Enferm Clin. 2019;29(S2):905–909

Enfermería Clínica

www.elsevier.es/enfermeriaclinica

Developing Shinta's Early Deterioration Detection by using Fuzzy Logic Algorithm in Indonesia☆

Shintha Silaswati[a], **Junaiti Sahar**[a,*], **Nina Kemala Sari**[c], **Saptawati Bardosono**[c], **Bino Christanto**[b]

[a] *Faculty of Nursing, Universitas Indonesia, Depok, West Java, Indonesia*
[b] *Bani Saleh Health Sciences Institute, Bekasi, West Java, Indonesia*
[c] *Dr. Ciptomangunkusumo Hospital, Jakarta, Indonesia*

Received 13 November 2018; accepted 17 April 2019
Available online 20 July 2019

KEYWORDS
Elderly deterioration detection;
Fuzzy Logic algorithm;
Indonesia's instrument

Abstract
Objective: To design an application that detects health deterioration in elderly (System for Health Aging Instrument Automation) Shinta's Early Deterioration Detection (SEDD) by using Fuzzy Logic Algorithm (FLA) for smartphone and android.
Method: The study design was experimental with simple random sampling method involving 130 data. Fuzzification, inference, and defuzzification are a process to formulate a mapping of independent variables processed into a groundwork, which decides dependent variables (output) by using fuzzy logic.
Results: Prototype or android-based Shinta's Early Deterioration Detection model facilitates detection of health deterioration in older people who are admitted in hospital in Indonesia with accuracy value α 96.85% and effectiveness value β 36.5 s.
Conclusion: SEDD is able to evaluate health deterioration in elderly patient at the moment of admission in ward. Nurse may make a clinical decision immediately. It may reduce the risk for disability and mortality as well.
© 2019 Elsevier España, S.L.U. All rights reserved.

Introduction

Age-related changes include diminishing function of body organs that may result in risk factors such as immobility, incontinence, insomnia, instability, isolation, polypharmacy, malnutrition, balance disorder, visual and hearing impairment, depression, and infection.[1] Health issues that develop

☆ Peer-review under responsibility of the scientific committee of the Second International Nursing Scholar Congress (INSC 2018) of Faculty of Nursing, Universitas Indonesia. Full-text and the content of it is under responsibility of authors of the article

* Corresponding author.
E-mail address: junsr@ui.ac.id (J. Sahar).

https://doi.org/10.1016/j.enfcli.2019.06.014
1130-8621/© 2019 Elsevier España, S.L.U. All rights reserved.

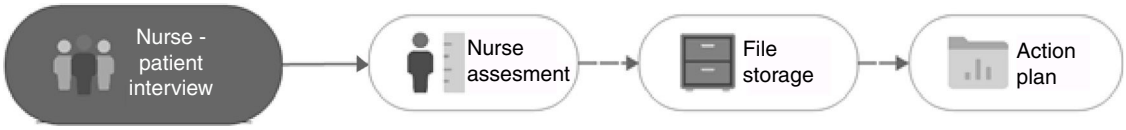

Figure 1 Old methods commonly used by nurses in Indonesia' hospitals.

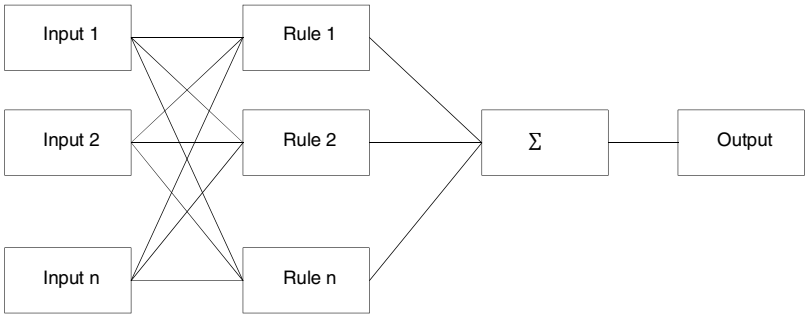

Figure 2 Fuzzy Logic Algorithm Process.

in elderly patient require immediate treatment from medical team, including nurse, in order to detect deterioration of health condition. Nurse is required to take a drastic measure by referring the elderly to a more complex health facility in order to minimize the risk for dependency and disability through an appropriate and rapid intervention. Specific skill is critical considering their multi-pathological characteristic and functional decline of multiple organs. Functional decline of multiple organs in elderly plays a major in fulfillment of daily needs.[2]

Health deterioration in older people may indicate physical, mental, cognitive, social, and spiritual changes. Decline in physical, mental, and cognitive capacity serves as an indicator of health deterioration in elderly.[3–5] Decline in social and spiritual aspect in elderly patients has always been neglected.[6–8]

Application of professional nursing care is a clinical decision-making process. A quick, accurate, and specific clinical decision should be planned since data collection or assessment phase until evaluation phase. Ability to systematically identify and evaluate achievement of objectives in nursing care is professional responsibility. Poor quality of assessment conducted by the nurse may lead to inadequacy in rapid detection of patient's condition.[9] Such circumstance affects the accuracy of clinical decision making by the nurse.[10] It may be difficult for nurse to accurately identify patient's condition and or response toward health deterioration[11] which requires a proper assessment technique capable of immediately identifying health deterioration in elderly so the nurse may provide a quick, appropriate, and accurate intervention.[12]

The common situation in hospitals in Indonesia is that nurse puts all paper-based data gathered from interview and assessment in file storage and it will be picked up only when establishing an action plan (Fig. 1).

This study was focused on development of nursing information system to facilitate information collection process, accelerate decision-making, and assist in data distribution process.

This study was aimed to develop a model detecting health deterioration in elderly by using digital application with expert system approach. Detection result on elderly's health deterioration which generated by this application was an initial summary. The user was the first nurse who met the patient prior to admission in ward and before further examination by physician in charge.

Method

SDD was developed by using FLA case-based reasoning method (Fig. 2). FLA is a system that utilizes old experience to solve recent issues. Stages of FLA performed by computer included: fuzzification, inference, and defuzzification.[13–15]

Case representation: FLA depends on the structure and content of data registered by the nurse. The case may be recalled to identify health deterioration based on clinical manifestations input into the device.[13,15]

Nearest Neighbor: is a method used to calculate similarity rate between new cases and old cases, which had been included in database.[13,15,16] The process is performed after retrieval of information of older cases that had been indexed. Nearest Neighbor, formula applied to calculate similarity between two cases is outlined below.

The fuzzy *K*-nearest neighbor (FNN) algorithm[17] was introduced to classify test objects based on their similarity to a given number *K* of neighbors (among the training objects), and these neighbours' membership degrees to (crisp or fuzzy) class labels (Fig. 3). For the purposes of FNN, the extent $C'(y)$ to which an unclassified object *y* belongs to a class *C* is computed as:

$$C'(y) = \sum_{x \in N} R(x, y)C(x)$$

where *N* is the set of object *y*'s *K* nearest neighbours,[18] obtained by calculating the fuzzy similarity between *y* and all training objects, and choosing the *K* objects that have highest similarity degree. $R(x,y)$ is the [0,1]-valued

Algorithm 1: The FNN algorithm

Input: X, the training data; $\mathcal{C}$, the set of decision classes; y, the object to be classified; K, the number of nearest neighbours

Output: Classification for y

begin

  $N \leftarrow \text{getNearestNeighbours}(y,K)$

  foreach $C \in \mathcal{C}$ **do**

    $C'(y) = \sum_{x \in N} R(x,y)C(x)$

  end

  output $\arg\max_{C \in \mathcal{C}} (C'(y))$

end

Figure 3 The fuzzy *K*-Nearest Neighbor (FNN) algorithm.

similarity of *x* and *y*. In the traditional approach, this is defined in the following way:

$$R(x,y) = \frac{\|y-x\|^{-2/(m-1)}}{\sum_{j \in N} \|y-j\|^{-2/(m-1)}}$$

where $||\cdot||$ denotes the Euclidean norm, and *m* is a parameter that controls the overall weighting of the similarity. Algorithm 1 shows an application of the FNN algorithm that classifies a test object *y* to the class with the highest resulting membership. The idea behind this algorithm is that the degree of closeness of neighbors should influence the impact that their class membership has on deriving the class membership for the test object. The complexity of this algorithm for the classiflcation of one test pattern is $O(|X| + K|C|)$.

Result

There is a well-established correlation between nurse and information through discussion, inquiry, and self-reflection, all of which are not only applied in professional environment but also in learning process and professional development among nurse practitioners. Nurse plays a major role in collecting information from patient rapidly and thoroughly. In the other hand, pace in collecting information, accuracy in making clinical decision, and dissemination of the information are all critical as well.

Development of information system for decision making is designed by using cloud computing technology that is capable of storing large amount of data, quickly processing all data, and distributing data to related parties.[16,19] The information system, which facilitate collection of health-associated data from interview or medical record and accelerate clinical decision making for nurses as well as data distribution to related parties.

In making a decision, information system does not operate on its own but under supervision and consent from head nurse before distributing the data to related parties (Fig. 4).

This health deterioration prediction model is designed to identify health issues in elderly patient from the moment of admission in ward, which are based on evidence-based practice input/registered by the nurse via smartphone/PC. Based on the registered data, the system will examine health parameters that have been determined before and provide recommendation of fast and accurate nursing intervention according to patient's condition thus health deterioration in elderly will be immediately identified. Quick prediction and recommendation for elderly's health deterioration which provided by the system will reduce the risk for disability and mortality in elderly.[14,16,19] Rapid and accurate prediction of health deterioration in elderly will eventually improve their quality of life throughout hospitalization, shorten length of stay, and reduce cost of care.

All data contained within medical record which registered by the nurse based on result of interview or information from previous medical record, the system will automatically examine it based on determined parameters and later perform analysis which its result would be sent to

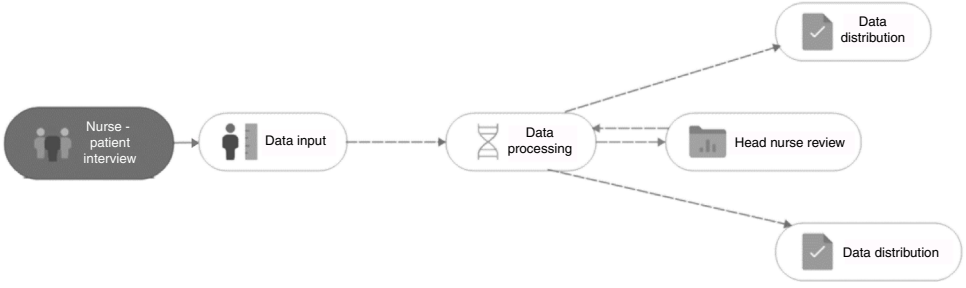

Figure 4 Proposed new operational workflow to replace old methods.

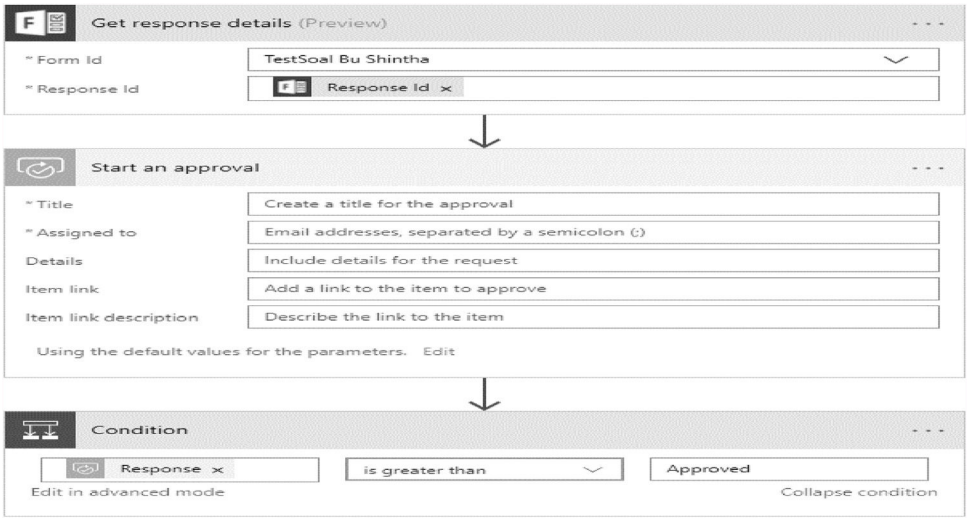

Figure 5 Proposed approval methods by the system.

head nurse for gaining consent prior to its distribution to related parties (Fig. 5).

Information and communication technology (ICT) actualizes all digital technology that support acquiring, storing, processing, and sharing of electronic information in order to promote health, prevent disease, treat illness, manage chronic disease, and so on.[13,14] In health sector, ICT refers to a series of project or service that allows long distance service (telehealth), interdisciplinary clinical support, and transfer of knowledge. ITC implementation has potential to promote patient-centered health service with low cost, improve quality of service and sharing of information, educate health professionals and patient, and encourage new form of connection between patient and health care provider, including cutting travel time.

Discussion

Despite its advantages, ICT is quite difficult to be implemented in practical condition and may result in changes in various levels, including those associated with patient, health care provider, and health organization. Nurses are the largest health care providers and very substantial for ICT implementation. They are compelled to deal with introduction of ICT in nursing care, such as telecare technology, that affects nursing practice. Technology redefines place and presence and creates distance between nurse and patient. Consequently, nursing care could not be provided in traditional way (face to face) which nurses used to do. This study aimed to generate a model capable of detecting health deterioration model in older people who are admitted in hospital.

Conflict of interests

The authors declare no conflict of interest.

Acknowledgements

This work is supported by Hibah TADOK 2018 funded by DRPM UniversitasIndonesia No. 1257/UN2.R3.1/HKP.05.00/2018. This study is an original dissertation of a doctoral program student of Faculty of Nursing – Universitas Indonesia. Writing of manuscript is in partnership with Bani Saleh Computer Science Institute, Bekasi – West Java.

References

1. Setiati S. Geriatric Medicine, Sarkopenia, frailty, dan kualitas hidup pasien usia lanjut: Tantangan masa depan pendidikan, penelitian dan pelayanan kedokteran di Indonesia. eJ Kedok Indonesia. 2013;1:234–42, http://dx.doi.org/10.23886/ejki.1.3008.
2. Colón-Emeric CS, Whitson HE, Pavon J, Hoenig H. Functional decline in older adults. Am Fam Phys. 2013;88:388–94.
3. Massey D, Chaboyer W, Anderson V. What factors influence the ward nurses' recognition of and response to patient deterioration? An integrative review of the literature. Nurs Open. 2017;4:6–23, http://dx.doi.org/10.1002/nop2.53.
4. The Joanna Briggs Institute. The Joanna Briggs Institute best practice information sheet: the psychosocial and spiritual experiences of elderly individuals recovering from a stroke. Nurs Health Sci. 2010;12:515–8, http://dx.doi.org/10.1111/j.1442-2018.2010.00555.x.
5. Pollock RD, Carter S, Velloso PC, Duggal NA, Lord JM, Lazarus NR, et al. An investigation into the relationship between age and physiological function in highly active older adults. J Physiol. 2015;593:657–80, http://dx.doi.org/10.1113/jphysiol.2014.282863.
6. Hirst S, Lane A, Miller CA. Nursing for wellness in older adults. 7th ed. Philadelphia: Lippincot Williams & Wilkins; 2015.
7. Koenig HG. Religious attitudes and practice of hospitalized medically ill older adults. Int J Geriatr Psychiatry. 1998;13:213–24, 10.1002/(SICI)1099-1166(199804)13:4<213::AID-GPS755>3.0.CO;2-5.
8. Koenig HG, George LK, Hays JC, Larson DB, Cohen HJ, Blazer DG. The relationship between religious activities and blood pressure in older adults. Int J Psychiatry Med. 1998;28:189–213, http://dx.doi.org/10.2190/75JM-J234-5JKN-4DQD.

9. Douw G, Schoonhoven L, Holwerda T, Huisman-de Waal G, van Zanten ARH, van Achterberg T, et al. Nurses' worry or concern and early recognition of deteriorating patients on general wards in acute care hospitals: a systematic review. Crit Care. 2015;19:230, http://dx.doi.org/10.1186/s13054-015-0950-5.
10. Benner P, Hughes RG, Sutphen M. Chapter 6 clinical reasoning, decision making, and action: thinking critically and clinically. In: Hughes RG, editor. Patient safety and quality: an evidence-based handbook for nurses. Rockville (MD): Agency for Healthcare Research and Quality (USA); 2008.
11. Jefferies D, Johnson M, Griffiths R. A meta-study of the essentials of quality nursing documentation. Int J Nurs Pract. 2010;16:112–24, http://dx.doi.org/10.1111/j.1440-172X.2009.01815.x.
12. Steen C. Prevention of deterioration in acutely ill patients in hospital. Nurs Stand. 2010;24:49–57, http://dx.doi.org/10.7748/ns2010.08.24.49.49.c7935.
13. Allahverdi N, Torun S, Saritas I. Design of a fuzzy expert system for determination of coronary heart disease risk. In: Proceedings of the International Conference on Computer Systems and Technologies, Association for Computing Machinery. 2007. pp. IIIA.14-1-8.
14. Shaheen A, Khan WA. Intelligent decision support system in diabetic ehealth care from the perspective of elder (unpublished thesis). Sweden: Department of School of Computing Belching Institute of Technology Soft Center; 2009.
15. Goupeng Z. Data analysis with fuzzy inference system. In computational intelligence: method and application. Singapore: School of Computer Engineering, Nanyang Technological University; 2006.
16. Moursund D. Brief introduction to educational implications of artificial intelligence. Oregon, USA: University of Oregon; 2006.
17. Dubois D, Prade H. Rough fuzzy sets and fuzzy rough sets. Int J Gen Syst. 1990;17(2–3):191–209, http://dx.doi.org/10.1080/03081079008935107.
18. Duda RO, Hart PE, Stork DG. Pattern classification. 2nd ed. New York: John Wiley & Sons Inc; 2001.
19. Heinonen P, Mannelin M, Iskala H, Sorsa A, Juuso E. Development of a fuzzy expert system for a nutritional guidance. IFSA-EUSFLAT. 2009, 1685-90.20.