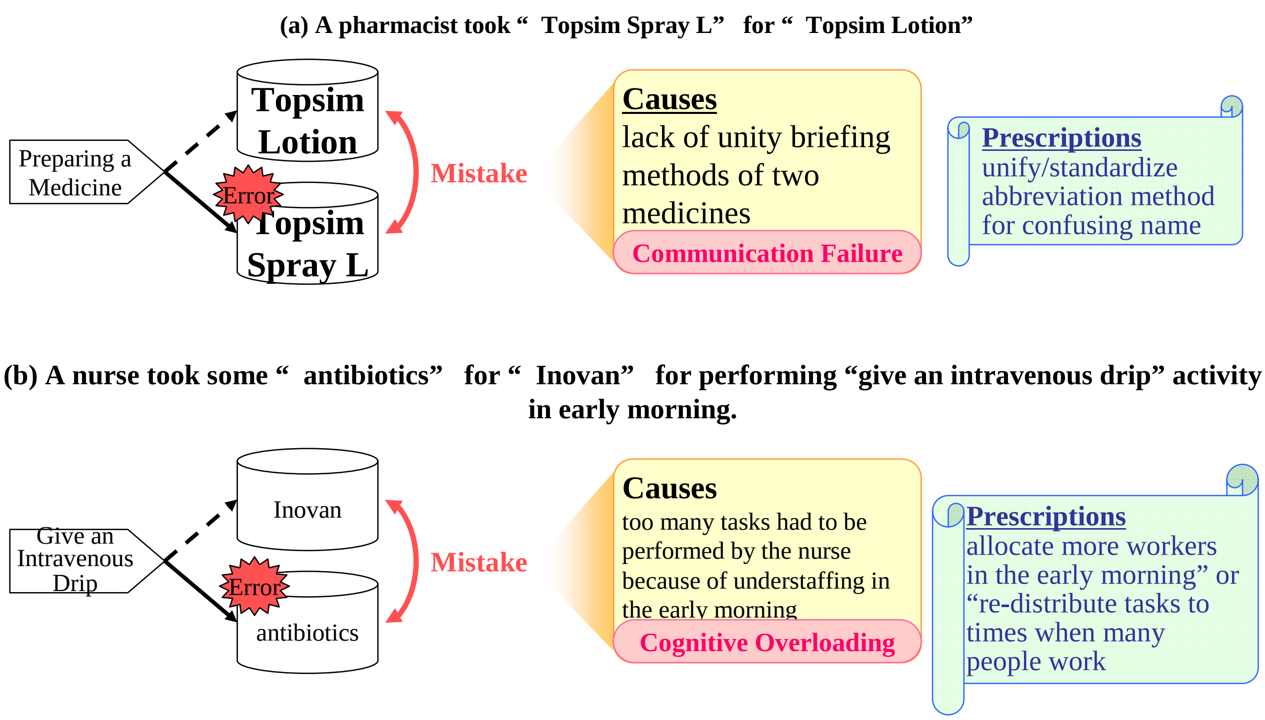

Figure 3: Two exemplary incident reports of mistakes

Reflective Activity

+ Activate
  + concerned with error
    + concerned with action at wrong time
    + concerned with action of wrong type
    + concerned with action at wrong object
  + concerned with action in wrong place
    + concerned with gaps between expectations and effects
    + concerned with gap of time
    + concerned with gap in method
    + concerned with gap in procedure
+ Observe
  + observe cognitive activities
    + observe active process
      + observe learning activities
      + observe problem-solving activities
    + observe the situation
      + observe knowledge state
      + observe environment state
      + observe condition
+ Identify
  + identify erroneous-cognitive activities
    + analyze error-mode
    + identify cause of error
+ Interpret
  + interpret effects of erroneous-cognitive activities
  + interpret by experience
    + grasp of cognitive characteristics
    + get lessons
+ Evaluate
  + evaluate erroneous-cognitive activities
+ Define task
  + define task to reconstruct errors
+ Formulate procedure
  + planning countermeasure
+ Execute
  + execute plan

\+ represents “is-a” relation

Figure 4: Is-a hierarchy of Error Analysis Activity Ontology (partial)

These two ontologies are domain-independent generic ones: they are useful for other domains, such as aviation, plant operation, and so on.

On the other hand, medical domain ontology and medical task ontology systematize medical field dependent concepts: they systematize concepts from the viewpoint of commonalities of medical meaning. In the medical domain ontology, for instance, the “8 a.m.” and “4 p.m.” time concepts are organized based on the common meaning of “shift change and briefing” times, although each is defined as its own time in the general domain ontology.

The medical task ontology systematizes medical-task-dependent activity concepts such as “preparing medication” and “giving an intravenous drip.”

Based on these ontologies, the system can guide collaborative analysis processes and attach semantic meta-data from the viewpoint of risk analysis behind the analysis processes. Therefore, users do not need to be conscious of tagging.

4 System Behavior – A Scenario –

In this section, we explain how the system works using a simple scenario described in the section above. Figure 5 presents an overview of human-computer interaction based on the ontologies.

When someone inputs an incident report (a mistake of “antibiotics” for “Inovan” for performing “give an intravenous drip” activity in early morning) into the system, the system first extracts keywords from the documents by referring to medical domain ontology and task ontology. In this case, keywords such as “early morning,” “intravenous drip,” “Inovan,” “antibiotics,” and “give an intravenous drip” are extracted based on the ontologies.

The concept of “early morning” defined in the medical domain ontology is connected to the domain-independent concept “cognitive overloading” defined in the erroneous cognitive activity ontology. Therefore, the system identifies it as a considerable priority candidate of causes.

In this example, the users can easily select “mistake” because it is the shallowest level cause, as explicitly written in the document. Therefore, the system and users can analyze deeper causes from the input erroneous cognitive activity of “mistake.”

The concept of “mistake” is connected to “wrong object.” Consequently, the system attaches the semantic tag of “wrong object” to the incident case.

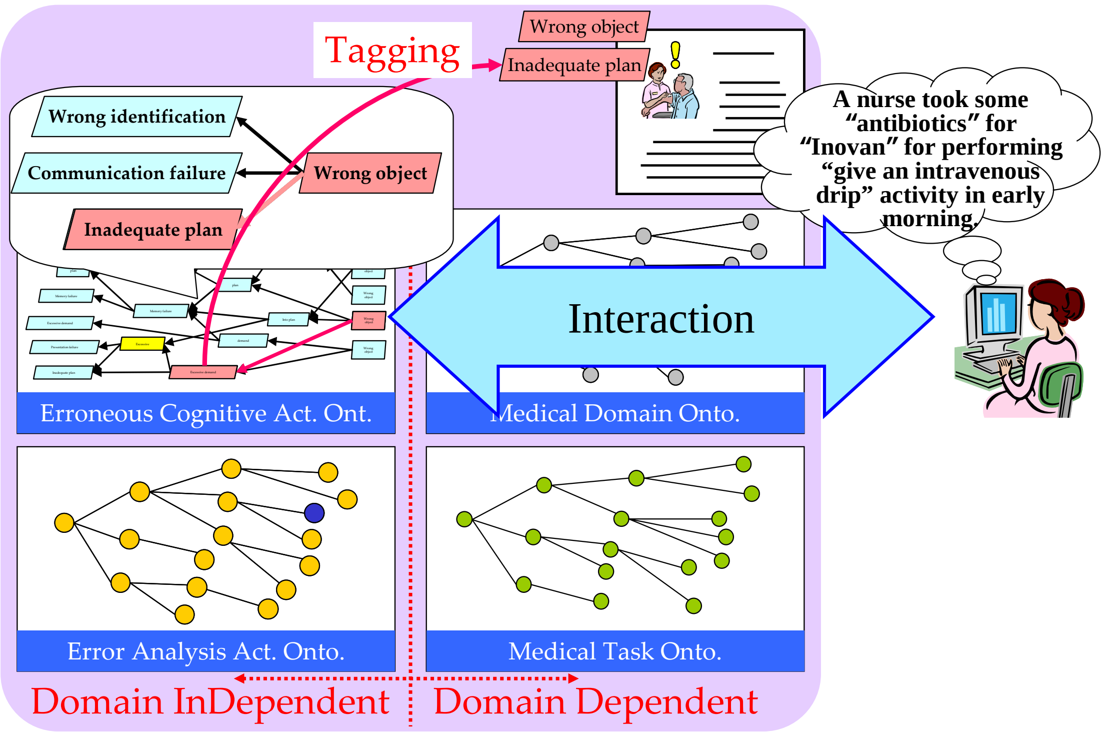

Figure 5: Overview of the Human-Computer Interaction Based on the Ontologies

Then, the system and users try to identify deeper causes: the system shows candidate causes such as "communication failure," "inadequate plan," "wrong identification," and so on using examples that are readily acceptable for nurses like "Is there some mislabeling of similar names" for choosing an "inadequate plan."

They need not select only one cause; they can select plural candidate. If they select "having a sense of urgency," then it is attached to the incident case.

By iterating these interactions, the system and users collaboratively identify the deeper causes and the system attaches the semantic tags simultaneously: the analytical processes and automatic tagging continues until they meet the terminal causes defined in the erroneous cognitive activity ontology.

Consequently, the system can store the individual incident report into the database with the semantic tags based on the domain-independent error concept; it can inform the incident cases to nurses who perform the activity of "giving an intravenous drip."

Furthermore, when we try to retrieve the incident cases of "mistake," for instance, we can ask using not only shallow level keywords of "mislabeling" but also semantic similarity matching.

The mechanism proposed herein can establish better support for creating and sharing organizational knowledge of risk management.

5 Concluding Remarks

This paper describes a framework that can contribute to quality refinement of medical treatment by supporting organizational knowledge creation based on incident reports. We first proposed the idea of an incident-report-based organizational risk knowledge creation framework to achieve the goal.

Then, we overviewed our ontology-based system, which can guide the analytical processes of the incident report and also attach semantic tags for semantic retrieval.

Salient advantages of this framework are: (i) the system and users can analyze deeper causes of an incident report collaboratively by interacting using human-friendly vocabulary that is readily acceptable for users based on medical domain-dependent ontologies; (ii) the system can guide analytical processes based on domain-independent ontologies systemized from the viewpoint of error analysis because domain-dependent and domain-independent ontologies are connected; and (iii) users can retrieve practically useful incident reports based on their semantic similarities because, during analytical processes, the system attaches semantic tags to an incident report based on domain-independent ontologies.

Acknowledgement

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