

## Rule based model for pneumonia (COVID-19) nursing care

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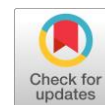
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### ABSTRACT

This research was conducted during the COVID-19 pandemic, when during the pandemic, many patients died. The mortality rate was caused by complications in the form of pneumonia in patients with deteriorating health conditions. This study aims to develop an inference model to become a decision support system in the enforcement of the clinical pathway of pneumonia COVID-19 nursing care. This research model is based on the application of NANDA International nursing diagnoses to determine the objectives of the Nursing Outcome Classification (NOC) and the interventions that must be carried out by the Nursing Intervention Classification (NIC). The data in this study were obtained from the results of expert interviews regarding the handling of pneumonia and medical literature on handling COVID-19 cases. The results of this study can guide the diagnosis and treatment of pneumonia caused by the COVID-19 virus, as well as a similar process that occurs with acute respiratory distress syndrome.



### KEYWORDS

Covid-19  
Pneumonia



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### 1. Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), better known as the Corona virus, is a new type of corona virus that is transmitted to humans. This virus can attack anyone, such as the elderly, adults, children, babies, including pregnant women and nursing mothers.[1][2][3]. Corona virus infection is called COVID-19 (Corona Virus Disease 2019) and was first discovered in the city of Wuhan, China at the end of December 2019 [4] [5]. This virus is spreading very quickly and has spread to almost all countries, including Indonesia. This has led several countries to implement policies to impose lockdowns in order to prevent the spread of COVID-19. In Indonesia itself, a Large-Scale Social Restriction (PSBB) policy was implemented to reduce the spread of this virus.

Corona virus is a collection of viruses that can infect the respiratory system. In many cases, this virus only causes mild respiratory infections, such as flu. However, this virus can also cause severe respiratory infections, such as lung infections (pneumonia). In addition to the SARS-CoV-2 virus or Corona virus, viruses that are also included in this group are the viruses that cause Severe Acute Respiratory Syndrome (SARS) and the viruses that cause Middle-East Respiratory Syndrome (MERS). Even though it is caused by a virus from the same group, namely the coronavirus, COVID-19 has several differences from SARS and MERS, including in terms of the speed of spread and the severity of symptoms [6].

The number of cases that died due to COVID-19 based on the WHO global surveillance database from January to July 2020 in Africa, Americas, Eastern Mediterranean, Europe South-East Asia, Western Pacific as many as 18,354,342 cases and 696,147 deaths [7]. Meanwhile, according to data released by OCHA in Indonesia, the number of confirmed positive cases as of August 18, 2020 is 141,370 people with a death toll of 6,207. The case fatality rate due to COVID-19 is around 4.4%.

When viewed from the percentage of mortality rates divided by age group, the elderly have a higher percentage of death rates than other age groups. Meanwhile, based on gender, 58.7% of sufferers who died from COVID-19 were male and 41.3% were women [8].

In severe cases, COVID-19 infection can cause several complications such as pneumonia (infection of the lungs), secondary infection in other organs, kidney failure, acute cardiac injury, acute respiratory distress syndrome and death. The mortality rate was caused by complications in the form of pneumonia in patients with deteriorating health conditions. Most coronaviruses actually trigger fairly common respiratory problems such as a cold or flu-like symptoms. However, SARS-CoV, MERS-CoV, and the novel coronavirus can cause a more dangerous complication, namely pneumonia. About 25 to 32 percent of infected people will need intensive care in the ICU. The novel coronavirus can indeed cause pneumonia. With early detection and proper treatment, the patient's condition can return to stability or even recover completely. Various efforts have been taken to reduce the death rate caused by COVID-19, one of which is improving nursing care, namely guidelines for nurses in enforcing good nursing care according to the evidence base [9][10][11]. The mortality rate was caused by complications in the form of pneumonia in patients with deteriorating health conditions. Most coronaviruses actually trigger fairly common respiratory problems such as a cold or flu-like symptoms. However, SARS-CoV, MERS-CoV, and the novel coronavirus can cause a more dangerous complication, namely pneumonia [12]. About 25 to 32 percent of infected people will need intensive care in the ICU. The novel coronavirus can indeed cause pneumonia. With early detection and proper treatment, the patient's condition can return to stability or even recover completely. Various efforts have been taken to reduce the death rate caused by COVID-19, one of which is improving nursing care, namely guidelines for nurses in enforcing good nursing care according to the evidence base [13]. This study aims to develop an inference model to become a decision support system in the enforcement of COVID-19 clinical pathway nursing care. This research model is based on the application of NANDA International nursing diagnoses to determine the goals of the Nursing Outcome Classification (NOC) and the interventions that must be carried out by the Nursing Intervention Classification (NIC).

## 2. Method

The data in this study were obtained from the results of expert interviews regarding the handling of pneumonia and medical literature on handling COVID-19 cases. The stages in this study consisted of four phases. The first phase is the analysis of nursing care in pneumonia that applies taxonomic triangulation techniques to identify diagnoses and the second phase is data collection, the third stage is analyzing data using NANDA, NIC and NOC diagnoses through a group of experts to validate the diagnosis. The last stage is the modeling of pneumonia nursing care. The research sample was the knowledge collected in the document "Clinical Management of Severe Acute Respiratory Infection (pneumonia) when a COVID-19 virus was suspected" through the Nurse Lab. This document was chosen because it is an international reference guide that establishes general guidelines for nursing care measures. This guide is intended for nurses in the care of patients diagnosed or suspected of having pneumonia, one of which is COVID-19.

## 3. Results and Discussion

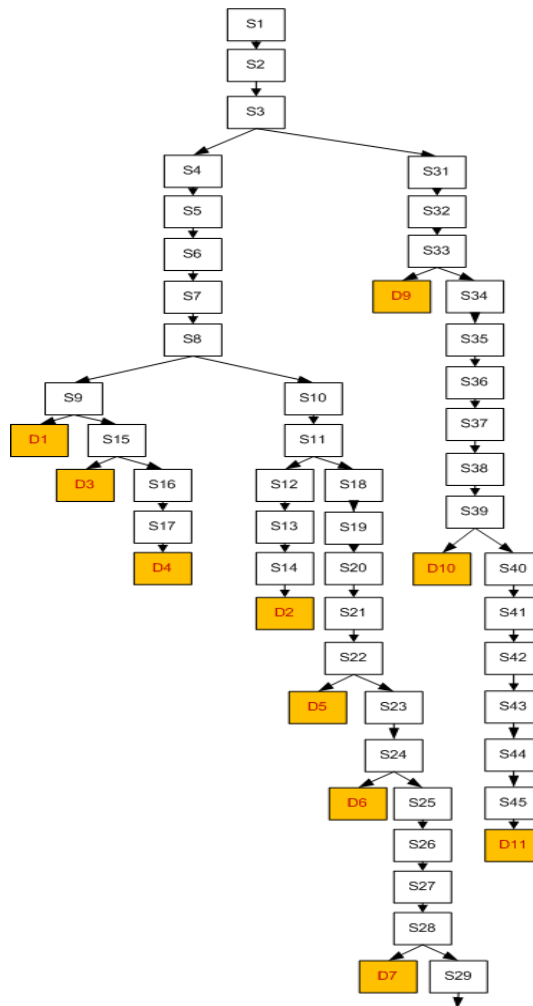
### 3.1. Clinical Pathway Pneumonia

Clinical pathway is a collaborative guideline for patient care that focuses on diagnosis, clinical problems and stages of service [14][15][16]. Clinical pathway combines the standard of care for each health worker in a systematic manner. The actions given are uniform in a standard of care, but still pay attention to the individual aspects of the patient. In general, individuals who develop pneumonia are caused by a decrease in the body's defense mechanism against the virulence of pathogenic organisms [17][18]. The onset of pneumonia is caused by viruses, bacteria, fungi, protozoa,

mycobacteria mycoplasma, and ricketts [19]. Figure.1 and Table 1 represents the clinical pathway for pneumonia patients based on the diagnosis of specialist nursing.

**Table 1.** Pneumonia Diagnosis

CODE	DIAGNOSIS	NANDA CODE
D1	Ineffective Airway Clearance	00031
D2	Impaired Gas Exchange	00030
D3	Ineffective Breathing Pattern	00032
D4	Risk for Infection	00004
D5	Acute Pain	00132
D6	Activity Intolerance	00092
D7	Hyperthermia	00007
D8	Risk for Deficient Fluid Volume	00028
D9	Risk for Imbalanced Nutrition: Less Than Body Requirements	00002
D10	Deficient Knowledge	00126
D11	Deficient Fluid Volume	00027



**Figure 1.** Clinical Pathway Pneumonia (COVID-19) For Nursing Care

Based on [Fig. 1](#), it can be seen that from the examination of each path it leads to the NANDA diagnosis which guides the nurses to determine the outcome or outcome to be achieved and the intervention or action that must be done according to the NANDA Code classification.

### 3.2. Knowledge Base

The problems in the research were solved by forming a heuristic model. The Heuristic Model is used to build a knowledge base model in the form of rules (IF-THEN Rules) [20]. The knowledge base in the form of these rules is a collection of rules that are related to one another. The rules to be used for nursing diagnosis (NANDA), Intervention (NIC) and Outcome (NOC) in the knowledge base of the system can be seen in [Table 3](#) and [Table 4](#).

**Table 2.** Knowledge Base

Code	Role
K1	<b>IF</b> Changes in rate, depth of respirations <b>AND</b> Abnormal breath sounds (rhonchi, bronchial lung sounds, egophony) <b>AND</b> Dyspnea, tachypnea <b>AND</b> Decreased breath sounds over affected lung areas <b>AND</b> Cyanosis <b>AND</b> Ineffective cough <b>AND</b> Purulent sputum <b>AND</b> Hypoxemia <b>AND</b> Infiltrates seen on chest x-ray film <b>THEN</b> Ineffective Airway Clearance
K2	<b>IF</b> Dyspnea, tachypnea <b>AND</b> Cyanosis <b>AND</b> Hypoxemia <b>AND</b> Pale, dusky, skin color <b>AND</b> Tachycardia <b>AND</b> Restlessness, irritability, changes in mentation <b>AND</b> Hypotension <b>AND</b> Disorientation <b>THEN</b> Impaired Gas Exchange
K3	<b>IF</b> Changes in rate, depth of respirations <b>AND</b> Abnormal breath sounds (rhonchi, bronchial lung sounds, egophony) <b>AND</b> Dyspnea, tachypnea <b>AND</b> Decreased breath sounds over affected lung areas <b>AND</b> Cyanosis <b>AND</b> Ineffective cough <b>AND</b> Purulent sputum <b>AND</b> Hypoxemia <b>AND</b> Infiltrates seen on chest x-ray film <b>AND</b> <b>THEN</b> Ineffective Breathing Pattern
K4	<b>IF</b> Reduced vital capacity <b>AND</b> Inadequate primary defenses (decreased ciliary action, stasis of respiratory secretions) <b>THEN</b> Risk for Infection
K5	<b>IF</b> Dyspnea, tachypnea <b>AND</b> Tachycardia <b>AND</b> Reports of discomfort: pleuritic chest pain, headache, muscle/joint pain <b>AND</b> Swelling of affected area <b>AND</b> Moaning, restlessness <b>AND</b> Facial mask, distraction behaviors <b>AND</b> Irritability <b>AND</b> Verbal report of weakness, fatigue, exhaustion <b>AND</b> Development/worsening of pallor/cyanosis <b>THEN</b> Acute Pain
K6	<b>IF</b> Dyspnea, tachypnea <b>AND</b> Tachycardia <b>AND</b> Verbal reports of weakness, fatigue, exhaustion <b>AND</b> Development/worsening of pallor/cyanosis <b>THEN</b> Activity Intolerance
K7	<b>IF</b> Body temperature above the normal range <b>AND</b> Hot, flushed skin <b>AND</b> Increased heart rate <b>AND</b> Increased respiratory rate <b>THEN</b> Hyperthermia
K8	<b>IF</b> Excessive fluid loss (fever, profuse diaphoresis, mouth breathing/hyperventilation, vomiting) <b>AND</b> Decreased oral intake <b>THEN</b> Risk for Deficient Fluid Volume
K9	<b>IF</b> Dyspnea, tachypnea <b>AND</b> Increased metabolic needs secondary to fever and infectious process <b>AND</b> Anorexia associated with bacterial toxins, the odor and taste of sputum, and certain aerosol treatments <b>AND</b> Abdominal distension/gas associated with swallowing air during dyspneic episodes <b>THEN</b> Risk for Imbalanced Nutrition: Less Than Body Requirements
K10	<b>IF</b> Requests for information <b>AND</b> Questions to health care team <b>AND</b> Statement of misconception/Failure to improve/recurrence <b>AND</b> Confusion about treatment <b>AND</b> Inability to comply with treatment regimen, including appropriate isolation procedures <b>THEN</b> Deficient Knowledge
K11	<b>IF</b> dry mucous membrane <b>AND</b> Decreased skin turgor <b>AND</b> Decreased urine output <b>AND</b> Increased urine concentration <b>AND</b> Fever <b>AND</b> Weakness <b>THEN</b> Deficient Fluid Volume

In addition to coding on the classification of nursing diagnoses (based on Nanda International), goals (Nursing Outcomes Classification–NOC) and interventions (Nursing Intervention Classification–NIC) in nursing care also have their own classification codes. The coding of the NOC classification (which is associated with pneumonia pathways) can be seen in [Table 3](#).

**Table 3. NOC Rule**

Code	Role
RNOC1	<b>IF</b> NANDA CODE00031 <b>THEN</b> NOC CODE 403 (Respiratory status: ventilation) <b>AND</b> 402 (Respiratory state: gas exchange) <b>AND</b> 410 (Respiratory status: patency of the airways) <b>AND</b> 1918 (Suction control)
RNOC2	<b>IF</b> NANDA CODE 00030 <b>THEN</b> NOC CODE 402 (Respiratory state: gas exchange) <b>AND</b> (403 Respiratory status: ventilation)
RNOC3	<b>IF</b> NANDA CODE 00032 <b>THEN</b> NOC CODE 403 (Respiratory status: ventilation) <b>AND</b> 410 (Respiratory status: patency of the airways) <b>AND</b> 802 (Vital sign status) <b>AND</b> 1402 (Anxiety control)
RNOC4	<b>IF</b> NANDA CODE 00004 <b>THEN</b> NOC CODE 204 (Consequences of immobility: physiological) <b>AND</b> 1101 (Tissue integrity: skin and mucous membranes) <b>AND</b> 1609 (Therapeutic conduct: illness or injury) <b>AND</b> 1807 (Knowledge: infection control) <b>AND</b> 1900 (Vaccination behavior) <b>AND</b> 1902 (Risk control) <b>AND</b> 1908 (Risk detection)
RNOC5	<b>IF</b> NANDA CODE 00132 <b>THEN</b> NOC CODE 2102 (Pain Level)
RNOC6	<b>IF</b> NANDA CODE 00092 <b>THEN</b> NOC CODE 1 (Resistance) <b>AND</b> 2 (Conservation of energy) <b>AND</b> 5 (Activity tolerance) <b>AND</b> 208 (Mobility level) <b>AND</b> 300 (Self-Care: Activities of Daily Living) <b>AND</b> 306 (Self-care: instrumental activities of daily living) <b>AND</b> 403 (Respiratory status: ventilation)
RNOC7	<b>IF</b> NANDA CODE 00007 <b>THEN</b> NOC CODE 08000 (Thermoregulation)
RNOC8	<b>IF</b> NANDA CODE 00028 <b>THEN</b> NOC CODE 602 (Hydration) <b>AND</b> 1608 (Symptom Control) <b>AND</b> 1902 (Risk control) <b>AND</b> 1908 (Risk detection)
RNOC9	<b>IF</b> NANDA CODE 00002 <b>THEN</b> NOC CODE 1004 (Nutritional status) <b>AND</b> 1005 (Nutritional status: biochemical determinations) <b>AND</b> 1008 (Nutritional status: food and fluid intake) <b>AND</b> 1009 (Nutritional status: nutrient intake) <b>AND</b> 1612 (Weight control) <b>AND</b> 1802 (Knowledge: diet)
RNOC10	<b>IF</b> NANDA CODE 00126 <b>THEN</b> NOC CODE 900 (Cognitive ability) <b>AND</b> 904 (Communication: receptive capacity) <b>AND</b> 905 (Concentration) <b>AND</b> 907 (Preparation of information) <b>AND</b> 908 (Memory) <b>AND</b> 1609 (Therapeutic conduct: illness or injury) <b>AND</b> 1802 (Knowledge: diet) <b>AND</b> 1805 (Knowledge: health behaviors) <b>AND</b> 1803 (Knowledge: disease process) <b>AND</b> 1808 (Knowledge: medication) <b>AND</b> 1811 (Knowledge: prescribed activity) <b>AND</b> 1813 (Knowledge: therapeutic regimen)
RNOC11	<b>IF</b> NANDA CODE 00027 <b>THEN</b> NOC CODE 501 (Bowel elimination) <b>AND</b> 503 (Urinary elimination) <b>AND</b> 601 (Water balance) <b>AND</b> 602 (Hydration) <b>AND</b> 1008 (Nutritional status: food and fluid intake)

Each NOC classification has different indicators and targets, which can be used as a knowledge base. The rules made in the knowledge base of the NOC classification on the pneumonia pathway are as in [Table 3](#).

**Table 4. NIC Rule**

Code	Role
RNIC1	<b>IF</b> NANDA CODE00031 <b>THEN</b> NIC CODE 3160 Aspiration of the airways <b>AND</b> 3140 (Airway management) <b>AND</b> 3230 (Respiratory physiotherapy) <b>AND</b> 3250 (Improving cough) <b>AND</b> 3320 (Oxygen Therapy) <b>AND</b> 3350 (Respiratory monitoring)
RNIC2	<b>IF</b> NANDA CODE 00030 <b>THEN</b> NIC CODE 3140 (Airway management) <b>AND</b> 3230 (Respiratory physiotherapy) <b>AND</b> 3230 (Respiratory physiotherapy) <b>AND</b> 3250 (Improving cough) <b>AND</b> 3320 (Oxygen Therapy) <b>AND</b> 3350 (Respiratory monitoring) <b>AND</b> 4490 (Help to quit smoking)
RNIC3	<b>IF</b> NANDA CODE 00032 <b>THEN</b> NIC CODE 3140 (Airway management) <b>AND</b> 3320 (Oxygen Therapy) <b>AND</b> 3350 (Respiratory monitoring) <b>AND</b> 5820 (Decreased anxiety)
RNIC4	<b>IF</b> NANDA CODE 00004 <b>THEN</b> NIC CODE 1876 (Urinary catheter care) <b>AND</b> 3660 (Woundcare <b>AND</b> 5622 (Teaching: Safe Sex) <b>AND</b> 6530 (Immunization / Vaccination)

	Management) <b>AND</b> 6540 (Infection control) <b>AND</b> 6550 (Protection against infection)
RNIC5	<b>IF</b> NANDA CODE 00132 <b>THEN</b> NIC CODE 1400 (Pain Management)
RNIC6	<b>IF</b> NANDA CODE 00092 <b>THEN</b> NIC COE 180 (Power Management) <b>AND</b> 200 (Exercise promotion) <b>AND</b> 1801 (Help with self-care: bathing / hygiene) <b>AND</b> 1802 (Help with self-care: dressing / grooming) <b>AND</b> 1804 (Help with self-care: grooming) <b>AND</b> 1850 (Encourage sleep) <b>AND</b> 3320 (Oxygen Therapy) <b>AND</b> 4040 (Cardiac care) <b>AND</b> 4310 (Activity therapy) <b>AND</b> 4410 (Establishing common goals) <b>AND</b> 4490 (Help to quit smoking) 5612 (Teaching: prescribed activity / exercise)
RNIC7	<b>IF</b> NANDA CODE 00007 <b>THEN</b> NIC CODE NIC 3740 (Fever Treatment) <b>AND</b> 4120 (Fluid Monitoring) <b>AND</b> 2380 (Medication Management) <b>AND</b> 6680 (Vital Sign Monitoring)
RNOC8	<b>IF</b> NANDA CODE 00028 <b>THEN</b> NIC CODE 4120 (Liquid handling) <b>AND</b> 4130 (Liquid monitoring)
RNOC9	<b>IF</b> NANDA CODE <b>THEN</b> 00002 NIC CODE 1030 (Management of eating disorders) <b>AND</b> 1100 (Nutrition management) <b>AND</b> 1240 (Weight gain aid) <b>AND</b> 2080 (Fluid / Electrolyte Handling) <b>AND</b> 5246 (Nutritional counseling)
RNOC10	<b>IF</b> NANDA CODE <b>THEN</b> 00126 NIC CODE 1100 (Nutrition management) <b>AND</b> 5510 (Health education) <b>AND</b> 5520 (Facilitate learning) <b>AND</b> 5566 (Parental education: family rearing of children) <b>AND</b> 5602 (Teaching: disease process) <b>AND</b> 5606 (Teaching: individual) <b>AND</b> 5612 (Teaching: prescribed activity/exercise) <b>AND</b> 5614 (Teaching: prescribed diet) <b>AND</b> 5616 (Teaching: Prescription Drugs) <b>AND</b> 6530 (Immunization / Vaccination Management) <b>AND</b> 7370 (Discharge planning) <b>AND</b> 7400 (Health system guides)
RNOC11	<b>IF</b> NANDA CODE <b>THEN</b> 00027 NIC CODE 4120 (Liquid handling) <b>AND</b> 4130 (Liquid monitoring) <b>AND</b> 4180 (Management of hypovolemia)

The coding of the NIC classification (which is related to the pneumonia pathway) can be seen in [Table 4](#). Each NIC classification has different activity details, which can be used as a knowledge base. Based on previous nursing diagnoses obtained from the pneumonia pathway, nursing care interventions can refer to the NIC classification code table. NIC rules on the pneumonia pathway can be seen in [Table 4](#).

### 3.3. Model Rule Based Reasoning For Pnuemonia Nursing Care

[Figure 2](#) shows the flow of the rule-based reasoning model in nursing care for pneumonia caused by bacteria, fungi and viruses (one of which is COVID-19). If there are new facts about the characteristics of pneumonia patients, the inference engine will search the knowledge base and assess suitability against the diagnostic classification of NANDA. If a match is found, the system will display the NOC and NIC which are used as a reference by the nurse to determine the outcome that must be achieved in the disorder and the interventions that must be done in the disorder. Meanwhile, if no match is found, the system will resolve the problem at hand, then look for and find new rules and new diagnoses related to the problem.

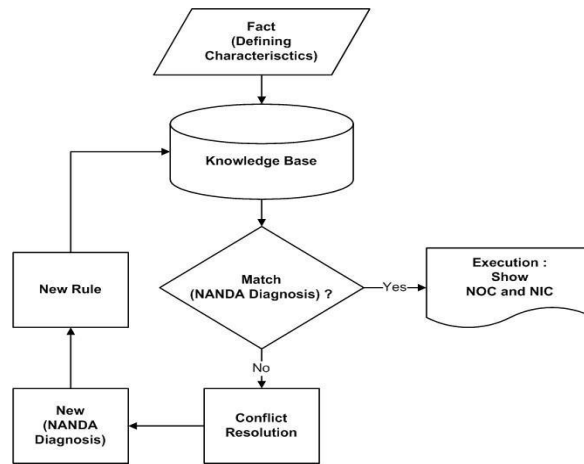


Figure 2. Model Rule Based Pneumonia (COVID 19) Nursing Care

### 3.4. Inference Method With Forward Chaining



Figure 3. Forward Chaining NANDA

Note :

- S31 : Increased metabolic needs secondary to fever and infectious process
- S32 : Anorexia associated with bacterial toxins, the odor and taste of sputum, and certain aerosol treatments
- S33 : Abdominal distension/Sas associated with swallowinS air durinS dyspneic episodes
- NANDA 00002 : Risk for Imbalanced Nutrition: Less Than Body Requirements

**IF** NANDA CODE 00002 **THEN** NOC CODE 1004 (Nutritional status) **AND** 1005 (Nutritional status: biochemical determinations) **AND** 1008 (Nutritional status: food and fluid intake) **AND** 1009 (Nutritional status: nutrient intake) **AND** 1612 (Weight control) **AND** 1802 (Knowledge: diet)

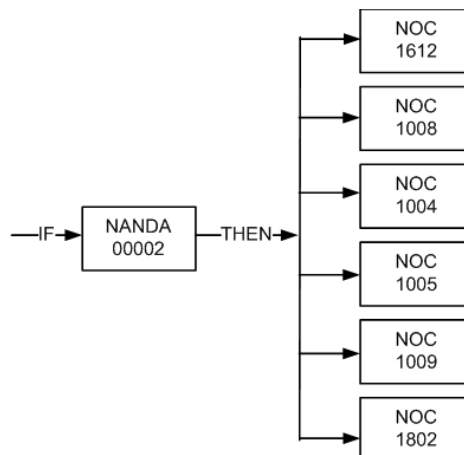


Figure 4. Output NOC

Note :

NOC 1612 : Weight control

NOC 1008 : Nutritional status; food and fluid intake

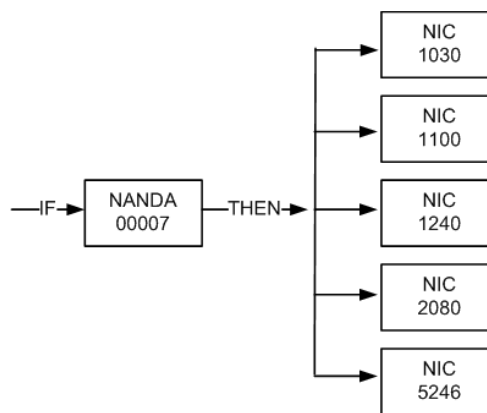
NOC 1004 : Nutritional status

NOC 1005 : Nutritional status; biochemical determinations

NOC 1009 : Nutritional status; nutrient intake

NOC 1802 : Knowledge diet

**IF** NANDA CODE **THEN** 00002 NIC CODE 1030 (Management of eating disorders) AND 1100 (Nutrition management) AND 1240 (Weight gain aid) AND 2080 (Fluid / Electrolyte Handling) AND 5246 (Nutritional counseling).



**Figure 5.** Output NIC

Note :

NIC 1030 : Management of eating disorders

NIC 1100 : Nutrition management

NIC 1240 : Weight gain aid

NIC 2080 : Fluid / Electrolyte Handling

NIC 5246 : Nutritional counseling

#### 1. 4. Conclusion

This study shows the variability of nursing care problems in pneumonia caused by one of them by COVID-19, both according to the area affected and according to the severity. The taxonomic triangulation technique has made it possible to identify a range of diagnoses and variables for assessment, planning, and intervention, from written sources supported by Nurse Lab and WHO. This methodology can be applied to generate other health processes knowledge from the nursing care model. Finally, these results are offered as a guide for the elaboration of individual treatment plans, clinical decision making, and as a reference for other similar studies.

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