

# Fuzzy-Based Nosocomial Infection Control

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## Abstract:

## Introduction

Nosocomial, or hospital-acquired, infections (NIs) are by far the most common complications affecting hospitalized patients. Currently, 5 to 10 percent of patients admitted to acute care hospitals acquire one or more infections. These adverse events affect approximately 2 million patients each year in the United States, result in some 90,000 deaths, and add an estimated \$ 4.5 to \$ 5.7 billion per year to the cost of patient care [1].

The growing availability of computerized patient records in hospitals allows extended monitoring of the signs of NIs for the purpose of reducing NI rates by early initiation of appropriate therapy. In addition, ward- and institution-based surveillance data of NIs analyzed by infection control personnel are used as a basis to implement preventive measures.

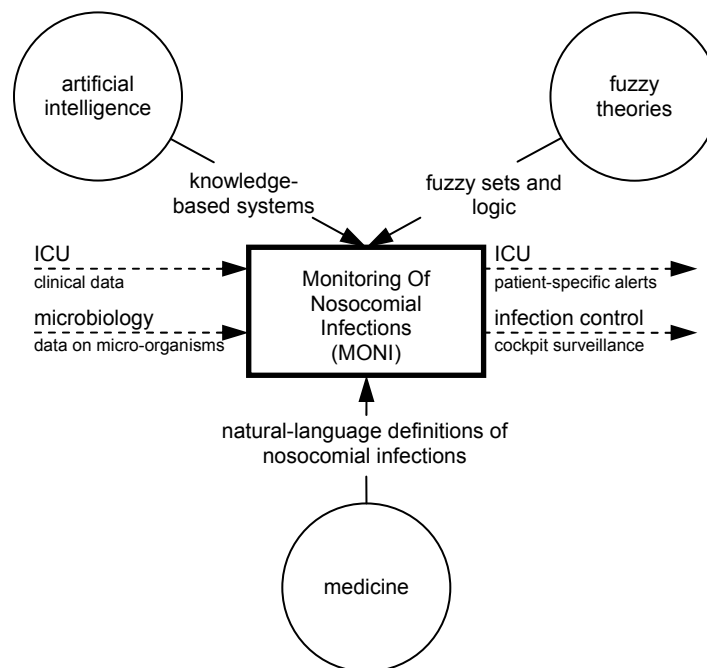


Fig. 1: Medical and formal areas that constitute the methodological basis of MONI.

## Methods

Based on the methodological and practical results obtained from the development and application of CADIAG-II/RHEUMA, a fuzzy-based differential diagnostic consultation system for rheumatology [2–5], the MONI system (cf., Fig. 1) was developed [6, 7]. MONI is a fuzzy- and knowledge-based system for the evaluation of definitions of NIs according to the European Surveillance System HELICS [8]. The definitions are derived from those issued by the Centers for Disease Control (CDC) in Atlanta [9, 10]. They are expressed as natural language text (see

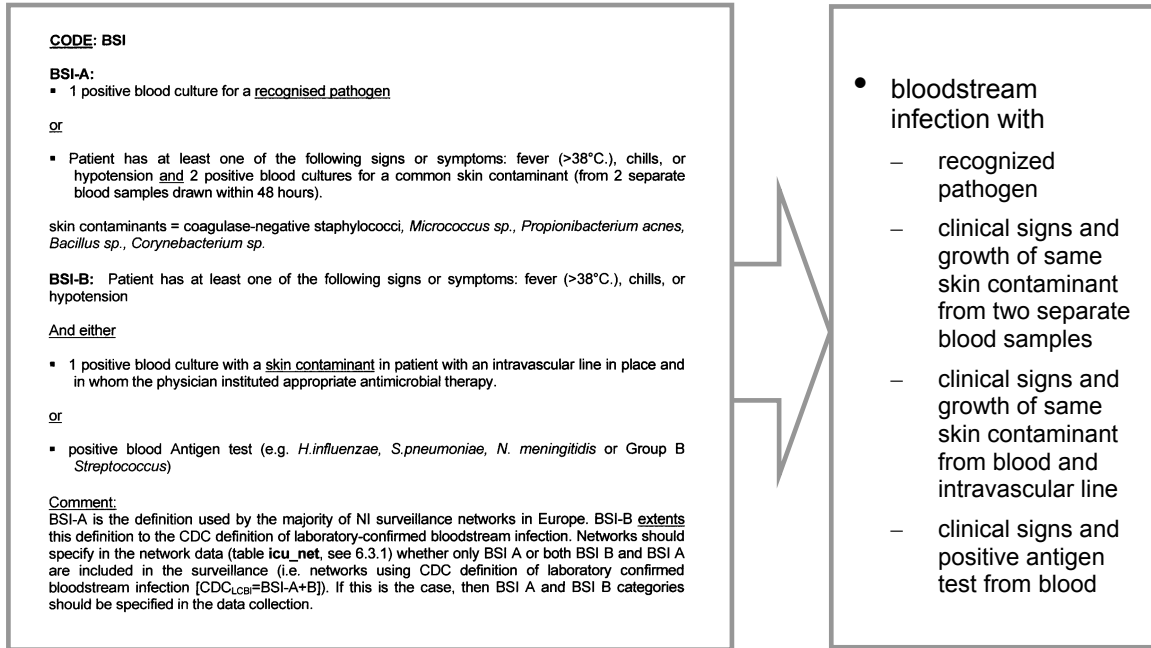


Fig. 2: Natural language definition for nosocomial bloodstream infections (BSIs; left part) from which four different entities of BSIs are derived (right part); excerpt from [8].

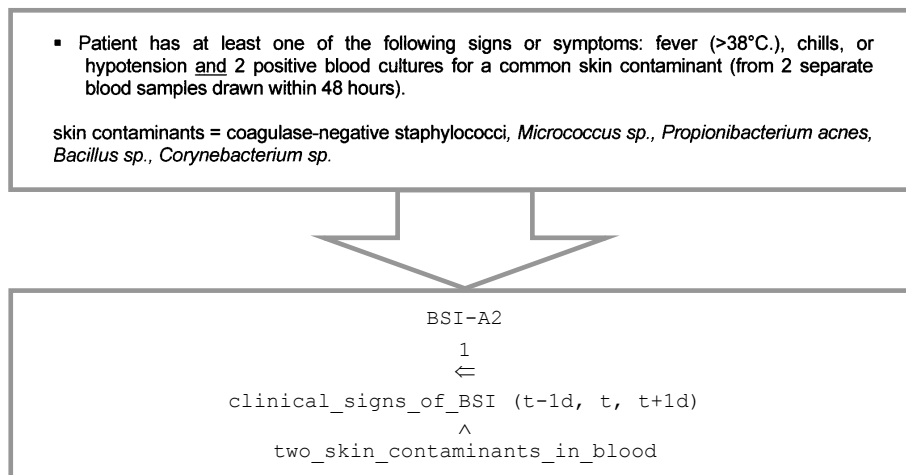


Fig. 3: Example of one BSI definition ( $\wedge$  denotes fuzzy logical and,  $\overset{1}{\leftarrow}$  denotes full implication if the premise on the right side is definitely fulfilled); each of the two conjuncts will be decomposed to less aggregated entities.

Fig. 2) and are analyzed and transferred into a fuzzy-rule-based representation with a step-wise decomposition of major medical concepts (such as “clinical signs of bloodstream infection”) to subconcepts (such as “CRP increased”) until data items from the patient records in the hospital can be mapped into these definitions (see Fig. 3, Fig. 4, and Fig. 5). MONI applies fuzzy sets to formally represent all medical entities such as symptoms, signs, interpreted laboratory test results (see Fig. 5), intermediate medical concepts, and diseases. Fuzzy logic, then, is the method of knowledge processing in MONI.

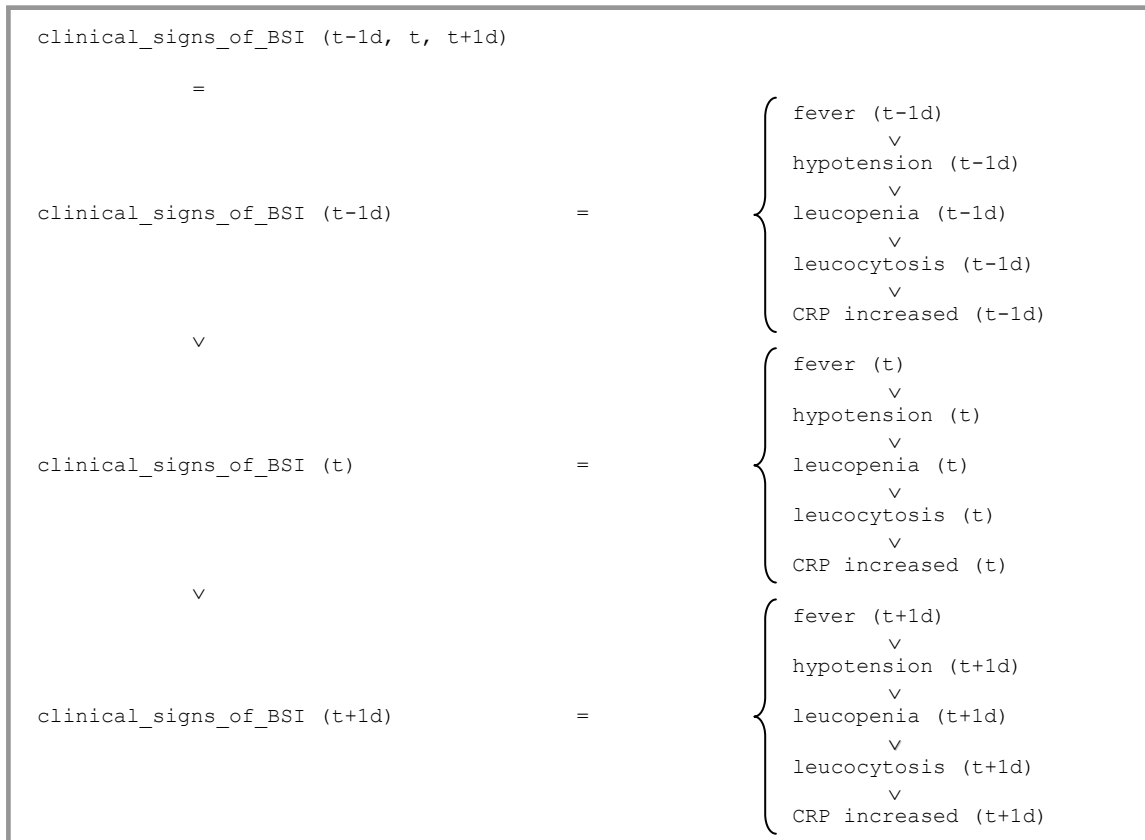


Fig. 4: Decomposition of the concept “clinical signs of BSI” ( $\vee$  denotes fuzzy logical OR; t-1d, t, and t+1d denote yesterday, today, and tomorrow, respectively).

## Results

MONI is operated in 12 adult intensive care units (ICUs) accommodating a total of up to 96 beds at the Vienna General Hospital, a 2,200-bed university hospital and the main teaching hospital of the Medical University of Vienna. It is fully integrated into the information technology (IT) landscape of the university hospital.

Twenty-four definitions of NIs were implemented in MONI. They cover bloodstream infections, ICU-acquired pneumonia, urinary tract infection, and central venous catheter-related infections.

At present, the system is being fine-tuned by physicians and infection control personnel. The preliminary results confirm the technical appropriateness of the system. The medical results are convincing, and a refined scientific study measuring the clinical correctness and potential impact on patient care and health care costs is under way.

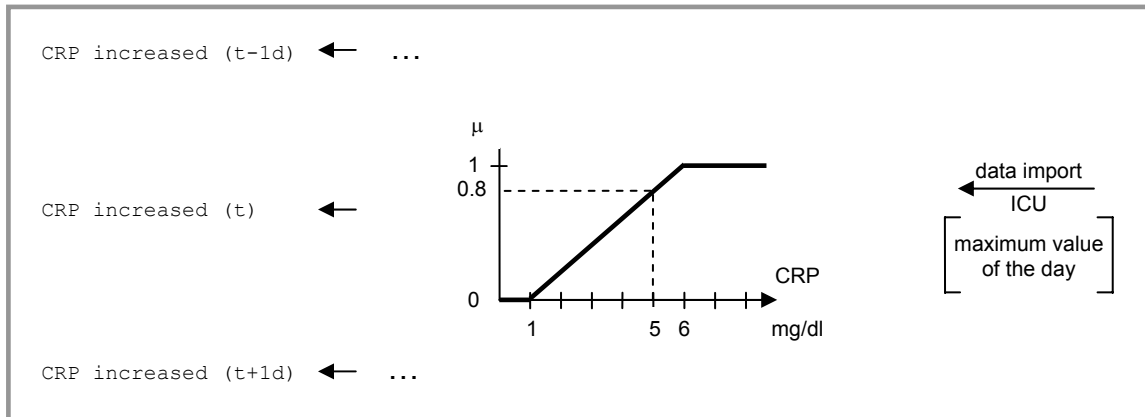


Fig. 5: Example of the definition of a fuzzy set; a measured CRP value of 5 mg/dl, for example, is compatible with the linguistic term “CRP increased” with a degree of 0.8, this degree of compatibility  $\mu$  is then propagated through the rule-based inference network of MONI via fuzzy logic.

## Conclusions

Medical knowledge is usually produced by human medical researchers for other human beings, who, as a rule, are practicing physicians. Natural language is used to document this knowledge, as is done with the definitions of nosocomial infections.

To automate and thus support the medical decision-making process, these texts have to be converted into a formal representation. The latter then allows application of this knowledge to medical data of specific patients through several layers of data abstraction. With the methodological framework of fuzzy theories, this is performed successfully and applied in extended clinical real-world settings.

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**Short Bio: Prof. Klaus-Peter Adlassnig**

Klaus-Peter Adlassnig received his MSc degree in computer science from the Technical University of Dresden, Germany, in 1974. In 1983, he obtained his PhD degree in computer sciences from the Technical University of Vienna, Austria, with a dissertation on “A Computer-Assisted Medical Diagnostic System Using Fuzzy Subsets”. Dr. Adlassnig was a postdoctoral research fellow with Professor Lotfi A. Zadeh at the Computer Science Division at the Department of Electrical Engineering and Computer Sciences of the University of California at Berkeley from 1984–86. Since 1988, he has been head of the Section on Medical Expert and Knowledge-

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Prof. Adlassnig was a visiting professor at the Department of Medicine, Section on Medical Informatics, at the Stanford University Medical Center in summer 1993, and a guest lecturer and professor at the Department of Electrical and Biomedical Engineering in the Technical University of Graz from 1994 to 2004. He spent the summer 2000 as a visiting scholar at the Department of Electrical Engineering and Computer Sciences, Computer Science Division, Berkeley Initiative in Soft Computing (BISC), University of California, Berkeley/U.S.A., and May 2005 as guest researcher at the Department of Computer Science, Meiji University, Kawasaki, Japan.

Since 2002, Prof. Adlassnig is the Editor-in-Chief of the International Journal “Artificial Intelligence in Medicine”, Elsevier Science Publishers B.V., and the founding director of the Ludwig Boltzmann Institute for Expert Systems and Quality Management in Medicine. He is the founder and present CEO of Medexter Computersysteme GmbH, a company established to broadly disseminate intelligent medical systems with clinically proven usefulness.

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