

# Towards a Framework for Untangling Complexity: The Interprofessional Decision-Making Model for the Complex Patient

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**Decision making for the complex patient is challenging for doctors because of increased complexity, such as multiple co-morbidities and interprofessionality for which evidence-based literature and guidelines are currently lacking. The consequent uncertainty causes vagueness, threatening patient safety and the quality of care. This article is motivated by the design science paradigm and describes the interprofessional decision-making model for the complex patient, namely, INDECO along with an example instantiation. Drawing on our experience in an intensive care unit of a tertiary hospital in Israel, the bi-dimensional view of this model includes the medical- and the interprofessional perspective. Retrospective assessment of 3 case studies of complex patients is used for assessing the usefulness of INDECO in decision making. The study reported here draws support from relevant literature, including the information science, information systems, and the medical domains. The findings resonate with emerging research developments focusing on healthcare decision making.**

## Introduction

The complex patient is a prominent phenomenon challenging hospital physicians in intensive care units as well as other hospital wards (Charlin et al., 2012; Durning et al., 2011; Schoen et al., 2011). The complex patient represents a spectrum of occurrences that may go wrong in a biological system, of which *severe illness and multiple co-morbidities* are an example. Advances in medical technologies, among other reasons, further extend the medical challenge to include ethical dilemmas, legal issues, and social implications, which together form the *interprofessional perspective* (Bærøe & Bringedal, 2011; Légaré et al., 2011a).

Although severe illness and multiple co-morbidities are seen with complex patients already in primary care (Grant & Ashburnr et al., 2011), subsequent complex, unprecedented events (Safford, Allison, & Kiefe, 2007; Weinberger & Tadmor, 2011) are typically encountered in intensive care units (ICU). These cases, which often require immediate response, are the focus of this research.

Healthcare decision making usually follows medical literature, including: domain specific evidence-based medicine (EBM), guidelines, checklists, and protocols to be implemented to improve decision making. These, however, are frequently insufficient for responding to complexity (Lundgrén-Laine et al., 2011; Rao, Mansingh, &

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Osei-Bryson, 2012). Consequently, ICU decision making is particularly distinguished by the spectrum of unprecedented events for which *no clear-cut solutions often exist for the multiplicity and complexity* of problems that arise in their management.

Against this background, studies have revealed that *uncertainty* was noted among physicians regardless of their competence (Angel, Sutton, Windridge, & Dixon-Woods, 2006; Durning, Artino, Pangaro, van der Vleuten, & Schuwirth, 2011; Fackler et al., 2009) or their reliability (Chassin & Loeb, 2011; Fernandez et al., 2012). Uncertainty (Hall, 2002) could prompt inconsistency (Angell et al., 2006; Asscher, Bolt, & Shermer, 2012; Dy & Purnell, 2012; Taylor, Kass, Ali, et al., 2011; Winters et al., 2009) and vagueness, distorting the decision-making process towards intuitiveness, which may incorporate bias (Hall, 2002). It has been acknowledged that organizations' handling of the unexpected could increase adaptability and support learning (Weick & Sutcliffe, 2001; Weick, Sutcliffe, & Obstfeld, 1999). Sense making is one way of dealing with uncertainty (Weick, Sutcliffe, & Obstfeld, 2005), provided critical contextualization information is offered as a way of enacting meaning (Zhang, 2013). However, the lack of actual support for sense making under uncertainty (Klein, Moon, & Hoffman, 2006) could jeopardize patient safety and the quality of care (Audétat et al., 2012; Brindley, 2010; Genuis, 2012; Wong, Levinson, & Shojania, 2012). The balance point between maintaining patient safety and jeopardizing the patient safety is found with physicians' sense making. Operating under uncertainty (i.e., lack of evidence-based literature and the ambiguity of patient data), decision-makers tend to either increase risk predominance or else decrease its significance because of the inverse relationship between solid evidence and risk-taking, as observed by Tversky and Kahneman (1992) in their notable contribution to prospect theory. Consequently, uncertainty can lead to biased presumption thus jeopardizing patient safety and the quality of care.

Recognizing the need to enhance physician decision making for the complex patient, this research seeks to answer the following research questions:

1. Which factors are most significant for decision making for the complex patient?
2. To what extent is the required content accessible through organizational information systems?
3. Which strategies are applied by physicians as part of critical reasoning?

Complexity is unpredictable and the need for untangling complexity as part of practice is real (Asher & Douglas, 2011; Chassin & Loeb, 2011; Schoen et al., 2011). Nevertheless, we have not encountered a decision-making model that is comprehensive enough, yet adaptable, for effectively supporting the spectrum of factors involved in decision making for the complex patient.

In this article we draw on our experience in a tertiary-care hospital to propose the interprofessional decision-making model for the complex patient, namely INDECO.

Following the introduction to the context of this research is a brief overview of decision making in the hospital setting. We then describe the research methods and the artifacts of the build process, before the discussion of a retrospective study, in which three case studies were used for assessing the prospective usefulness of this research. The article concludes with a discussion and conclusions indicating further research directions.

By studying the results in the context of the retrospective study, this article offers insights into the factors structuring the decision-making process, the contents accessible by hospital information systems and the associated shortages.

## Decision Making for the Complex Patient

Healthcare decision making can be seen as a generative dance between patient data, information, and evidence-based literature, and between physicians' critical reasoning as it is formed from previous experiences (Angell et al., 2006; Begun, Zimmerman, & Dooley, 2003; Durning et al., 2011; Fackler et al., 2009; Lundgrén-Laine, 2011) in the context of hospital guidelines and practiced information behavior (Ferran-Ferrer, Minguillón, & Pérez-Montoro, 2013).

Patient data and information are obtained from hospital laboratories, imaging, and hospital (sometimes also community) information systems. Physicians' critical reasoning, however, may be at risk of failing to balance expertise and uncertainty (Asher & Douglas, 2011; Wegwarth, Gaissmaier, & Gigrenzer, 2009; Weinberger & Tadmor, 2011) because of the difference between data objectivity and the subjectivity of sense making (Durning et al., 2011; Garvin, 1993; Genius, 2012).

Objective data are obtained from a spectrum of resources, of which Decision Support Systems (DSS) are a major example for the integration of evidence-based literature and its assimilation at the point of care (Finnegan & Hamid, 2009; Kohli & Piontek, 2010). DSS assist medical staff in making informed clinical decisions based on prevailing standards, guidelines, and best practice data, yet lack the adaptive ability to respond to unprecedented events (Hall, 2002; Kohli & Piontek, 2010; Schoen, 2011). Unprecedented events are characterized by instances of multiple co-morbidities as well as the interprofessional perspective (Finnegan & Hamid, 2009). Usually, the data required for establishing medical evidence would be lacking for these.

At present, a preliminary attempt has been made at the identification of ICU decision-making categories (Lundgrén-Laine et al., 2011). These include measures used for identifying adverse events (Classen et al., 2011), scoring systems for the critically ill (Vincent & Moreno, 2010), and guidelines as recently crystallized for physician-patient communication for the end of life (Kryworuchko, Dawn, Peterson, Heyland, & Graham, 2011).

Yet another shortage pertains to decision models. A physician's skilled decision making is much dependent on the provision of a structural approach to critical reasoning (Charlin, 2012; Durning et al., 2011; Luu et al., 2012). A

series of publications discussed the occurrence of situations challenging physician decision making because of increasing degrees of uncertainty (Chassin & Loeb, 2011; Hall, 2002). The consequent appeal to physician heuristics and intuitiveness might threaten consistency, introducing bias and misconception, while jeopardizing patient safety and the quality of care.

The increasing number of complex patients, together with the lack of evidence-based literature covering many aspects of their care, indicates that an innovative approach is required for providing medical care without harming individuals (Bærøe & Bringedal, 2011), without impairing group performance or otherwise misusing economic resources (Perez, d'Empaire, & Kajdacsy-Balla Amaral, 2012).

It has been argued that complexity, as a trigger for intuitiveness, makes any attempt towards a methodological approach redundant (Chassin & Loeb, 2011). However, lessons learnt from quality assurance studies (Asher & Douglas, 2011) indicate otherwise. Having the potential for using decision aids maintains intuitiveness, while negating uncertainty's predominance (Guadagnoli, Morin, & Dubrowski, 2012; Weick et al., 2005; Winters, 2009). Responding to this challenge requires adherence to engineering methods (Allen, 2011; Brindley, 2010) capable of facilitating change in healthcare systems.

For the design artifact to be effective, this endeavor should be attentive to collaboration practices (Adler, Baets, & Koning, 2011; Baloh, Desouza, & Hackney, 2012; Dy & Purnell, 2012; Kolfshoten, Niederman, Briggs, & De Vreede, 2012; Perez et al., 2012), which are fundamental to the decision-making process.

## Research Approach and Methods

### *Design Science Paradigm*

The design science paradigm and behavioral science are two distinct yet complementary research paradigms (Hevner, 2007; Hevner, March, Park, & Ram, 2004). From a design science perspective there are two design processes and four design artifacts. The processes are: *build* and *evaluate* (March & Smith, 1995), and the artifacts are: *constructs*, *models*, *methods*, and *instantiations*.

Of the research activities outlined in this framework, this research attends to build (i.e., this research is limited to the build of a conceptual model rather than an information technology [IT] artifact) and evaluate, an artifact, using also techniques mentioned by (March & Smith, 1995). This research concerns and relates to a model (INDECO) that informs a method for the assessment of complex patient case studies. A retrospective study was conducted for assessing the prospective usefulness of this model based on three case studies of complex patients. This guides the development of instantiations of the model.

### *Research Methods*

The research approach taken here is *multidisciplinary*, applying methods of the information systems (IS) design

science paradigm (Hevner, 2007; Hevner et al., 2004; March & Smith, 1995), for the investigation of medical phenomena. Striving to balance rigor and relevance (Davenport & Markus, 1999), the application of the design science principles is motivated by the case study research method (Yin, 2002).

The setting for this research was a tertiary care, university-affiliated hospital in Israel. In this research, the development of the proposed model involved five senior doctors from the general ICU and a senior representative of the hospital management. The ICU comprises 18 beds, with a turnover of 450 patients per year.

The participants in this study were chosen because of their frequent encounters with and continuous responsibility for patients whose management was found to provoke uncertainty and debate, while also attracting interprofessional involvement beyond the medical perspective. Additional physicians were recruited based on the snowball method either directly, based on their exposure to the ongoing study in their department (the ICU), or following a seminar to which physicians of various wards were invited. For the model validation, the interviews conducted for this research included senior physicians from the cardiothoracic ICU, emergency medicine department, and representatives of senior management.

### *The Case-Study Approach*

For the empirical investigation, this research follows the case-study approach defined by Yin (2002, p. 13) as “an empirical inquiry that investigates a contemporary phenomenon within its real life context.”

Furthermore, three guidelines are applied to its implementation. First is the heterogeneity in the selection of the cases (Hevner et al., 2004; Mingers & Brocklesby, 1997). Complex patient case studies were selected that differ by decision question and by subject procedure. Three patients with different backgrounds, circumstances, and context were selected. In this way, we ensured that the patients' cases differed in terms of the subject dilemma from the clinical and the interprofessional perspectives (Mingers & Brocklesby, 1997).

The second guideline recommends the use of a logical format, which we use consistently in all cases (Table 3). Third, we use two evaluation methods: a comparative method and a qualitative one. For the interpretive perspective, we used multiple sources of information, primarily from interviews, to direct the investigation process while making the research more relevant to practice. The description of the three case studies is consistent by following the model decision factors. For each case study, We describe the specific resources, or lack thereof, that factored into the decision-making process. The discussion of the evaluation of each case study is arranged accordingly, by the six decision factors. A summary of the results is shown in Table 3.

## The INDECO Construction

### *Designing the Model*

Following the description of the *analysis* and *conceptualization*, which is focused on knowledge acquisition and classification, *modelling* activities are described, preceding the retrospective *evaluation*.

### *Analysis and Conceptualization*

For the analysis, a two-faceted approach was taken in which the theoretical investigation of prevailing practices (Fackler et al., 2009; Valerio & Ricciardi, 2011; Wegwarth, Gaissmaier, & Gigrenzer, 2009; Whitehead, 2007) complemented the empirical study to establish the ontological view of complexity as we see it (Fonseca, 2007).

Ontologies are effective in formalizing problems to create a coherent domain model (Almeida, 2013, Gruber, 1995). Ontology developers aim at balancing the ontological cognitive and methodological aspects—the knowledge of the domain and its semantics (McGuinness, 2002). Usually this entails also a certain world view of the ontology developers (Fridman Noy & McGuinness, 2001). In information science (Fonseca, 2007), as in healthcare informatics, ontology development is a means of reaching beyond content and task towards the inclusion of the social, historical, and organizational context as well (Kuziemytsky et al., 2009).

A review of the literature preceded the empirical investigation. Motivated by the ontological approach (Fridman Noy & McGuinness, 2001), a search was conducted of the medical ethics, critical care, and healthcare education literature, and of the decision making, information science, and the information systems literature. This included the following issues: complexity, complex patient and decision making, as well as clinical reasoning knowledge management and organizational memory.

The empirical investigation was conducted in the hospital in the form of a *retrospective* cohort case study (Eisenhardt, 1989; Mann, 2003). Two knowledge acquisition *techniques* were used: a review of hospital information systems and semi-constructed interviews. Organizational information systems were investigated to structure the discussion of the availability and completeness of data and knowledge (Weinberger, Te'eni, & Frank, 2008).

IT is usually used to assess performance in professional practices of which an example is healthcare (Urquhart et al., 2003). Documentation and retrieval conventions were investigated through the study of electronic patient records (EPR) and the ICU designated information system. Interviews were conducted over a period of 8 months for the analysis of complex patient case studies. The interviews were semi-structured and in-depth, using the critical incident technique (CIT) (FitzGerald, Seale, Kerins, & McElvaney, 2008). The questions guiding the semi-structured interviews were designed to assist physicians in reflecting on past events and

structured in light of the physicians' descriptions of their role (Chassin & Loeb, 2011).

Conceptualization follows knowledge acquisition of the analysis phase, as a means for the crystallization of previously identified concepts (Galster, 2013). These were extracted from the investigation of example cases, based on the interviews conducted with participating physicians, and also were tested against the findings of the theoretical investigation.

The consequent decision-making model consists of six factors that were constantly required as part of the decision-making process. These are: (a) patient data and hospital information systems; (b) primary physician, case manager, and common sense; (c) patient and family (wishes, consent, and information); (d) medical literature: evidence-based medicine, hospital guidelines, rules and regulations; (e) medical technology; and (f), decision models (consultation and reasoning models). The inclusion of business process elements alongside decision partners and decision elements which are at times neglected constitute the upper-level ontology of the decision-making process for the complex patient enables the efficient applicability of the resulting design process (Rao et al., 2012). Deliverables for this stage included the initial conceptualization of the complex patient definition, and the identification of the decision-making factors.

### *Modelling*

Modelling means the representation of design notions to reshape business processes (Rao et al., 2012). Modelling and associated deliverables pave the way for understanding adaptation challenges and guiding further research. An example is creating the articulated representation of decision factors to guide action. First, this could be in the form of a checklist guiding decision making, as suggested here. Based on this checklist, further decision-making tools could be developed.

Aiming for the design to maintain relevancy to practice necessitated the valuation and adaptation of modelling conventions towards the representation of a concise model. Two instances of modelling challenges are discussed here.

First is the representation of the idea of common sense. Although common sense might represent an attribute assigned to an entity of which a physician is an example, this notion was not useful in the present case. Rather, common sense indicates an abstract entity. There are several reasons for this. Common sense builds on physicians' qualifications, such as accountability and reliability (Chassin & Loeb, 2011). These, in turn, include the unbiased use of a spectrum of EBM. Furthermore, common sense entails the enhancement of clinical encounters (Mansingh, Osei-Bryson, & Reichgelt, 2011; Towle et al., 2010) towards the unified perspectives. The unified view is vital to physicians' perception of patient safety and the quality of care (Mansingh et al., 2011; Towle et al., 2010).

Second is the introduction of the case manager. Although several doctors are indeed collaborating as part of decision making, a balancing voice is required. Nevertheless, the case manager is not an instance of doctor, nor is it an attribute or a method assigned to one.

Yet another important factor in the modeling of this notion is in attending for the need to compensate for the sometimes implicit expression of decision-making values (Fackler et al., 2009). Current practice, adhering to the unified view of the medical and the interprofessional perspective (Stacey et al., 2010; Towle et al., 2010) implies the use of values and norms as part of the decision partners' communication. This further implies the need for a thorough investigation of decision-making values and norms.

In this research, this need was recognized and a measured approach taken. Nevertheless, to establish the complete ontological view of these, further investigation is required that is beyond the scope of this research. All in all, modeling in this research is motivated by the need for maintaining rigor and relevance.

### The Interprofessional Decision-Making Model for the Complex Patient

In this section, we introduce the six factors of the decision-making model for the complex patient, following the definition of the complex patient and preceding the discussion of the instantiation model.

#### *The Definition of the Complex Patient*

The definition of the complex patient is derived from a study of the literature, while also reflecting findings from empirical investigation. The identification of the complex patient is crucial for case management and for the design of decision-making tools. Examples are checklists, guidelines, and protocols, as a means of maintaining communication and collaboration (Guadagnoli, Morin, & Dubrowski, 2012; Olthuis, Leget, & Grypdonck, 2012; Winters et al., 2009).

Recent clinical experience provided a spectrum of diversified examples of complex patients challenging physician decision making. Légaré and colleagues (Légaré et al., 2011a), among others (Grant, 2011), investigated complexity from the primary care point of view, whereas others (Kuziemyk et al., 2009; Légaré et al., 2010; Lundgrén-Laine et al., 2011) studied shared, virtual, and ad hoc decision making. Relating to major patient specifications and associated activities we follow these endeavors.

Analyzed in the context of the empirical investigation, the findings of the theoretical study informed the conceptualization of the complex patient. These include the following:

1. Severe illness has been identified.
2. Multiple co-morbidities (Safford, Allison, & Kiefe, 2007) exist.

3. There is no evidence for clear-cut solutions for the multiplicity and complexity of problems that arise in their management (Grant et al., 2011).
4. The decision making may involve considerations of the interprofessional perspective.
5. Decision paths, which sometimes call for immediate response, trigger critical consequences for both the medical perspective and either one or all of the ethical, legal, and social perspectives.

Specifically, the fifth factor was established from our experience in the ICU, in view of the spectrum of constraints of which risks and time are an example.

#### *Decision Factors of the Interprofessional Decision-Making Model for the Complex Patient*

There are six factors in this model, representing the contents, tasks, and agents of the decision-making process. The description of these factors and their role herein are shown in Table 1. (Figure 1)

First, organizational information systems are investigated to establish the patient's medical record. At times, additional

TABLE 1. INDECO factors & associated activities.

Model factor	Description
Data	Data obtained from organizational information systems, which includes: EPR; results of laboratory, imaging, and pathology investigations; patient records; monitoring and computerized systems. Additionally, patient information may be obtained from affiliated, community-based organizations.
Primary physician, case manager & common sense	The ongoing utilization of a physician's experience, accountability, heuristics, moral views and expertise to assure the patient's well-being. The application of common sense, albeit expected of each expert, is specifically attributed to two roles: the primary physician and case manager, who each in his own time take responsibility for the patient.
Patient and family: wish, consent, information	Knowledge regarding the wish of the patient, directly or via the family or primary physician; patient consent; facilitating and ensuring patient and family understanding of the situation, ideally in consultation with the primary physician.
Medical literature: evidence-based literature, guidelines, rules, regulations & opinions	Exhaustive and comprehensive investigation of the medical literature from evidence-based medicine to systematic reviews, randomized controlled studies, case reports and previous clinical experience; while guidelines, rules, and regulations are investigated from the medical and interprofessional perspectives.
Medical technology: facilities, medicines & experts.	Assessing the options and feasibility of medical technology—facilities, medications and experts. The optional consultation of domain experts beyond the hospital's personnel (i.e., second opinion).
Decision models	Consulting domain-specific decision models and applying reasoning models in context.

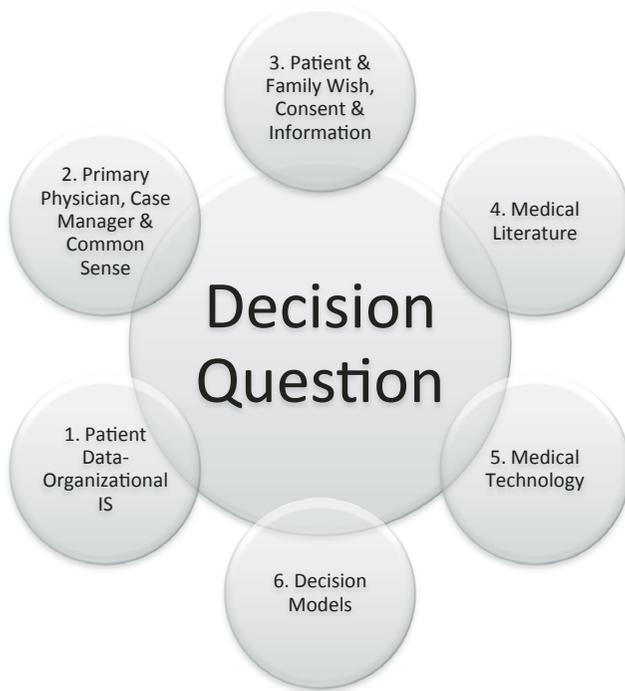


FIG. 1. The interprofessional decision-making model for the complex patient.

effort will be required for consulting affiliated organizations. For this end, effective communication between the primary physician and the case manager, as indicated in the second decision factor, is a way of extending the organizational memory (Weinberger et al., 2008) to include not only the medical, but also the interprofessional perspective (Thistlethwaite, 2012; Whitehead, 2007). The engineering mechanism for this end would be creativity as part of sense making (i.e., mentioned in the second decision factor).

Responding to the challenges imposed by complexity requires skilled sense making and advanced critical reasoning proficiencies (Charlin, 2012; Eva, 2005; Kreiter & Bergus, 2009). Common sense (Genuis, 2012; Weick et al., 2005) is used as a knowledge engineering method (Asher & Douglas, 2011) for simultaneously practicing strategic and tactical thinking (Fackler et al., 2009) and steering leadership throughout the decision-making process.

Patient and family are considered in the third decision factor. The interaction between the patient, the patient's family, and the physician is one where they all must understand what is desired, where consent must be acquired, and information exchanged. The patient or the patient's family need to understand the medical situation and express (or object to) consent and wishes accordingly.

Decision making is best reached using the *medical literature*, which is represented in the fourth factor. Medical literature is accessed to establish diagnosis and to establish adequate evidence for (or against) proposed interventions. The role of medical literature is to establish consistency,

TABLE 2. INDECO factors in context.

Example case	Model element
<i>A patient with cancer is admitted with severe pneumonia. Uncertainty regarding the type of cancer, responsiveness to therapy and stage of disease in order to make an informed management decision.</i>	Data
<i>Uncertainty regarding the benefit of additional therapy after initial response followed by relapse and systemic infection</i>	Primary physician, case manager & common sense
<i>The patient requires mechanical ventilation. Uncertainty regarding the wishes of the patient in such an event.</i>	Patient and family: wish, consent, information
<i>Uncertainty regarding the newest protocols for treatment, or else uncertainty regarding the course to be taken when physicians recommend a life-prolonging procedure which the family rejects while the patient wishes are unknown. Ethical committee opinion may be required.</i>	Medical literature—evidence-based medicine, guidelines, rules, regulations & physician and hospital personnel opinions.
<i>Uncertainty regarding whether specialized radiotherapy techniques are available. Uncertainty regarding the use of multiple chemotherapeutic agents together with radiotherapy.</i>	Medical technology
<i>Uncertainty regarding the outcome of cancer patients in your center requiring mechanical ventilation.</i>	Decision models

thus avoiding uncertainty and intuitiveness (Genuis, 2012; Kreiter & Bergus, 2009; Taylor et al., 2011). The consequent practice of expertise and judgment (Sevdalis & Brett, 2009) assures the quality of care (Brindley, 2010). The scarcity of guidelines to advices complexity, however, may impair performance (Eva, 2005; Genuis, 2012).

The use of medical technology, indicated by the fifth decision factor, involves the consideration of challenges such as the limitations of medical insurance or service at the point of care, medication implications for the patient, and the opinion of domain specific experts. Decision models, indicated by the sixth decision factor, are an example of bringing together individual- and organizational-level knowledge towards what could be extended to be organizational memory (Kishore, Zhang, & Ramesh, 2006; Nevo, Benbasat, & Wand, 2012; Weinberger et al., 2008). Decision models are a means of exercising medical reasoning (Audétat et al., 2012). Examples are domain specific consultation models, as in the case of prescribing medications and reasoning models, which are designed to support evidence extraction of hospital information systems, (Fackler et al., 2009; Hazelzet, 2009).

In Table 2, for each model factor, an example is used (a patient with cancer) illustrating each factor in the context of uncertainties and the decision-elements required to cope with them.

This illustration of a real-life case study complements the former description of the model factors. In this way, the

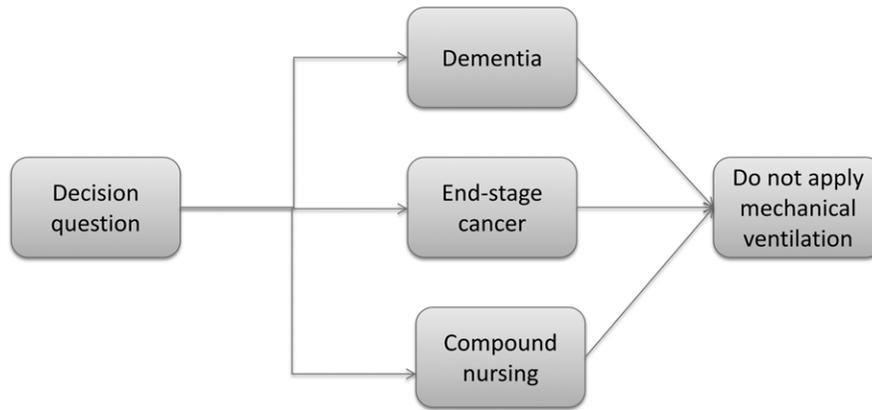


FIG. 2. Consultation model: Mechanical ventilation decision path.

consistent attitude towards the many facets of complexity guides decision making towards the ongoing consideration of procedures and foreseen consequences.

#### *Model Instantiation: Decision Model*

One of the major hurdles encountered in decision making stems from the emergence of an unprecedented event. Recent research suggests the cultivation of physicians' critical reasoning education (Krupat et al., 2011; Stacey et al., 2010; Taylor, 2011; Thistlethwaite, 2012), and the corresponding development of reasoning models. Research indicates that the golden path for ensuring patient well-being and optimal care (Hall, 2002; Brindley, 2010; Schoen, 2011; Vincent & Moreno, 2010) involves constantly striving to establish consistency and deter vagueness (Chassin & Loeb, 2011; Durning et al., 2011). One way to approach this could be the coordination of the involved multiple perspectives and their related implications (Légaré et al., 2011b).

Decision models are a means of effectively responding to the well-known challenge of integrating evidence as part of care (Alavi & Leidner, 2001; Baloh et al., 2012; Ibrahim & Allen, 2012; Winters et al., 2009). Reasoning models are an example of evidence extraction, whereas consultation models can be used for supporting communication and collaboration with decision partners (Adler et al., 2011).

An instance consultation decision model is suggested (Figure 2), aiming to guide doctors through their encounters with a well-known phenomenon: mechanical ventilation. Although the procedure in itself is not unprecedented, the context of this encounter would often suggest otherwise. Figure 2 represents the decision path, indicating three patient-related phenomena that would rule out this procedure. This decision path illustrates the consideration of the spectrum of decision factors indicated by INDECO (Figure 1; Table 1).

#### **Retrospective Assessment of the Model**

This section is dedicated to the retrospective evaluation of the potential usefulness of INDECO. Three case studies

of complex patients were selectively chosen for the retrospective assessment. The case studies were analyzed and distilled to present the core characteristics of the complex patient. The discussion evolves based on a series of interviews conducted with senior physicians and management participating in this research.

#### *Instituting Mechanical Ventilation for End-Stage Patient: The First Case Study*

The setting was the emergency ward. A well-known physician working at another hospital was admitted suffering from acute pneumonia with increasing respiratory distress. The patient was known to suffer from advanced, metastatic cancer. The decision question was: "whether (or not) to institute mechanical ventilation."

The wish of the patient could not be ascertained as he was semi-conscious. The family was not immediately available. Eventually, the patient was identified and the medical history of cancer noted. Mechanical Ventilation (MV) was instituted, although it might be futile in the context of a patient with advanced metastatic cancer, as in this case.

Information received after consulting the out-patient oncology records revealed that the patient had left specific instructions with the family not to undergo mechanical ventilation.

#### *Patient Data*

The completeness of patient data are grounds for communication between decision partners and for decision making. In this case a complete understanding of patient data and patient wish was not obtained. Doctors instituted therapy for an acute, potentially reversible condition (i.e., pneumonia) (Asscher, Bolt, & Shermer, 2012; Diringier & Yende, 2012), rather than acknowledging the futility of treatment when faced with a chronic, irreversible condition (the advanced cancer). This could be regarded as a poorly derived decision, which also sets an example of the ethical

tension that can arise in these situations (Lundgrén-Laine et al., 2011). A senior management executive commented on this:

The faults in this case are clear. A partial explanation could be attributed to the need for providing an immediate response; nevertheless, this is not what we expect.

Setting the terms to avoid such circumstances is a management challenge as well. At present, there are no decision-making tools to guide physicians through complexity in a way which would prevent instances of unnecessary procedures, specifically under emergency conditions.

Complexity in this case was provoked by weighing prospects and consequences in the context of the patient's multiple co-morbidity. A senior doctor noted:

The challenge in decision making in this case was not in responding to the common medical question: "what can be done," but rather in responding to the question: "what is to be avoided." Taking this notion one step further might indicate the need for developing and confronting a simultaneous multi-dimensional decision path—indicating what should be avoided in context.

This comment extends to the fifth element of the definition of the complex patient, emphasizing the importance of consequence awareness in decision making for the complex patient.

#### *Primary Physician and Case Manager—Common Sense, Competence, Expertise, and Moral View*

In this case several doctors were acting in parallel. Although expressing different views, they failed to prevent a poor outcome. This could be an indication of the need for a case manager to act as facilitator of the interaction, and to assist not only the individual, but also the group towards a common sense approach. A senior doctor who is experienced in emergency medicine commented that:

Much can be learnt from this case, for instance with regard to physician education and for instructing the development of an IT solution. For both, we have to assure the conscious establishment of context awareness.

Thus far, physician education has not been extended to include complexity (Thistlethwaite, 2012). Rather, there is evidence in the literature of a lack of adequate critical reasoning in this context (Audétat et al., 2012; Perez et al., 2012).

#### *Patient and Family Wish, Consent, and Information*

In this case, faults in obtaining patient data resulted in a failure to respect the patient's wish. Consequently, the specific intervention intended to achieve short-term patient relief (e.g., institution of mechanical ventilation) was not

conducive to the patient's well-being in the long term (Kuziemsky et al., 2009; Wegwarth et al., 2009).

Considering the lack of contextualized documentation (Zhang, 2013), only by realizing the patient state could the attending physicians continue to investigate the patient's wishes (Levy, 2011; Valerio & Ricciardi, 2011). This indicates the need for integrated adherence to the first three decision factors.

#### *Medical Literature*

We wanted to know how best to inform decision making in this context. A senior physician acknowledged several more questions applicable to this case:

This is a challenging case. The decision making under investigation entails hospital guidelines and individual physician medical critical reasoning, moral views and subjective ruling. Several questions arise in view of what appears to be an emotional reaction: would the doctors have decided differently for another patient? Was this decision the consequence of poor prioritization of tasks - i.e., between responding to an emergency and the allocation of time for tracing the corresponding data?

Noting these accounts, we postulate that an attempt towards the design of an IT solution to this end could allow the representation of patient data and patient wish, in a way that would facilitate accurate decision making.

#### *Medical Technology*

Several senior doctors were interviewed to obtain their view of this case study. The discussion indicated what may appear as a slippery slope of implications. A senior physician commented:

This decision sets an example for daily decision making hurdles unfolded in practicing medicine. It shows the invisible line between technology as lifesaving and technology as a technique.

The reasoning behind technology utilization is not always straightforward for the complex patient. Maintaining coherent reasoning for the consideration of patient well-being in the long term is not a simple task (Krupat et al., 2011).

For the understanding of the implications in the use of medical technology, resemblance can be drawn from other domains such as information consumption (Genuis, 2012) or semantics (Román, Hulin, Collins, & Powell, 2012)

#### *Decision Models*

Critical reasoning could provoke differences of opinions among decision-makers as a result of objective and subjective interpretations. For the latter, an approach to

avoiding misconception would be the modelling of decision values. A senior physician concluded:

This case is an example of the need to enhance decision making with further information not only of the patient but also of physicians' (hidden) motives as a means for tackling bias as part of decision making.

Against this background, the instantiation model introduced earlier in this article was introduced in a meeting of internal wards personnel. Consequently, this led to the recounting of an incident by a senior management:

An experienced nurse professional on shift at an internal medicine ward called (the management) for consultation regarding the decision making for instituting mechanical ventilation for an end-stage patient. In this particular case, the attending physician was a trainee, while the nurse professional both recognized the situation and had the sense of mind to make a suggestion.

Under certain circumstances, decision models may compensate for a lack of evidence.

### **Allowing a Third Lung Transplantation: Case Study 2**

The setting was the ICU. A young female patient with cystic fibrosis who had previously undergone two lung transplantations was admitted with worsening shortness of breath. On admission, and realizing the possible consequences, the patient expressed her objection to undergoing mechanical ventilation. However, as her condition deteriorated and she lost consciousness, her family was reluctant to fulfil her wishes and requested that mechanical ventilation be instituted; this was subsequently performed.

The only possible medical solution for the patient was to undergo a third lung transplant, a situation that is not acceptable in Israel, as in most other parts of the world, because of the severe shortage of organs. However, the family was joined by the media and community organizations as well as by the primary physician in an effort to find a surgeon somewhere in the world who would be willing to perform such a procedure.

The ICU physician in charge was obliged to maneuver between a clearly defined situation (end-stage lung disease and no possibility to obtain a third transplant) and the patient's wishes on the one hand, and her family, supported by the primary physician and the media, on the other.

There were several decision questions in this case. The first question that persisted over 10 days was: "the plausibility of a third lung transplant." If a third lung transplant was not possible, then there was the question of "allowing organ donation." Needless to say, this was a difficult situation for all involved as the patient was young and had tried to maintain a normal life.

As her condition deteriorated, the attending physicians identified an organ donation opportunity in the event that the patient did not receive a transplant and developed cardiac arrest. The patient had expressed her consent to take this opportunity should it arise. The family agreed to organ donation when they realized that a third transplant was not possible.

#### *Patient Data*

Evidence was not scarce for this case. Nevertheless, the resulting havoc stimulated considerable interest in developing decision-making tools. An ICU physician commented:

Apparently, complexity may significantly interfere with the way resources are utilized (Perez et al., 2012). Complexity affects interactions between decision partners in a way that might introduce bias. This further indicates the need for developing communication tools for supporting decision partners' interactions.

An example in this context is the recently reported communication guidelines for end-of-life as signifying the interface between physicians and patients on the one hand, and between the medical-clinical and ethical and legal domains on the other (Kryworuchko et al., 2011).

#### *Primary Physician and Case Manager*

Facing complexity demands not only the interpretation of multiple data, but also consideration of differences of opinion. Several senior physicians noted:

In this case, there were various controversial issues discussed for the two major decisions mentioned above. It is evident that bias was not excluded, yet it was not explicitly accounted for. Balancing the two-fold dilemma between the medical-ethical and the social perspectives resulted in decision making which was medically acceptable, ethically sensitive and socially aware. However, this was not straightforward. Physicians moved between the clinical-ethical path and between the family, primary physicians and media pressure. Nevertheless, eventually, the patient's will was respected and a life saved.

This could instruct the understanding of roles and perspectives as motivating decision-making courses.

#### *Patient and Family*

In this case, the patient's wish directed decision making. Nevertheless, the delicate interface between patient and family highlights the necessity in making the patient's wish evident. Further, the primary physician's empathy towards the patient and family may at times distract professional judgment. A senior physician noted in this regard:

The two decision questions elaborated in this case are an example for the sometimes inseparable association between the medical perspective and the interprofessional perspective.

Against this background, the position adopted by the primary physician is not surprising. Of significance is that (implicit) bias may sometimes delude the family.

The conceivable inconsistency between the medical-clinical and the interprofessional perspective of the decision making should be acknowledged as part of the design. An approach to bridging perspectives could be the introduction of intelligent information systems (Kishore, Zhang, & Ramesh, 2006; Kuziemsy et al., 2009) towards *enhanced communication between partners*.

### *Medical Literature*

The scarcity of evidence for the complex patient is significant, regardless of country or culture. Ethical dilemmas abound (Asscher, Bolt, & Shermer, 2012; Levy, 2011; Olthuis et al., 2012) and legal issues and social implications (Bærøe & Bringedal, 2011) may be provoked by the plethora of medical technologies. Examples of this include the decision regarding the right treatment (i.e., time, type, and effort) and the right to receive or to refuse treatment (Asscher et al., 2012; Levy, 2011). Common to these examples is the importance of considerations, beyond the clinical dimension, that cause dilemmas between experts and patients (Kantor, Bullinger, & Gal, 2012). A senior physician observed:

While it could be assumed that all aspects are considered as part of routine decision making, experience instructs otherwise. This is not to say that these factors are routinely ignored, yet sometimes their absence may have crucial consequences.

For the medical literature to match the dynamic pace of complexity, an innovative approach is required for knowledge sharing and reuse, of which evidence extraction is an example. For instance, healthcare organizations' use of data mining for operational management could be extended to include the identification of similarities and associations (Fackler et al., 2009; Hazelzet, 2009) in hospital information systems.

Although this should not imply that similarities and associations are a tradeoff for evidence, this could perform the role of indicating a decision context that includes decision perspectives, consequences, and implications.

### *Medical Technology*

The perception of healthcare organizations as complex adaptive systems (Begun, Zimmerman, & Dooley, 2003) could be extended towards the systematic improvement of information utilization (Zhang, 2013). An example is enhancing the understanding of opportunities and threats in medical technologies. A senior physician noted:

Technological advancements abound, regardless of assessing the non-technical effects of their utilization. The logical syllogism for either adopting or rejecting a suggested procedure should be extended to include the wider perspective of associated risks.

This case is an example of an attentive response to the interprofessional perspective of decision making. This lesson can be extended to include additional situations, also as a means of contributing to organizational memory (Dow, Hackbarth, & Jeffrey Wong, 2013; Nevo et al., 2012; Stacey et al., 2010).

### *Decision Models*

It is argued that using critical decision-making tools in context (Allen, 2011; Zhang, 2013) could encourage collaboration (Ibrahim & Allen, 2012; Légaré et al., 2010; Olthuis et al., 2012; Schoen et al., 2011; Sevdalis & Brett, 2009). Examples are the extraction of a checklist (Audétat et al., 2012; Winters et al., 2009), which can also function as a basis for the further development of decision-reasoning tools (Brindley, 2012; Román et al., 2012). A management official noted:

Patient consultation took place before the patient deterioration based on the foreseen consequences. This could incite awareness towards exploring an arena of circumstances in which case management and patient care could rely upon enhanced communication guidelines.

Adequate decision-making tools facilitate informed encounters with complex patients. This approach could be regarded as a way to handle complexity, while enhancing physician education (Wong, Levinson, & Shojanian, 2012) parallel to their information behavior (Genuis, 2012).

Table 3 follows the retrospective evaluation of the first two case studies, and precedes the discussion of the third case study with a summary of the results.

## **Allowing a Liver Transplantation from the Living: Third Case Study**

A surgeon in the hospital was diagnosed with liver disease and required a liver transplantation. As his condition was stable and transplantation was not considered urgent, he joined the organ waiting list. By coincidence, a transplantation procedure in another hospital was interrupted because of unforeseen circumstances and our patient was prioritized and summoned for the transplantation.

The post operative stage was characterized by primary non-function of the liver. The patient was admitted to the ICU suffering from multi-organ failure and severe abnormalities of the clotting system. His condition was assessed to be reversible only in the event of significant recovery of the liver function.

In the prevailing situation, there were several possible solutions for the patient. The first was to undergo an immediate second transplantation from a brain-dead, heart-

TABLE 3. The representation of INDECO factors in the three case studies.

INDECO factor	Case #1: Instituting mechanical ventilation for end-stage patient	Case # 2: Allowing a third lung transplantation	Case # 3: Allowing a liver transplantation from the living
Data—organizational IS	Data collection was not comprehensive. Medical records beyond the local setting were not immediately accessed: the oncology ward and physician familiar with the patient were excluded from the decision-making process.	Exhaustive investigation	The investigation of patient data was complete, yet communication was incomplete for the decoding of associated consequences.
Primary physician, case manager, & common sense	Several physicians were acting in parallel, expressing different views.	The case manager was acting to maintain the patient’s will while also reviewing the wider perspective of society.	Common disagreements were because of false expectations, emphasizing the need for exhaustive investigation as basis for decision making.
Patient & family: wishes, consent, & information	Family members were not actively contacted to provide information regarding the patient wishes, or to provide information regarding the patient’s awareness of his state	Patient’s consent was documented; family and community organizations initially objected.	Family involvement contributed to possibility of lessened appreciation of risks.
Medical literature: EBM, guidelines, rules, regulations, and opinions	Was used selectively; organizational clinical guidelines, regarding institution of MV were considered in the context of the partial data collected in this case.	Investigated beyond regulations extensively. Accordance with guidelines was preserved. Family sensitivities were considered, yet the patient’s will was respected.	Medical literature was studied, yet not excluding bias because of emotional effect.
Medical technology	Used for conceivably futile treatment. Second opinion was not requested.	Investigated extensively.	Used intensively on the one hand, while avoiding an attempt abuse on the other.
Decision models	These were not applied.	Introducing the transplantation domain.	Were not explicitly available or applied.

beating organ donor. Because of the severe shortage of organs, this was not a possibility. The second was for the patient to undergo a re-transplant, but from a living donor. His son, a surgeon in the hospital, understood the gravity of his father’s worsening condition and expressed his wish to donate a lobe of his liver to his father.

The son’s suggestion received the support of the attending surgeons and the primary physician. The ICU doctors were, however, more reluctant. Time was scarce, because any further deterioration in liver function might have precluded a second transplantation because of his general condition. In addition, initial indications suggested that the liver might yet recover. In this case, there were two parallel decision questions. As a result of the son and surgeon’s insistence, the first question, which was a composite one, was: “*the plausibility of a second liver transplant,*” which includes yet another question: “*allowing organ transplantation from a living donor.*” If the liver previously transplanted was to recover this question would become redundant. Hence, this raised an intersecting question, specifically: “*would the original liver recover.*”

In this case, the physicians were facing a dual clinical-ethical dilemma. Moreover, this case indicates the allusive and imbalanced nature of decision partners’ bias. The conceivable bias of the son cannot be concealed, yet the likely bias of other physicians is concealed.

### Patient Data

In this case, the third question sets a particular documentation challenge in the context of the EPR. Facing complexity is one way to realize the need for attributing meaning to patient data. For instance, indicating risks and plausible opportunities could serve as basis for accurate decision making. A senior physician postulated:

The line between missing data and patient safety is at time concealed. This requires the continuous investigation of complexity in order to identify critical knowledge representation shortcomings.

Data insufficiency is a potential obstacle to collaboration (Adler et al., 2011; Baloh et al., 2012; Dy & Purnell, 2012; Kolfshoten et al., 2012), apparent by shortages in information retrieval and knowledge sharing and reuse (Ibrahim & Allen, 2012; Nevo et al., 2012). Efforts to achieve a seamless path between data and evidence could motivate the next generation of healthcare information systems.

### Primary Physician and Case Manager

Generally, the primary physician would establish the context for the case manager to include the patient medical

data and social background. At times, the primary physician would be divested of medical considerations, much like a family member. A senior physician commented on this reoccurring phenomenon:

Differences of opinion could be motivated by uncertainty as much as it could originate with bias provoked by considerations beyond the medical perspective. However, on occasion, when the primary physician and case manager experience dispute, this could trigger an unfortunate communication fault which also affects the family. An example is the rise of false expectations.

In this particular case, there was a two-fold challenge: maintaining the quality of care and avoiding bias, while at the same time avoiding the risks associated with false expectations.

Disagreements are not foreign to the decision-making process. However, bias, similar to lack of comprehension, could impair communication (Kryworuchko et al., 2011) and information use (Zhang, 2013) as part of the decision-making process.

#### *Patient and Family*

The family's apparent emotional distress could not allow the balanced consideration of risks and opportunities. Hazards unfolded not only in the medical situation, but also in the inseparable (emotional) response it provoked. A senior management representative reflected:

In this case, differentiating between decision questions was not an easy task. This case is an example for the importance in the transparent balancing of decision perspectives. Suggestions and opinions alike ought to be examined in the context of both patient data and of the decision partner's conceivable bias.

A systematic approach towards decision making should be advocated in favor of inhibiting reasoning faults. An example would be developing a matrix for the investigation of roles and perspectives.

#### *Medical Literature*

For the first decision question in this case, the answer was not to be found in the medical literature but rather in the well-known fact of the scarcity of organs for donation. For the second decision question, there was evidence of the risks to both the patient and the living donor. In the context of the third question, there was evidence in the literature to support the apparent positive signs found from the patient data.

Recent publications on the correlation between organizational memory and information behavior (Dow, Hackbarth, & Wong, 2013; Ferran-Ferrer et al., 2013) emphasize the importance of constantly examining not only the content elements but also the associated meaning. In the context of

the challenge presented in this case, medical evidence alone could not balance opportunities and threats. A senior physician noted:

This case is an example for complexity which was not instructed by the lack of medical literature. Rather, untangling complexity involved the weighing of medical and ethical considerations in the context of the medical literature. Uncertainty was not introduced to this case due to insufficient evidence, but rather due to the risks involved in medical technologies.

This case highlights the intertwined relationship among decision factors, alongside the need for the use of reasoning methods for either compensating for insufficient evidence or balancing the medical and interprofessional perspectives (Légaré et al., 2011b).

#### *Medical Technology*

Attentive use of hospital resources should strive towards consent that is formed in the context of not only patient well-being but also the wider perspective of the community and the society to which the patient belongs. A senior physician acknowledged:

This means bridging the tacit-explicit divide towards an inclusive perception of factors such as risks, prospects, and alternatives. A united view of the interprofessional perspective and of the medical perspective could incite a disambiguate decision-making model.

Specifically, this observation is set in the context of the first two questions. The first concerns a second transplantation, whereas the second references the acceptance of donation from the living. Against this background organ donation is an example of the delicate line between technology use and apparent abuse, from the individual and from the societal perspective.

#### *Decision Models*

Physician education has not yet extended to include complexity (Thistlethwaite, 2012), nor has complexity been recognized as a paradigm within medical practice. Rather, there is evidence in the literature of a lack of adequate critical reasoning in this context (Audétat et al., 2012; Perez et al., 2012). A senior management representative concluded:

Often, the dilemma is found in the juxtaposition of attempting immediate or short term relief and between the adjustments of care from the wider perspective. The subject procedure ought to be assessed to meet a spectrum of considerations, while decision partners could side with a specific concern.

Decision models should adhere to the medical literature, yet facilitate a dynamic approach in responding to the

spectrum of decision questions. This calls for decision models to account for, and provide direction for managing the “do” and “do not” dilemmas that can be encountered during the treatment of the complex patient. Although these questions are not unique to the complex patient, decision making for the complex patient stimulates the development of tools for guiding decision making.

## Discussion and Future Research Directions

This article addresses the concept of the complex patient as encountered in the ICU and proposes a comprehensive understanding of the critical factors of the decision-making process. Although the criticality of complexity has been acknowledged (Plesk & Greenhalgh, 2001; Plesk & Wilson, 2001) and a definition of the complex patient within the context of the primary care has been suggested (Grant et al., 2011), a comprehensive framework is still lacking.

Treatment plans have been at the center of efforts to manage complexity (e.g., heart attack, asthma, diabetes) and different populations (e.g., elderly people). Risk factors beyond the biological arena were acknowledged by Safford et al. (2007), emphasizing the shortage of patient-centered rather than diseases-centered guidelines.

This article approaches complexity from both the medical/clinical perspective, as well as the interprofessional perspective, and presents the insufficiencies and inconsistencies that can result from the absence of either perspective. (Angell et al., 2006; Asher, 2012; Dy & Purnell, 2012; Taylor, 2011; Winters, 2009).

Envisioning enhanced guidance for critical decision making in complex circumstances, this paper outlined a hybrid human and information systems approach towards current and required roles. Particular emphasis has been given to the enhanced perception of patient safety and the quality of care in this context.

The need to bring together prescriptive and predictive capability in the redesign of the decision-making process guided us towards a joint model development effort. This means bringing together ontology engineering and conceptual modeling (Fonseca, 2007; Mansingh et al., 2011; Rao et al., 2012), alongside retrospective case study evaluation. The result of this design effort is a model that is an upper level ontology (Almeida, 2013; Fridman Noy & McGuinness, 2001) of complexity as groundwork for the further development of complexity theory (Plesk & Wilson, 2001) and quality improvement methods (Asher & Douglas, 2011), and as a basis to inform design (Baloh et al., 2012) and guide critical reasoning (Audétat et al., 2012).

Three research questions were introduced for this study for which several design artefacts were suggested. The first focused on the identification of critical decision-making factors; the second aimed at the investigation of the content accessible through hospital IS, while the third was intended for the investigation of critical reasoning means used for sense making.

Of the research deliverables, the first is the interprofessional decision-making model for the complex patient, namely, INDECO, adhering to the bi-dimensional view of the decision-making process, which includes the medical- and the interprofessional perspectives. Revealed in this representation of the ecology of the individual complex patient, is the need for balancing immediate, sometimes lifesaving responses against value-based considerations of the ethical perspective. This notion was echoed through the retrospective evaluation of the three case studies.

The five-segment definition of the complex patient included in this model and extensively elaborated in the evaluation section, embodies the understanding that technological advances may act as a double-edged sword, sometimes provoking not only futile, but also heroic, yet unnecessary treatment, without a significant indication of long-term contribution to patient well-being. For this reason, balanced decision making is required, which is not only shared but also informed of foreseen consequences.

The second question aimed at the investigation of the content accessible through hospital information systems. The findings of the retrospective evaluation of INDECO revealed the gap between factors acknowledged as imminent to the decision-making process and data availability as part of organizational information systems. Currently, organizational information systems are not designed to respond to all the combinations of content items required for decision making for the complex patient. An exhaustive identification of roles and tasks (Kolfshoten et al., 2012) is imperative in this context.

Physicians' comments, which were included in the retrospective evaluation, reveal the spectrum of considerations interwoven in partners' decision making. Indications were apparent, and also echoed in the instantiation model, that at times the advice focused on what was to be avoided, that is, what not to do.

This finding is a natural response to the third question. The findings of the retrospective study and of the theoretical investigation revealed that decision-making tools for guiding physician decision making are currently lacking (Audétat et al., 2012; Charlin et al., 2012; Krupat et al., 2011). These shortages should not be attributed to the organizational perception of information systems, given that the organizational culture acknowledges the benefits of information and communication technology. The reason for this could therefore be attributed to the dynamic pace of complexity—specifically as encountered in the ICU.

The findings indicate that currently there are neither decision models to compensate for the lack of evidence for the complex patient, nor are there reasoning means to allow for the consideration of interventions under various circumstances. Adhering to these recommendations, healthcare organizations might appreciate their role as complex, adaptive systems by developing an inclusive model of interprofessional decision making for the complex patient that is vigorously responsive to medical and ethical implications.

### Future research directions

A decade and a half ago, the BMJ published a series of publications on the emergent complexity embodied in health-care (Fraser & Greenhandge, 2011; Plesk & Greenhalgh, 2001; Plesk & Wilson, 2001). At present, there still remain important, unresolved issues related to this topic.

From a theoretical perspective, healthcare professionals do not have an ontological model (Almeida, 2013; Fonseca, 2007) of complexity. Complexity management touches on a series of questions of which resources management is an example (Perez, d'Empaire, & Kajdacsy-Balla Amaral, 2012) and our experience supports this view. For the former, future research could pursue whether complexity is indeed a unique paradigm (as suggested by Weinberger & Tadmor, 2011). For the latter, the problem of resource management includes the prioritization of tasks and the utilization of medical technologies (Asher & Douglas, 2011; Brindley, 2010; Lundgrén-Laine et al., 2011) for which prevailing care guidelines are insufficient.

Ideally, physicians' responses to the challenges caused by complexity integrate patient data and evidence-based literature. It is not yet known how best to formulate meaningful evidence in a way that will acknowledge complexity characteristics and eventually allow for the extraction of evidence for supporting patient safety and the quality of care (Vincent & Moreno, 2010).

Hospital and ICU resource management is not a simple task. Decision makers follow regulations and guidelines that fall short of meeting the pace of technological advances or the implications of complexity. There are as yet no clinical, ethical, or educational procedures for the provision of standardized complexity-intensive care. Extending INDECO to information behavior and the development of appropriate communication protocols is yet another direction for action (Genuis, 2012; Kuziemyk et al., 2009; Nevo et al., 2012; Zhang, 2013).

There is more to be made explicit about shared decision models and for enhancing physicians education (Wong et al., 2012) towards the inclusion of the spectrum of involved shared decision models (Audétat et al., 2012; Lindgren, 2013; Stacey, Legare, & Pouliot, et al., 2010) on the one hand, and for supporting individuals or group collaboration towards the integration of tacit and explicit knowledge as part of organizational memory (Nevo et al., 2012; Sevdalis & Brett, 2009; Weinberger et al., 2008), on the other.

The development of a strategic complexity management tool as a means for quality improvement (Asher & Douglas, 2011; Wong et al., 2012) and for sense-making (Weick et al., 2005; Winters et al., 2009) remains a challenge. Subjective reasoning plays a large part in the decision-making process, and this calls for further study into how physicians can consistently deliberate decision factors.

### Conclusions

The future of healthcare depends on trusted interprofessional information. Data interchange, comprehension, and

evaluation are the basis for the provision of advanced, consistent, and timely care. To achieve this, healthcare information systems should allow for the explicit contextualization of information in respect of all roles and all tasks.

Against this background, the contribution of this research is revealed in the representation of decision factors in the context of an ICU of a tertiary hospital, as basis for the interprofessional analysis of patient safety and the quality of care.

Complexity is dynamic and agile. We need to adapt perceptions and practice to the development of an adequate theory, methods, and tools for these issues. Areas to explore which are mentioned in this paper, include the reconsideration of shared decision making as well as design issues, enhancing physicians' education alongside the innovative structuring of hospital procedures. Ideally, complexity management architecture would bring together vigorous theoretical investigation and rigorous design for guiding significant, intelligent context-sensitive and timely decision making.

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