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International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 8, August 2018, pp. 17–26, Article ID: IJCIET_09_08_003
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

ANALYSIS OF NURSING DIAGNOSIS USING AN EXPERT SYSTEM IN PAEDIATRIC PATIENTS

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ABSTRACT

Nursing diagnosis refers to clinical decision-making in nursing care. It can determine precision of nursing actions, speeding up the patient's recovery. The problem faced by nurses in Indonesia is that most nursing diagnoses enforced by them in hospitals do not have high accuracy, due to uneven quality of resources. One solution is to develop a nursing diagnosis analysis with an expert system using a forward chaining method, done by a search starting from picking up new facts (symptoms) to drawing a conclusion. This method is also designed using the programming language PHP (Hypertext Pre-processor) and MySQL as software or database management software system with rule-based reasoning. The system is designed with high speed and high accuracy. The expert system design's result is that there are 58 nursing diagnoses in paediatric patients with medical diagnoses of bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, upper respiratory tract infection, febrile seizures and morbilli in common between the expert system and expert nurses (100%). Therefore, it can be used as an alternative support for nursing diagnoses in paediatric patients.

Key words: Expert system, forward chaining, nursing diagnosis, paediatric patients.

Cite this Article: Abdul Aziz Alimul Hidayat and Musrifatul Uliyah, Analysis of Nursing Diagnosis Using an Expert System in Paediatric Patients. *International Journal of Civil Engineering and Technology*, 9(8), 2018, pp. 17-26.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=8

1. INTRODUCTION

Nursing diagnosis is one form of clinical decision-making in nursing care. Its accuracy can help speed patient's healing. However, many established nursing diagnoses have low accuracy. In Indonesia, most nurses do not refer to nursing diagnoses in performing nursing actions, but follow doctors' instructions, partly due to their low ability in clinical decision-

making (nursing diagnosis). Additionally, it takes longer to serve the patient, without utilising information technology in decision-making [1].

One effort can be to use an expert system tool, already widely used in the medical technology field. It is a system, seeking to adapt human knowledge to the computer, so that it can solve problems in same way as experts. Several studies have been conducted using expert systems in diagnosing diseases. Mulyani and Restianie's research [2] produced an expert system to diagnose under-five children's illness. Suwarso et al. [3] produced an expert system for childhood diseases, using a forward chaining method. Aribowo [4] developed an intelligent system using case-based reasoning for diagnosis of endemic virus diseases, while Kusnadi's research [5] produced an expert system for diagnosing diseases in humans. Wijaya and Prastiyowati [6] produced an expert system diagnosing typhoid fever and dengue with a forward chaining method. Labellapansa and Boyz [7] produced an expert system for early diagnosis of vitamin and mineral deficiencies. The pomegranate research [8] produced an expert system for diagnosis of autistic patients. Dhani and Yamasari's research [9] produced an expert system to diagnose degenerative diseases. Yunus and Setyowibowo's study [10] resulted in a lung disease diagnosis support system application with a forward chaining method. Madeso's research [11] resulted in an expert system of determining nutritional status in infants using a forward chaining method. Handayani and Sutikno [12] produced an expert system capable of diagnosing liver diseases and another one capable of diagnosing otolaryngology diseases [13].

Some of these studies are still based on medical diagnostic research, but no studies utilise expert systems for nursing diagnoses, despite the clear distinction between medical and nursing diagnosis: medical diagnosis is pathologically-oriented, while nursing diagnoses are oriented towards human response and thus are more complicated [14-16], to the extent that using human capability would take a long time, thus raising the need for an easy, fast and highly accurate alternative. This is made possible with a computer's help by using an expert system, from which a model of computer-based nursing diagnosis analysis with an expert system is developed. This article aims to explain the use of such expert system in the analysis of nursing diagnoses in paediatric patients.

2. RESEARCH METHOD

Data were collected from paediatric patients treated at Muhammadiyah Hospital Surabaya, East Java, in January-July 2017. Sample criteria included paediatric patients with medical diagnosis of bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, upper respiratory tract infection (URI), febrile seizures or morbilli.

The expert system used in this study applies a forward chaining method, a search method starting from picking up new facts to drawing a conclusion. In this case, symptoms are facts. After identifying all selected symptoms, nursing diagnosis' conclusion of an existing disease can be drawn. Furthermore, knowledge base used is rule-based reasoning as shown in Table 1, using the IF-THEN syntax connecting antecedents with consequences. Assessment of the nursing diagnosis is divided into two categories, namely actual diagnosis and risk diagnosis. Actual diagnosis is made if >80% of major symptoms are identified, while risk diagnosis covers at least one risk factor (symptom). This method is also designed using the programming language PHP (Hypertext Pre-processor) and MySQL as software or database management software system.

Table 1 Knowledge base of the association of signs and symptoms with diagnosis of paediatrics in paediatric patients, based on Indonesian nursing diagnosis standards

No	Regulation
1	IF ineffective cough AND *unable to cough AND clean sputum AND wheezing or dry bronchi AND meconium in the airway (neonatal)* THEN ineffective airway clearance
2	IF *dyspnoea AND PCO2 increases/decreases AND* PO2 decreases AND *tachycardia AND arterial pH increases/decreases AND additional breath sounds T*HEN impaired gas exchange
3	IF *dyspnoea AND* PO2 decreases AND *use of respiratory auxiliary muscles AND tidal volume decreased AND PCO2 increases AND SaO2 decreased T*HEN impaired spontaneous ventilation
4	IF *dyspnoea AND use of respiratory auxiliary muscles AND* lengthy expiratory phase AND abnormal breathing patterns (tachypnoea, bradypnea, hyperventilation, Kussmaul, Cheyne-Stokes) THEN ineffective breathing pattern
5	IF not responding AND *pulse rate <50 times/minute or >150 times/minute AND systolic blood pressure <60 mmHg or >200 mmHg AND* frequency of breath <6 times/minute or >30 times/minute AND decreased consciousness or unconsciousness THEN impaired spontaneous circulation
6	IF capillary refile time *>3 seconds AND* peripheral pulses decreased or not palpable AND cold acral AND *pale skin colour AND skin turgor decreases* THEN ineffective peripheral tissue perfusion
7	IF lack of fluid volume AND hypoxia AND hypothermia AND hypokalaemia/hyperkalaemia AND hypoglycaemia/hyperglycaemia AND acidosis AND poisoning AND heart tamponade AND *pneumothorax tension AND* heart thrombosis AND pulmonary thrombosis (pulmonary embolism) THEN risk of impaired spontaneous circulation
8	IF aneurysm AND gastrointestinal disorders AND liver dysfunction AND *coagulation disorders AND* effects of pharmacological agents AND surgery AND trauma AND malignant process THEN risk of bleeding
9	IF hypoglycaemia/hyperglycaemia AND heart tamponade AND aneurysm AND gastrointestinal disorders AND liver dysfunction AND *coagulation disorders AND* effects of pharmacological agents AND surgery AND trauma AND acute gastrointestinal bleeding AND abdominal compartment syndrome THEN risk of ineffective gastrointestinal perfusion
10	IF hypoglycaemia/hyperglycaemia AND trauma THEN risk of ineffective peripheral perfusion
11	IF lack of fluid volume AND hypoxia AND hypoglycaemia/hyperglycaemia AND acidosis AND surgery AND trauma AND malignant process AND abdominal compartment syndrome AND *hypoxemia AND* burns AND *sepsis* THEN risk of ineffective renal perfusion
12	IF BMI >25 kg/m2 (adult) or weight and height >95 percentile for child <2 years or BMI in 86-95 percentile (child 2-18 years) THEN overweight
13	IF *weight decreases at least 10% below ideal range* THEN nutritional deficiency
14	IF *defecation is more than three times in 24 hours AND soft or liquid faeces* THEN diarrhoea
15	IF no flatus AND *abdominal pain/cramps AND* peristaltic voice changes (no peristaltic voice, hypoactive or hyperactive) THEN gastrointestinal motility dysfunction
16	IF *dyspnoea AND orthopnoea AND* paroxysmal nocturnal dyspnoea AND oedema anasarca and/or peripheral oedema AND weight gain increases in a short time AND Jugular Venous Pressure (JVP) and/or Central Venous Pressure (CVP) increases AND *positive hepatojugular reflexes* THEN hypervolemia
17	IF *skin turgor decreases AND* pulse frequency increases AND pulse is weakly palpable AND *blood pressure decreased AND pulse pressure narrows AND dry mucous membranes*

	AND urine volume decreased AND *increased haematocrit* THEN hypovolemia
18	IF sleepy AND dizzy AND coordination disorder AND low blood glucose/urine levels AND weak or lethargic AND high blood glucose levels or urine THEN unstable blood glucose level
19	IF BMI >27 kg/m2 (in adults) or more than the 95th percentile for the age and sex of the child THEN obesity
20	IF weight gain increases in a short time AND hypoglycaemia/hyperglycaemia AND *less daily activity AND* excess sugar consumption AND eating disorder AND *energy use is less than intake AND* often snacking AND often eating greasy/fatty foods AND heredity factor AND use of formula foods AND *low calcium intake AND* solid food before the age of 5 years THEN risk of overweight
21	IF *unable to swallow a meal AND* unable to digest food AND *unable to absorb nutrients AND* increased metabolic requirements AND lacking economic factors AND psychological factors (stress, reluctance to eat) THEN risk of nutritional deficiency
22	IF hypoglycaemia/hyperglycaemia AND gastrointestinal disorders AND effects of pharmacological agents AND surgery AND *less daily activity AND* psychological factors (stress, reluctance to eat) AND anxiety THEN risk of gastrointestinal motility dysfunction
23	IF gastrointestinal disorders AND effects of pharmacological agents AND *lack of fluid intake AND* overweight AND evaporation AND hypermetabolic THEN risk of hypovolemia
24	IF gastrointestinal disorders AND surgery AND trauma AND burns AND *intestinal dysfunction AND* kidney illness THEN risk of imbalanced fluid volume
25	IF lack of fluid volume AND gastrointestinal disorders AND surgery AND hypermetabolic AND kidney illness AND excess liquid volume THEN risk of electrolyte imbalance
26	IF overweight AND stress AND uncontrolled medication management AND inappropriateness of glucose monitoring THEN risk of unstable blood glucose level
27	IF lack of fluid volume AND hypoxia AND *hypoxemia AND sepsis AND* hypotension THEN risk of shock
28	IF *urge to urinate (urgency) AND* urine drip (dribbling) AND *frequent urination AND nycturia AND* wetting the bed AND *enuresis AND* bladder distension AND urination is not complete (hesitancy) AND *the volume of urine residue increases* THEN impaired urinary elimination
29	IF extremity hyperextension AND finger stretch or handgrip AND abnormal response to sensory stimuli AND uncoordinated movements THEN infant behavioural disorder
30	IF weak or lethargic AND heart frequency increase >20% of resting conditions THEN activity intolerance
31	IF weak or lethargic AND feel energy not recovered despite sleep AND *feel less energy AND* complaining tired AND *unable to maintain routine activities* THEN fatigue
32	IF excess sensory stimulation AND *prematurity AND* invasive procedures AND motor disorders AND congenital abnormalities AND *genetic disorders* THEN risk of infant behavioural disorder
33	IF *circulatory disorders AND* physical inadequacy AND respiratory disorders AND history of activity intolerance THEN risk of activity intolerance
34	IF hypoglycaemia/hyperglycaemia AND surgery AND trauma AND burns AND immobilization AND *fracture AND* vascular obstruction AND *mechanical suppression* THEN risk of peripheral neurovascular dysfunction
35	IF complaining uncomfortable AND anxious THEN impaired comfort
36	IF complaining of nausea AND *feeling like throwing up AND* not interested in eating THEN nausea
37	IF pulse frequency increases AND anxious AND complaining of pain AND *without grimacing AND* be protective (avoid pain) AND *hard to sleep* THEN acute pain
38	IF anxious AND complaining of pain AND *without grimacing AND feel depressed AND* unable to complete activity THEN chronic pain
39	IF anxious AND *hard to sleep AND* feel confused AND feel worried AND difficult to concentrate AND look tense THEN anxiety

40	IF unable to perform specific age-appropriate skills or behaviours (physical, linguistic, motor and psychosocial) AND physical growth disturbed THEN impaired growth and development
41	IF effects of pharmacological agents AND *prematurity AND* congenital abnormalities AND *genetic disorders AND* nutrient inadequacy AND inadequate prenatal care AND delay of prenatal care AND endocrine disorders AND brain damage AND *chronic illness AND* infection AND persecution AND hearing disorders AND impaired vision AND learning disability AND weak economy THEN risk of impaired growth
42	IF *prematurity AND* congenital abnormalities AND *genetic disorders AND* nutrient inadequacy AND *chronic illness AND* infection AND weak economy THEN risk of impaired development
43	IF *asking for problems encountered AND* showing inappropriate behaviour AND shows wrong perception of the problem THEN knowledge deficiency
44	IF refuse to undergo treatment AND *refuse to follow suggestions AND* behaviour does not follow the treatment program AND behaviours do not apply recommendations THEN noncompliance
45	IF damage to tissues and/or skin layers THEN impaired skin/tissue integrity
46	IF body temperature above normal value THEN hyperthermia
47	IF allergies to food such as avocados, bananas, kiwis, nuts, processed seafood, tropical fruits, mushrooms AND exposed to allergens AND exposed to environmental allergens AND insect stings THEN risk of allergy
48	IF lack of fluid volume AND *circulatory disorders AND* immobilization AND *mechanical suppression AND* changes in nutritional status AND h*umidity AND* radiation therapy AND *extreme environmental temperature* THEN risk of impaired skin/tissue integrity
49	IF effects of pharmacological agents AND trauma AND *prematurity AND* low environmental temperature AND extreme body weight AND damage to the hypothalamus AND malnutrition AND wear thin clothes AND *no activity AND* heat transfer (conduction, convection, evaporation, radiation) AND new-born baby AND *low birth weight* THEN risk of hypothermia
50	IF invasive procedures AND *chronic illness AND* malnutrition AND peristaltic disorders AND *damage to skin integrity AND decreased haemoglobin AND* leukopenia AND vaccination is not adequate AND *immunosuppression AND suppression of inflammatory response AND* change of pH secretion THEN risk of infection
51	IF lack of fluid volume AND effects of pharmacological agents AND infection AND *extreme environmental temperature AND* extreme body weight AND acute brain injury AND clothes do not fit the ambient temperature AND the need for oxygen increases THEN risk of ineffective thermoregulation
52	IF skin cold/warm AND shivering AND fluctuating body temperature THEN ineffective thermoregulation
53	IF *defecation less than 2 times a week AND long and* difficult release of stools AND *hard stool AND intestinal peristalsis decreases* THEN constipation
54	IF malnutrition AND changes in cognitive function AND changes in psychomotor function AND tissue hypoxia AND *biochemical dysfunction AND* autoimmune dysfunction AND *change of sensation AND* changes in affective orientation AND abnormal blood profile AND inability of transportation AND exposed to nosocomial agents AND exposed to toxic chemicals AND exposed to pathogens THEN risk of injury
55	IF G106 & G107 THEN D55 interrupted family processes
56	IF feel neglected AND does not meet the needs of family members AND intolerant AND ignore family members THEN disabled family coping
57	IF patients complain/worry about the response of closest people to health problems AND the closest person withdraws from the patient AND limited communication of people closest to the client THEN derivation of family coping
58	IF complaining difficulty to move extremities AND muscle strength decreases AND *range of motion (ROM) decreases* THEN impaired physical mobility

3. RESULTS AND ANALYSIS

Expert system for analysis of nursing diagnoses in paediatric patients with bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, URI, febrile seizures, morbilli diseases is shown in Figure 1.

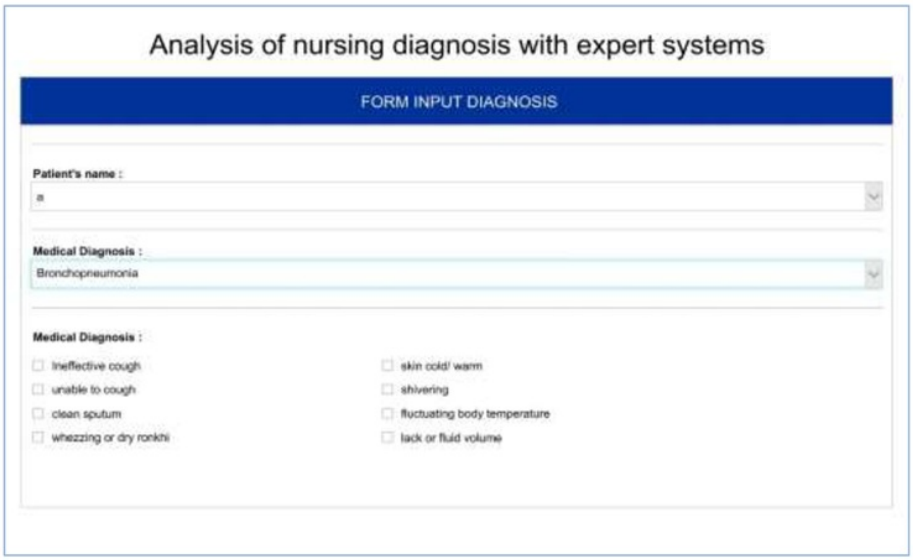

Figure 1 Input display of the nursing diagnosis expert system

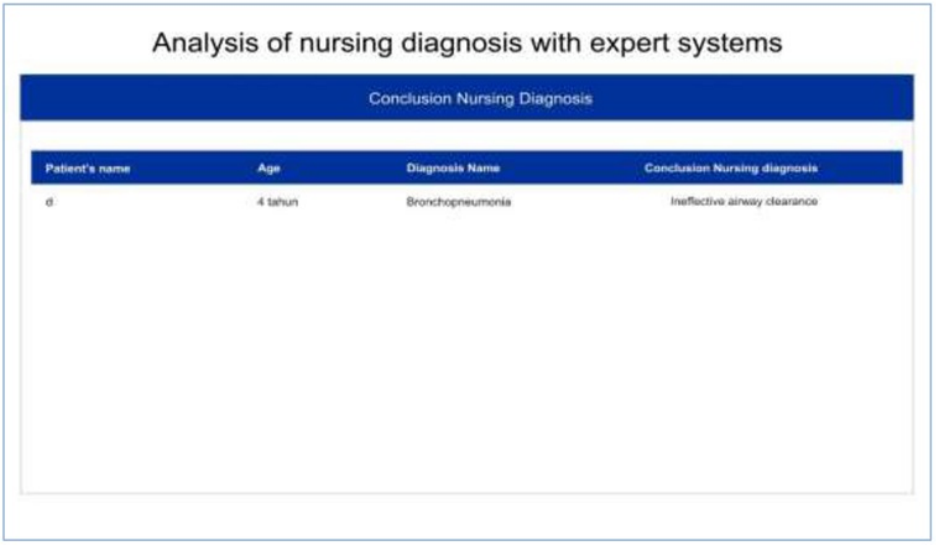

Figure 2 Conclusion page of the results of nursing diagnostic analysis in paediatric patients using the expert system

Figure 1 shows the initial stage of nursing diagnostic analysis using the expert system. The input menu consists of patient's name and choice of medical diagnosis comprising bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, upper respiratory infection (URI), febrile seizures and morbilli. Users can use the system by inputting name and

age and choosing a diagnosis of illness experienced. Afterwards, the user will be asked to choose symptoms experienced from among the listed symptoms. After completion of the choice of symptoms, the user is asked to click the diagnosis check button, then the conclusion of the diagnosis will appear as in Figure 2.

Results of the nursing diagnosis analysis between expert nurses and expert system in 30 paediatric patients show no difference with 100% similarity; hence, the expert system has high accuracy in the analysis of nursing diagnoses in paediatric patients, as shown in Table 2.

Table 2. Experimental nursing diagnostic analysis test results

No	Patient Nursing Diagnosis with Expert System	Nursing Diagnosis by Nurse
1	nutritional deficiency	nutritional deficiency
2	risk of electrolyte imbalance	risk of electrolyte imbalance
3	diarrhoea	diarrhoea
4	anxiety	anxiety
5	impaired gas exchange	impaired gas exchange
6	ineffective airway clearance	ineffective airway clearance
4	knowledge deficiency	knowledge deficiency
8	risk of hypovolemia	risk of hypovolemia
	risk of infection	risk of infection
9	risk of nutritional deficiency	risk of nutritional deficiency
	risk of infection	risk of infection
10	risk of nutritional deficiency	risk of nutritional deficiency
	knowledge deficiency	knowledge deficiency
11	hyperthermia	hyperthermia
12	constipation	constipation
	impaired comfort	impaired comfort
13	risk of impaired skin/tissue integrity	risk of impaired skin/tissue integrity
14	chronic pain	chronic pain
	risk of impaired development	risk of impaired development
15	gastrointestinal motility dysfunction	gastrointestinal motility dysfunction
	risk of ineffective thermoregulation	risk of ineffective thermoregulation
16	anxiety	anxiety
	risk of hypothermia	risk of hypothermia
17	hyperthermia	hyperthermia
	acute pain	acute pain
18	risk of gastrointestinal motility dysfunction	risk of gastrointestinal motility dysfunction
19	nausea	nausea
	ineffective thermoregulation	ineffective thermoregulation
20	activity intolerance	activity intolerance
21	risk of bleeding	risk of bleeding
22	impaired growth and development	impaired growth and development
23	risk of hypovolemia	risk of hypovolemia
24	nausea	nausea
	ineffective breathing pattern	ineffective breathing pattern
25	ineffective thermoregulation	ineffective thermoregulation
	infant behavioural disorder	infant behavioural disorder
26	impaired growth and development	impaired growth and development
	impaired gas exchange	impaired gas exchange
27	disabled family coping	disabled family coping
	impaired comfort	impaired comfort
28	knowledge deficiency	knowledge deficiency
	nutritional deficiency	nutritional deficiency
29	ineffective airway clearance	ineffective airway clearance
	hyperthermia	hyperthermia
30	anxiety	anxiety
	impaired spontaneous ventilation	impaired spontaneous ventilation

The expert system generated in the development of a model of nursing diagnostic analysis in paediatric patients with eight medical diagnoses, including bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, URI, febrile seizures and morbilli, was able to identify 58 actual and familial density diagnoses with 235 symptoms and risk factors.

The system uses web-based forward chaining inference method, easily accessible by nurses or nursing students anywhere with the provision of an internet network. The system has an input menu, including patient's name, age, type of medical diagnosis, symptoms experienced and inference results for paediatric patients according to symptoms or risk factors experienced by patients.

It is built to facilitate the application of theory into practice in the appropriate field and has high accuracy in making the diagnosis. Such system can provide a nursing diagnosis solution. The system processes can be exemplified as follows: in the first step, the patient is asked to choose a medical diagnosis, used for focus questions related to the diagnosis, which will occur. If not limited to aspects of medical diagnosis, the symptoms and risk factors raise many choices, taking a long time in the data input, which should be tailored according to priority of nursing problems experienced by the patient.

The second step chooses symptoms and risk factors experienced by the patient along with the results of interviews, physical and laboratory examinations, put into the menu of experienced symptoms' selection. The third step involves searching for a type of nursing diagnosis with symptoms and risk factors according to the knowledge base, finding the number of symptoms met by the selected symptoms on the knowledge base and performing calculations of minimum percentage requirements of symptoms experienced in accordance with the knowledge base. Actual nursing diagnosis requires a minimum of 80% of the major symptoms available, while risk nursing diagnosis occurs when at least one risk factor can be labelled as a risk diagnosis.

Based on results of the trial on patients in Table 2, no difference was found between results of nursing diagnosis analysis by the expert system and by expert nurses. This proves that the system can be used as an alternative in providing nursing services and establishing a nursing diagnosis quickly and accurately. This condition is very appropriate with condition of nurse resources in various hospitals with diverse backgrounds and abilities, especially in analysis of nursing diagnoses.

This is also supported by Handayani and Sutikno's [13] research that an expert system designed with e2gLite Expert System Shell for diagnosis of otolaryngology diseases can work as expected. It can identify 23 types of otolaryngology diseases, based on input variations of 38 symptoms given. Dhani's study [17] on an expert system's use for childhood disease diagnosis declared that an expert system with forward chaining inference method can identify symptoms in children to diagnose childhood illness along with its causes and treatment. Norouzi et al.'s study [18] also states that an intelligent fuzzy expert system can accurately predict the type of a chronic kidney disease. Putra and Prihatini's research [19] using fuzzy logic in expert system can overcome vagueness of symptoms experienced by the disease, with the result of 94.99%; there is similarity of expert system with expert diagnosis, so that the system can be used in supporting the validity of disease diagnosis. Similarly, Supriyanti [20] developed a simple system, which can be used to screen high-risk pregnancies. Based on an expert system, it uses the Analytical Hierarchy Process (AHP) method for decision-making about potentially high-risk pregnancies. The result is that expert systems can screen for high-risk pregnancies.

Several other research results that support this study's results have differences with this study, which all studies using expert systems to support medical diagnosis (diagnosis based on disease's pathology), but this study's finding is the expert system developed is able to diagnose the diagnosis nursing (diagnosis based on patient response, not disease pathology).

Based on these, the expert system can be used as a tool to help support determination of the diagnosis. This system application in nursing, now developed, is used as a tool to support clinical decisions. In its development, it is necessary to construct the concept of nursing, nursing information and decision-making to improve professional services and required standards in nursing practice [21].

4. CONCLUSIONS

The expert system generated using web-based forward chaining inference method comprises an input menu, including patient name, age, type of medical diagnosis, symptoms experienced and inference results for paediatric patients according to symptoms or risk factors, experienced by the patient. The system is able to identify 58 types of nursing diagnoses in both actual and risk diagnoses with 235 signs and symptoms, as well as risk factors from eight types of medical diagnosis in paediatric patients, including bronchopneumonia, bronchitis, typhoid fever, febris, gastroenteritis, URI, febrile seizures and morbilli. Nursing diagnostic tests' results with the expert system and nursing diagnoses by expert nurses show 100% similarity. Therefore, the expert system in the analysis of nursing diagnoses in paediatric patients can be implemented in nursing diagnosis. It is a tool to assist validation of nursing diagnoses in paediatric patients, is accurately effective and efficient and can provide convenience to nurses in conducting nursing diagnosis analysis.

ACKNOWLEDGMENTS

The researcher would like to thank the Ministry of Technology Research and Higher Education of the Republic of Indonesia for funding Research of Applied Products by Letter No. 147/SP2H/K2/KM/2017.

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