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Managing COVID-19 Crisis using C³HIS Ontology

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Abstract

The paper aims to present the C³HIS Ontology project, a web based solution for Covid-19 Crisis Health Care Information System. In the health care services, employee skills are a major resource and an essential part of everyday practice and a requirement for all health professions. We aim to prove how using individual profiles based on competencies can make a difference between life and death in times. As the performance assessment is driven by actors competencies we have to put human actors in the core of quality processes of health care services management in COVID-19 crisis.

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1. Introduction

On 30th January 2020, the WHO declared the Chinese outbreak of COVID-19 to be a Public Health Emergency of International Concern posing a high risk to countries with vulnerable health systems [1]. Globally, the number of cases has continued to rise, and is currently placed at 1,988,618 active cases with over 228,270 deaths [2]. While COVID-19 becomes more intense in times it is clear that Healthcare Information System (HIS) is in crisis.

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This complex and unusual situation touches and affects all levels of healthcare organizations. It requires significant rapid crisis management, a coordinated and effective operational action plan of certain groups of people exists, and is implemented in case of imposed threat on civilians’ health and health systems, regardless of cause and extent [3]. In the crisis management literature, the term crisis has long been used to describe an event or problem that (1) threatens high-priority values of the organization, (2) presents a restricted amount of time in which a response can be made, and (3) is unexpected or unanticipated by the organization [4].

Therefore health care system must remain prepared for a potential upsurge of cases during the transition which requires creating “elasticity” in the use of acute and intensive care facilities [5]. Hospitals in fact need a strategy to manage their space, staff, and supplies so that optimum care is provided to patients. These preparations involve multiple stakeholders and can present a significant challenge [6].

On the frontline of the epidemic stand healthcare workers whose are themselves highly exposed to infection. COVID-19 originated in Wuhan, China has caused many healthcare workers (HCWs) infected [7] and the doctor who first warned about the virus has died too so it is important to protect healthcare workers to ensure continuity of care and to prevent transmission of infection to other patients [8].

Working with limited medical resources, such as facemask shortage which become a social concern [9]; The shortage of testing, masks, other personal protective equipment, and ventilators, shortage of medications [10]; shortage of personal protective equipment (PPE) [11]; lead to the loss of a staff member and increase their infection which produce a two-fold issue: the loss of a team member and the addition of a new patient [12]. Another reason for healthcare workers loss in a healthcare disaster is that selected healthcare workers are not equipped with knowledge, specific technical skills and abilities. For example the inadequate training for IPC, leaving them with a lack of knowledge of IPC for respiratory borne infectious diseases [11], while the differences among healthcare workers such as cultural and educational backgrounds, prior training, work experience and abilities.

At this end in the health care services, employee skills are a major resource [13] and an essential part of everyday practice and a requirement for all health professions. So identifying competencies ensures that healthcare professions are well defined, promotes competent workforces, facilitates assessment, facilitates professional mobility, and helps to analyze and evaluate the expertise of the profession and the professional [14].

To help in coping with the huge impact of this crisis, resources can be redirected from the surgical department to the COVID-19 section of the hospital [12] also a novel tools arising to stem the tide such as the digital health community to provide possible health solutions [15]. And in our contribution to strengthen capacities for monitoring and response to health emergencies and crisis we propose to explore competency assessment in health care information system (HIS). We aim to prove how using individual profile based on competencies can make a difference between life and death in times. As the performance assessment is driven by actor’s competencies we have to put human actor in the core of quality processes of health care services management in COVID-19 crisis.

Our contribution aim to improve and manage actor’s competencies within a HIS which can lead to significant improvements at the operational level. Our approach aims to improve the ability of HIS to respond to new requirements quickly and effectively by providing a clear definition of desired acts, identifying the impacted component and measuring the actor performance. The proposed approach is an actor-centred approach to support Health care services management based on Covid-19 Crisis health Care ontology.

In this paper we propose the adapt ontology entitled Ontology of Enterprise Oriented Competence (OnEOC) proposed by Jabloun [16] to COVID-19 crisis in HIS.

2. Related Work

2.1. Relation Between actor, competence and performance

The analysis of enterprise models allows us to identify a set of components that we qualify as key components. We will detail these components from actor and competence perspective, as follows:

The actor concept can be presented as an organizational unit with expressible and collective knowledge [17]. An actor has competences that reflect the implementation of his knowledge in an operational context and assigned to
a role within a business process. The actor should use its expertise for the conduct of activities belonging to his role [18][19].

The competence concept is multi-form because it recovers knowledge, know-how and behavior. It is also multi-level because it can be described using an individual or a collective aspect. We notice three granularity levels related to competences [18]:

- Unit competence which is considered as the basic level and entity in the model, it is tightly linked to an activity.
- Individual competence which is the set of unit competences and resources developed/required by an actor within the framework of assigned activities.
- Collective competences which is considered as the highest competence level and linked to processes and group of actors.

An activity is a sequence of operations, which consume resources and are realized by one or several actors. An activity is an elementary step of one process. An activity is characterized by all competencies necessary for its implementation.

A role is a collection of activities performed by a single actor. This concept provides the link between actor and processes. A role requires suitable competence.

The process concept is "a set of interrelated or interacting activities that transform input elements into outputs. The performance concept refers to the achievements, in quality and quantity, of an individual or group work. Employees are critical components of business success and their performances directly influence company performance [20].

We notice a strong relation between actor’s performance and their competencies. In fact the role concept is based on required and acquired competence in order to assign the right actor to the right activity by identifying the available competence [21]. The competence concept produces a competitive advantage. This helps to stress on competence importance into performance assessment. The assessment should take into account the competence level of a candidate when performing the corresponding task. This assignment ensures a performance level that should be maintained after any changes.

2.2. Actor, competence and performance in health care services before COVID-19 Crisis

Human resources are perhaps “the most important of the health system’s inputs and usually the biggest single item in the recurrent budget for health” [22].

Several researches were made focusing on the development of key competencies and terminal objectives for training of all healthcare workers in disaster preparedness [23]. A competency-based approach was proposed for healthcare worker disaster preparedness and response training [23].

Other research identify the competencies that were seen by health service managers to be related to effective teamwork within a health service workplace, they conducted 18 skills, nine knowledge areas, 18 traits and 15 motives were identified as having relevance for effective teamwork [24].

2.3. Using Ontology in the Health care services management and crisis situation

Ontologies are needed for the prevention and resolution of communication issues between heterogeneous systems, knowledge sharing, and information fusion; they facilitate information integration and interoperability between heterogeneous knowledge and information sources while maintaining a high level of abstraction. Many researches have tried to implement health care ontology [26] for specific need but we find that they could not be used in Covid-19 crisis.

In this project we are interested of adapting the Ontology of Enterprise Oriented Competence (OnEOC) proposed by Jabloun and Sayeb as a competence-oriented ontology to ensure capturing relevant information for actors’ performance (e.g., skills, training, etc.) in a dynamic change context [16][17][21]. The ontology is composed of:
• Thing, an abstract object representing the class of all things.
• Enterprise view refer to the different enterprise aspect, it is directly linked with [25]:
  ➢ The strategy view is used to describe the alternatives or missions and the strategic objectives. It also shows performance concept, their indicators and all concepts that influence the strategic component such as the conditions, difficulties, intentions, etc.
  ➢ The resource view is used to describe a part of what is conventionally called the computer system
  ➢ The business view is used to describe the business processes and activities.
  ➢ The organization view is used to describe the various organizational units, e.g., determine workstations and involved actors and their activities, skills, relationships and all interactions in the business work unit is a component that refer to a decision unit it is linked with the performance estimation and the choice of changes reasons.

The actor concept is a key concept. Actors have different competencies and roles [21]. Hierarchical relationships are often complex, and it is important to understand the relationships between the actors to understand the difficulties to monitor the organization. Thus an actor in OnEOC can be considered through different views depending on his role and his capabilities. So, we find the strategic actor with a direct link with the strategic component, the business actor who deals with the conduct of business process and the technical actor who manages the internal resources and systems.

The competence concept identifies the unitary competence, personal competence and collective competence.

The change concept is also defined in the OnEOC where it ensures the evolution of an existing state (AS-IS) to a desired target state (TO-BE). The ontology takes into account the purpose of the change regarding the various aspects of IS and changes properties such as the change degree that can be partial or total, the change duration that can be temporary or permanent, the change pace that can be immediate or delayed, and the change anticipation that can be planned or ad hoc.

The OnEOC ontology allows different types of research via ontology’s interrogations. For instance, actors executing tasks with a given value of KPI: "number of resolved complaint in an hour". The ontology allows a semantic interpretation of KPI, where technical actors interprets the KPI query execution time by the computer system, while actors at the strategic level interprets this KPI according to customers satisfaction percentage.

3. Proposed Approach

Our contribution aim to improve and manage actors competencies within a HIS which can lead to significant improvements at the operational level. Our approach aims to improve the ability of HIS to respond to new requirements quickly and effectively by providing a clear definition of desired acts, identifying the impacted component and measuring the actor performance. The proposed approach is an actor centered approach to support managing COVID-19 crisis based on HIS ontology.

In this paper we propose the adapt ontology entitled Ontology of Enterprise Oriented Competence (OnEOC) proposed by Jabloun [16] to COVID-19 crisis in HIS.

3.1. The proposed C³HIS Ontology:

The proposed ontology is built in Protégé 3.4.1, which uses the knowledge representation language Web Ontology Language (OWL). This language is based on logic which is machine interpretable, designed to be read by computer applications rather than humans [26]. A partial representation of the C³HIS Ontology can be seen in
Fig. 1. The proposed C³HIS Ontology.

The structure illustrates the crisis specifically health crisis such as Covid-19 and trace the path to the other parts. The ontology takes into account the impact of the crisis and crisis’s properties, for example: The degree of crisis that can be partial or total or radical, and the duration of crisis that can be temporary or permanent. The organization view is used to describe the various units where the actor concept is the key concept in this view. In fact, actors have different skills and roles and it is important to understand the relationships between the actors to understand the difficulties in the control of the health care.

The actor in can be considered through different views depending on his role and his characteristic. Thus we find the administration actor, operation actor or technical actor.

The concept of competence therefore distinguishes between two important characteristics of competence namely: skills required and the skills acquired by the actors (individuals or group of individuals).

The ontology needs to be dynamic and consistently maintained [26].

To experiment the propose ontology we choose to considerer the two parts dealing with the action and role as illustrated in the figure 2.

Fig. 2. Crisis-Action and Actor semantics in the C³HIS Ontology.
3.2. Using the C³HIS Ontology to manage Health care Services in HIS

In this research we develop a web application solution labeled C³HIS as Covid-19 Crisis Health Care Information System to provide many services to health care responsible to be able to manage the Covid-19 crisis with more agility and providing better decision making. We illustrate in the figure 3 the home page of the developed solution:

![Home Page of the web based solution in HIS](image)

During a sudden crisis a health care responsible can jump into action quickly. As illustrated he can choose either to manage healthcare worker, space or equipment. The developed solution is interacting with the ontology to adapt to demands that require skilled health workers. As the ontology defines Actor and their roles and required competencies in the health care services, it can be interrogated to establish whether a competency gap exists between an individual's profile and the competency requirements specified for a particular role, This competency ontology has the potential to facilitate the identification of the appropriate health worker even if he is in distant place. It also has potential to assist the health care responsible to see the different profile and competency of the health care worker as illustrated in figure 4. This form provides support through management of health care worker competencies, managing professional roles, and characteristics in response to the crisis.

From this form user can introduce their needs based on health care worker profile and provide a list of workers ordering by their competence and localization. Health care worker with appropriate competence and features, adequate professional role, play a key role in dealing successfully with crisis.
In this part we have to distinguish the difference between ontology and database. Ontology creation is a process comprising several stages. Some of these phases, namely specification, conceptualization, implementation, and maintenance are materialized during the development process; other operations are performed throughout the entire existence of the ontology. It is true that in our HIS the web based developed solution will interact with a specific database which contains entities; an entity describes a certain portion of the real world. For example, a relational database comprises entities which are tables in the database. But while databases concentrate on data storage ontologies are focused on adding meaning and comprehension. In other words, databases are created as effective data warehouses, whereas ontologies are formed for better communication, interoperability, and as the communication bridge between a human and a machine.

4. Conclusion:

Covid-19 crisis causes a complex and unusual situation which touch and affects all levels of health care services management. In this paper we have discussed the potential benefits of the use of C^3HIS Ontology in a health care information system. Our objective is to assign the right actor to the right activity by identifying the available competence. The competence concept produces a competitive advantage which helps to stress on competence importance into performance assessment. To experiment the proposed ontology we develop a web based software solution to illustrate how we can use gather the appropriate health care workers in critical situation. The proposed solution will be tested in a real context through a Covid-19 Unit of crisis.
In this paper we have discussed the potential benefits of the use of C 3HIS Ontology in a health care environment. Ontologies are formed for better communication, interoperability, and as the communication bridge between human and machine. Whereas databases are focused on adding meaning and comprehension. In other words, databases are created as effective data warehouses, whereas ontologies represent the real world. A database comprises entities which are tables in the database. But while databases concentrate on data storage, ontologies are focused on adding meaning and comprehension. In other words, databases are created as effective data warehouses, whereas ontologies represent the real world.

In the existence of the ontology model for E-Health Systems, we must distinguish the difference between ontology and database. Ontology creation is a process where ontologies are formed for better communication, interoperability, and as the communication bridge between human and machine. However, databases are focused on data storage and management.

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