Modelling and Simulation of the COPD Patient and Clinical Staff in the Emergency Department (ED)

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Abstract

Chronic Obstructive Pulmonary Disease (COPD) is a critical and major social health problem. Comorbidities and coexisting conditions and symptoms are associated with and affected the whole body of COPD patients. Regarding the Exacerbation COPD patient, the Emergency Department (ED) and Emergency Medical Service (EMS) responsibility is managing, decision making, treating the initial response to the COPD patient. During the process, the head nurse and emergency medicine specialist should make various decisions for COPD patients. The first aims of this research is to create a new conceptual model to investigate the model of COPD patient, exacerbation COPD in EMS, Multiple COPD pathologies in ED, nurse action in the emergency box, nurse decision making, evaluation of the patient's condition, and reaction to the emergency box. The second purpose of this research is to create a computational model which will concentrate on the simulation model to use the probabilistic finite-state machines for training the nurses for professional decision with treatment and decision without treatment to evolves nurse with intervention to prevent exacerbation of COPD patients.
Keywords: Simulation, COPD, Pathologies, Emergency Department (ED), Emergency Medical Service (EMS)

Introduction:

Nowadays, in different societies, the quality of Emergency Department (ED) and Emergency Medical Services (EMS) is an essential factor for people and governments. The EMS can be a matter of life and death in different incidences such as accidents and epidemics. As we have seen in recent months with the outbreak of COVID-19, the living conditions have become much more difficult for people particularly for patients with Chronic Obstructive Pulmonary Disease (COPD) and medical staff. Emergencies are usually the first entry point for acute COPD patients that emergency personnel have to assess the patients' condition with COPD and treat, should be able to make the right and timely decisions in the shortest possible time [1]. Therefore, a Decision Support Toolkit (DST) is needed to meet the needs of patients [2]. Decision-making in the ED as a vital and substantial process depends on the medical knowledge, training of nurses, and emergency medicine specialist duties of the personnel[3]. The nurses and physicians of the ED should be able to make correct and timely decisions in emergencies applying the theoretical and practical training programs and knowledge. The most important mission of the medical schools is to train specialized and skilled physicians to provide health care services, having

sufficient knowledge to diagnose and treat diseases and also the ability to perform scientific and clinical skills. So, accurate and appropriate planning in the field of clinical education is essential in creating the capabilities of these people.
As healthcare personnel must make many decisions and also apply the results quickly, giving rise to possible errors due to lack of training in unexpected situations. If we refer to mortality data, in the 1999 report of the Institute of Medicine of the United States entitled "To Err is Human: Building a safe health system" estimated at 100,000 deaths per year due to medical errors [1]. Hence, the need to try to avoid these errors by improving the training of professionals will already arise. All increases in errors were attributed to several factors such as the lack of investment in technology and the increasing complexity of therapeutic procedures. Following this report, health educators began to add simulation components to their pedagogical activities.
Clinical simulation is a participant-centered learning technique or method offering better curves than classical learning. Thus, the main limitation for its generalized application is the highest costs derived from their training in teaching methodology, infrastructure, and the excess time spent by them and by participants themselves in each clinical activity
On the other hand, computational simulation is a genre that helps student self-evaluation, feedback in real-time, carry out simulations at any time and place without teacher on site thanks to the possibility of sending messages throughout. In short, the learning process facilitates online training for the both student and the professionals. For this reason, we think that the idea of designing a training simulator for students/professionals can further enhance the learning curve and, also, taking into account today that we live in a period of a pandemic where capacity limitations, mobility, etc, are marking academic training towards a more digitized environment given that clinical simulation is affected by the impossibility of carrying it out.

Research Objectives and Methodology:
The objective of the research proposal is to implement a training simulator that reflects, the evolutionary conceptual model behavior of COPD (First Modeling of COPD evolution patient), which is already working with great pedagogical interest, would be to know all the variables for the state of the patients and Exacerbation of COPD Patient. The Second Modeling Reasoning is to computational model for evolution behavior of COPD in the face of interventions (decision-making) by the student or professional the aim is for training/improving the nurse/student knowledge in a critical situation such as emergency box, real patient analysis feedback form simulator, improve the medical knowledge of junior student, nurse, doctor without much experience in EMS at ED. For the development of the simulator, the Iterative Spiral Development Model (IDMS) will be followed [4]. This system iterates permanently on the traditional software development cycle[5]. The objective of this process is to gradually implement the models in each cycle to define a more complex model. There are three stages of research that described below:

Stage1: Already in this research, we defined several variables which are most relevant to our conceptual model such as heart rate, blood pressure, skin color (Cyanosis), etc, which would make up the state situation of the COPD patient. Each variable is classified according to Fig 1.

Stage 2: Normally the COPD patient doesn't coverage solely one disease, for this purpose including other pathologies is mandatory for own research. In addition to the objective of design simulation is to create a methodology that helps us implement

other conceptual models of other pathologies following the same philosophy that we have been developing in the COPD model.

CYANOSIS (SKIN COLOR)	lack of Oxygen (Hypoxia) and in COPD Exacerbation the skin color in hand and lips are (purple or bluish).	Visible Variable
ACCESSORY MUSCLE	It (Intercostal retraction) includes the sternocleidomastoid, Scalene, Trapezius, which place in the diaphragm. The COPD patients need oxygen for 20-30 minutes and rubbing the muscle	Visible Variable
HEART RATE	by reference the Global Initiative Chronic Obstructive Lung Disease (GOLD) the <65 bpm and >85 bpm, 5.5 years without COPD, 9.8 years in mild (stage I, GOLD), 6.7 years in moderate (stage II, GOLD), 5.9 years in severe (stage III , GOLD)	Non- Visible Variable
OXYGEN SATURATION	OS should >90% in COPD exacerbation and the COPD patients needs 24% Or 28% Oxygen	Non- Visible Variable
PULMONERY ASCULATION	Respiratory sound provide the vital information regarding the COPD patients, COPD exacerbation has several Asculation such as (wheezing, Cracking, Stridor and Rhonchi)	Complementary Test
X-RAY	It shows Hyperinflated Lungs (the lungs appear larger than normal). X-Ray may reveal bullae (Bullae is a pocket of air that forms near the surface of the lungs)	Complementary Test
Sputum (Mucoid)	The normaly is clear and white but the COPD exacerbation may darker with either a yellow of green tinge, The COPD (Needs medicine Mucolytics, such as Hypertonic saline (Nebusal), dornase alfa (Pulmozyme)	Visible Variable
Temperature	The body's temperature in COPD patients is normally high by the infection. the body temperature of COPD is >=38	Non- Visible Variable
ECG	The COPD patients in different case have, Rightward QRS Axis (90 degrees) P wave = P>2.5mm R wave = Right precordial leads (SV1, SV2, SV3) low Voltage - left side (I, aVL, V5-6)	Complementary Test
ALTERIAL BLOOD GAS	--The normal hydrogen ions (H+) in the blood are between 7.38 and 7.42 and the acidic blood (PH<7.38) -- Partial Pressure of oxygen (PAO2) should be below 75 to 10 mmHg and Acidic blood (PH<7.38) --Partial Pressure of Carbon Dioxide (PACO2) should be above (38 to 42 mmHg) and acidic (PH less than 7.38), normally in COPD patients the blood is more Acidic and PH level is low and PACO2 level is above normal	Complementary Test

Fig 1. Patient's relevant variables

Stage 3: Emergency Decision Making (EDM) is one of the critical ways of deal with any emergency in the environment and has a prominent role in loss properties, then focus on EDM is widely used in emergencies[6].

Fig 2, shows the cycles of COPD patient evaluation and decision making of the doctor/nurse to purpose of state variable of the COPD patient.

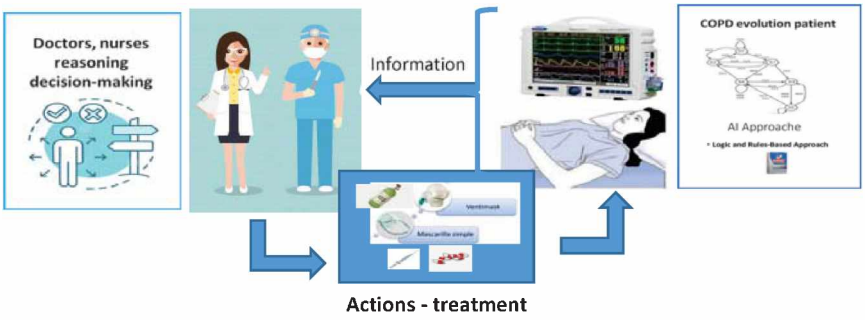

Fig 2. Patient's evaluation for decision making

Normally people make decision-making based on the potential value of losses and gains, for this reason, we propose three R's in EMS.

1. **Immediately Recognition and patient Examination**

The nurse activity should be immediately measured and examined these items of patients such as HR: (<59, 60-99, >100), BR: (<11, 12-19, >20)
OS: (<80, 81-89, 90-95, >95), TE: (36-37.4, 37.5-37.9, >38)

2. **Immediately Right Decision**

The critical idea to realize, whenever having to decide on EMS, is about the patient's status [7]. There are several aspects can help the nurse and emergency medical specialist in EMS to have immediately decision such as:
1. Is your patient going to die?
2. Your patient's stability condition and how about now
3. Is your immediate decision safe?

3. **Immediately Reaction**:

The nurse and EMS specialist should act immediately to save the patient's life. This ability can improve by training to enhance the capability and encounter with the real situation and simulation

Conclusions and Future Work:

This research is based on the conceptual model (Qualitative) and the computational model (Quantitative) that explores the conditions for the implementation of simulating based on COPD intervention to help/improve the quality of the medical services to aim the enhance the student/nurse knowledge. This research has high potential to gather/connect all pathologies relevant to COPD to create a highly professional conceptual and computational reference

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