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Fuzzy Information Enrichment for Self-healing Recommendation Systems of COVID-19 Patient

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Abstract

The global emergency caused by the COVID-19 pandemic does not yet have a registered drug. Many studies suggest strengthening the immune system in the human body as an alternative solution to treating COVID-19 before the discovery of drugs. This study reports on various types of potential treatments and factors associated with the immune response to the virus. The analysis shows that the effectiveness of the treatment depends on the current preferences of the COVID-19 patient. Therefore, this study aims to use crowdsourced fuzzy information enrichment through Self-healing Recommender Systems (ShRS) to provide recommendations for the best treatment therapy. It is hoped that the proper treatment therapy will cure the healing of COVID-19 patients who are self-isolating. To demonstrate the ShRS, an illustrative example was conducted. We used a crowdsourcing approach to generate treatment therapy recommendations in Bojonegoro, an area with a high number of COVID-19 cases in Indonesia. Most contextual input parameters such as age category, physical condition, and nutritional status are fuzzy. Therefore, we perform ShRS in proposing fuzzy inference to compute a new score/rank with each treatment pooled in it. The purpose of this study is to build a more practical recommendation system because the use of website applications and gadgets can open up opportunities for the public to contribute to human care. This study proposes a system to uncover the best options for healing people infected with COVID-19. It can help health practitioners and the general public cope with self-healing during a pandemic as an alternative lifesaver.

Keywords: COVID-19 patient, Fuzzy Information Enrichment, recommendation system, self-healing therapy.**Please cite this article in APA style as:**Ma'ady, M. N. P., Sahri, S., & Wardhani, S. A. K. (2022). Fuzzy Information Enrichment for Self-healing Recommendation Systems of COVID-19 Patient. *Teknologi: Jurnal Ilmiah Sistem Informasi*, 12(1), 15-23. <https://doi.org/10.26594/teknologi.v12i1.2825>© 2022 The Author(s). Published by Department of Information Systems, Universitas Pesantren Tinggi Darul Ulum. This is an open access article under the CC BY-NC-NA (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).**1. Introduction**

The high spread of the Covid-19 virus in Indonesia is not balanced with public awareness and knowledge about the dangers of this virus. This problem causes the number of Covid-19 cases to continue to increase. Many government efforts have been made to inhibit Covid-19 cases, such as limiting social activities to giving vaccines to the public, but a cure for the COVID-19 virus has yet to be found. Such conditions increase researchers' interest in investigating the strengthening of the immune system in the human body as an alternative solution for treating Covid-19.

Strengthening the immune system is highly dependent on the immune response to the virus. The optimal immune response depends on an adequate diet and nutrition to prevent infection (Iddir, 2020). Meanwhile, according to (da Silveira, 2021), the immune response to viruses depends on genetics, age, and physical condition. The primary input receptor is the angiotensin-converting enzyme 2. This study focuses on factors related to the immune response to viruses, especially based on age, physical condition, and nutrition. The effectiveness of the treatment depends on the current preferences of the Covid-19 patient. In the case of Covid-19 patients with moderate and severe symptoms, they must immediately seek treatment at the hospital. However, in mild symptoms, it is better to self-isolate with recommended self-healing therapy.

Through the recommendation system on self-healing therapy, the best steps can be found to improve the immune system of Covid-19 patients. Recommendations were obtained from experts, namely Covid-19

self-healing patients who managed to recover. However, the healing rate of each expert is so different that it is difficult to get the best and most effective self-healing recommendations (Chibber, 2020; Hoffman, 2021). Information enrichment with crowdsourcing can combine various recommendations from experts to get the best recommendations. Therefore, this study aims to use crowdsourced fuzzy information enrichment through Self-healing Recommender Systems (ShRS) to provide recommendations for the best treatment therapy for the recovery of Covid-19 patients (see Fig. 1 for the research gap). This research is necessary because it can propose a system to reveal the best options for curing people infected with Covid-19. In addition, the results of this study can help health practitioners and the general public cope with self-healing during the pandemic as alternative medicine.

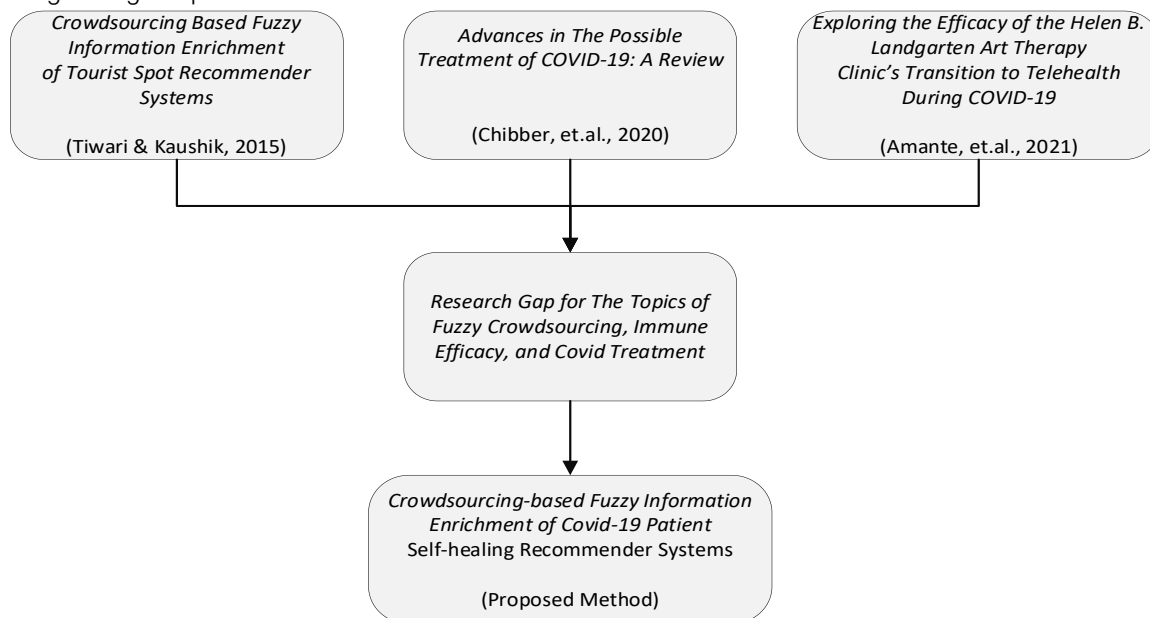


Fig. 1. Research gap analysis

Finally, the rest of the paper is organized as follows. In the next section, we provide related literature of some case studies along with our research gap. Then, the system overview and problem formulation are described. Next, to assist the main findings from work, we provide the methods and results section.

Coronavirus Disease 2019 (Covid-19) is a subfamily Orthocoronavirinae in the Coronaviridae family in the order Nidovirales. Coronaviruses primarily cause enzootic infections in birds and mammals and, in recent decades, have been capable of infecting humans as well (Zhang, L. and Liu, 2020). This virus has caused a global pandemic in the past few years, and no cure has been found while writing this study. Therefore, various studies have emerged that recommend self-medication as an alternative. Self-healing therapy is carried out to stimulate the body's immune system to reduce the risk of more severe illness (Ali et al., 2020; Kemenkes, 2020). Various factors can increase a person's immune system: genetic factors, physical status, age, nutritional conditions, and so on (da Silveira, 2021).

The body's immune system can protect against viruses and disease by producing antibodies to kill pathogens. According to the World Health Organization (WHO), healthy food and adequate water are vital in maintaining immunity. Individuals who consume well will have a more robust immune system and reduce the risk of infection. (Chibber, 2020) summarizes potential therapies for dealing with COVID-19 in China. Traditional Chinese medicines such as Lopinavir, Arbidol, Favipiravir, Tocilizumab, etc., are recommended with certain doses (Chibber, 2020). Other factors, such as the patient's efforts not to panic, have also been analyzed (Ali and Alharbi, 2020). A unique finding by (Conti, P. and Younes, 2020) states that female genes are less affected by Covid-19 than males. These various things are input data for our research system as data mining for patients.

To deepen the understanding of what can increase the strength of the body's immune system, (Chowdhury, 2020) and (Bhardwaj, 2020) summarize from the literature the things that can strengthen or reduce immune function. Their research found literature on vitamin C, which can protect against various viruses that cause flu or the like (Wessling-Resnick, 2018). In addition, vitamins D and E (Jayaweera, J. A. A. S., Reyes, M. and Joseph, 2019), as well as minerals containing iron (Maares, M. and Haase, 2019), zinc (Jin et al., 2020), protein (Cross, Martin L.; Gill, 2000), etc. is also recommended. Not all the recommendations presented, certain excessive consumption is also considered, such as caffeine,

fruit sweeteners, soda, and saturated fat (Emro, 2019; Meszaros, 2020; Park, 2020). To find the best therapeutic concoction for Covid-19 patients, it is necessary to know what to eat, drink, or what activities to do. All the recommendations for vitamins and minerals also depend on the patient's condition when he has Covid-19 (Damiano, 2021). Therefore, data obtained from self-isolated patients who have successfully recovered from Covid-19 with their therapeutic mix are critical as recommendations to other self-healing patients suffering from Covid-19.

Self-healing is an effort made by oneself to heal oneself. Even a study says that everyone is able to heal themselves with a success percentage of 18-75%(Raab, 2019). In the United States, (Amante, 2021) conducted an experimental therapy on the therapeutic effectiveness of telehealth services at a clinic at Loyola Marymount University. The result is that treatment is able to have a positive impact on the patient's mentality. (Farmawati, C., Ula, M. and Qomariyah, 2021) found the phenomenon of various ways of self-healing from the Covid disease that occurred in Indonesia. (Braus, M., & Morton, 2020) emphasizes that against Covid-19 utilizing self-isolation following various self-activities that can be carried out, referred to in his research as Art Therapy. The system that we propose in this study is crowdsourcing to explore recommendations from Covid-19 self-healing patients who have successfully recovered from being processed using the Fuzzy information enrichment method to become the best recommendations according to the preferences of the existing condition of patients suffering from Covid-19.

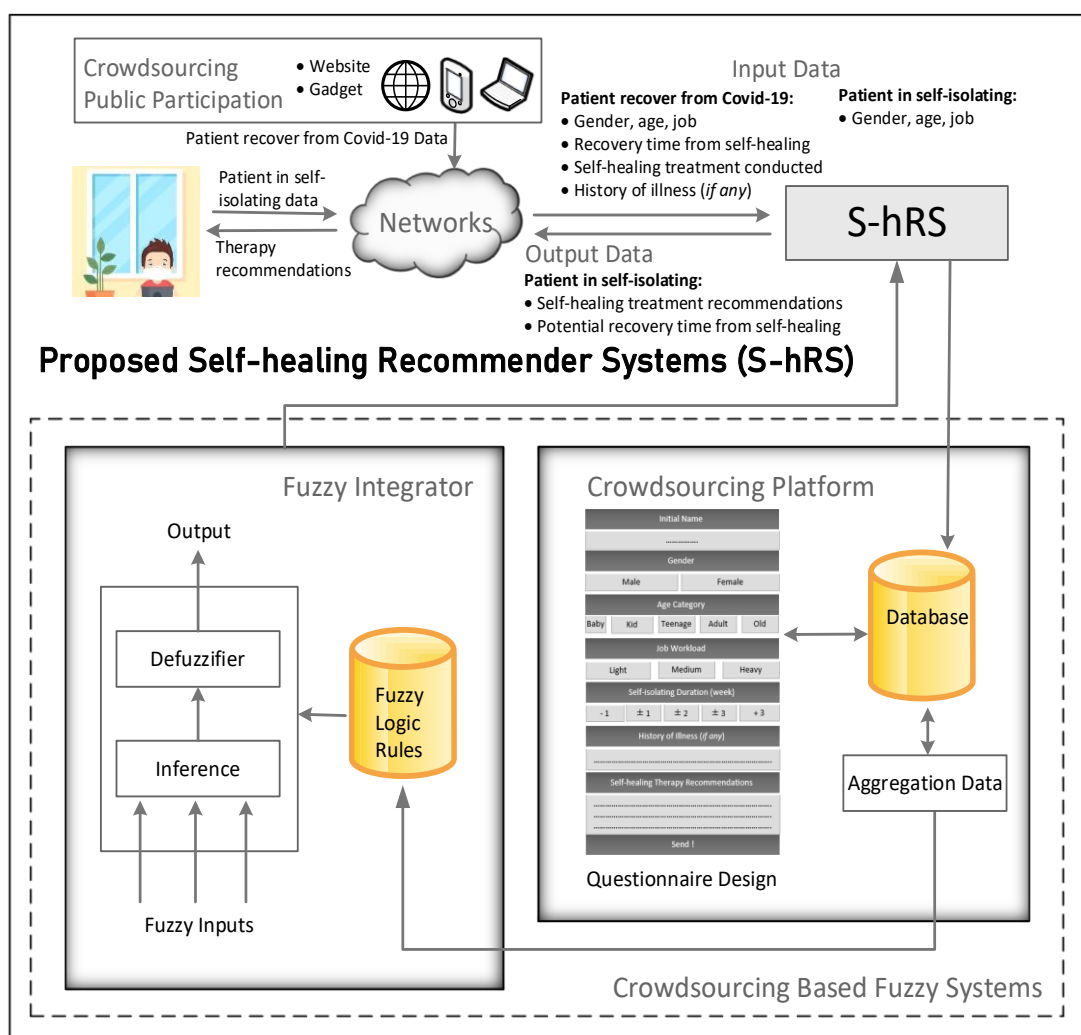


Fig. 2 Overview design of the proposed system adopted from (Tiwari, S. and Kaushik, 2015)

Input data, as described above, is data that is fuzzy or fuzzy. For this reason, we propose a fuzzy method for processing our data. The Fuzzy method by utilizing input data from crowdsourcing has been applied by (Tiwari, S. and Kaushik, 2015) to provide the best recommendations for tourist spot locations. The same thing has also been done before (Bachrach, 2014) to build a personalized image of tourist places.

(Shi, Z. R., Lizarondo, L. and Fang, 2021) The Self-healing Recommender system is the development of existing studies. leveraged crowdsourcing to increase the accuracy of the recommendation system on a food rescue platform from wasting food waste. Then, the crowdsourcing-based fuzzy method for service

assessment and monitoring to determine consensus trust has been well implemented (Sharifi, 2014). The following is a chart showing the position or research gap compared to the previous studies reviewed above.

Fig. 1 explains how our research gaps in the existing literature. The main topics of the Self-healing Recommender System are research related to using the Fuzzy information enrichment method on a crowdsourced basis to produce the best recommendations, then the topic of research on self-healing as an alternative treatment for Covid-19, and research around the exploration of therapies that can improve the immune system against Covid-19. Thus, the gap in our study is that there is no research on the application of the fuzzy crowdsourcing method to self-healing-based immune enhancement therapy. For this reason, we propose research on building a Self-healing Recommender System or abbreviated as ShR, using a crowdsourcing-based fuzzy information enrichment system specifically for Covid-19 self-isolated patients.

2. Methods

This section presents the proposed system design, as shown in Fig. 2. The system workflow is as shown in Fig. 3. Fig. 3. Overview Design of The Proposed System Adopted from (Tiwari, S. and Kaushik, 2015):

- a. The system questionnaire was administered to self-healing patients who had successfully recovered provided by web-based Self-healing Recommender Systems.
- b. Update the fuzzy logic rules that have been made previously based on the new input data.
- c. The faster recovery potential output class data will update the logic rules of the more extended recovery potential class. The process is to be done by a crowdsourcing platform that aggregates recovered patients.
- d. Collecting data on patients with Covid-19 who are undergoing self-healing.
- e. The process of calculating the Mamdani fuzzy inference system.
- f. Fuzzy integrator based on the inputs from crowdsourcing platform computes data from recovered patients. Obtained the potential output of the patient's recovery time with self-healing therapy.
- g. Crowdsourcing Platform on Web-Based.

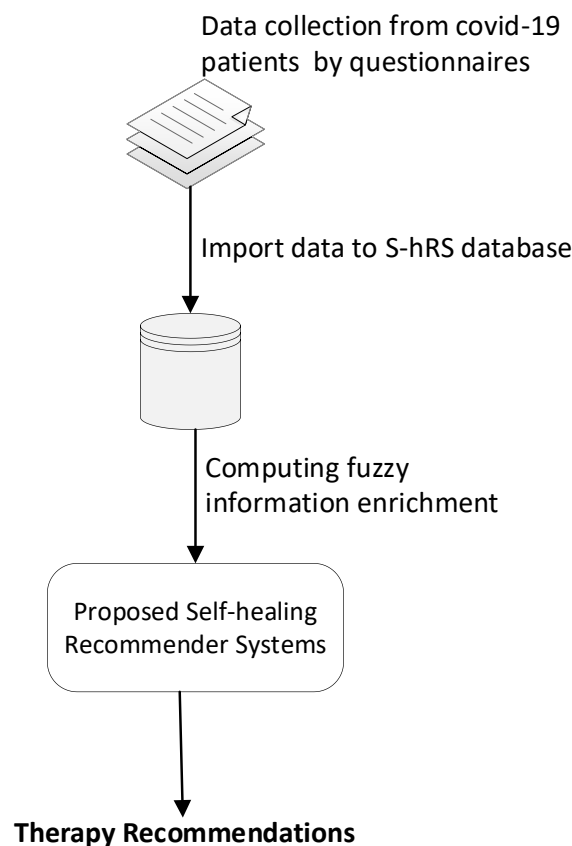


Fig. 3. Overview Design of The Proposed System Adopted from (Tiwari, S. and Kaushik, 2015)

Clients are gadget users suffering from Covid-19 or patients who have recovered from Covid-19 to encourage healing recommendations based on their respective self-healing. The client will be registered in a web-based system. This system was created as a form of crowdsourcing-based public participation that is useful as an alternative means of recommending healing from patients who have recovered from self-isolation. Patients who are in the process of treatment can register as new users to find out healing recommendations. This recommendation can be seen by filling in data such as name, gender, age, and occupation, as shown in the illustration in Fig. 4.

Self-healing Recommender Systems: Questionnaire form for Covid-19 patients who have recovered

<div style="background-color: #444; color: white; padding: 5px; text-align: center;">Initial Name</div> <div style="border: 1px solid #ccc; height: 20px; margin-bottom: 5px;"></div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Gender</div> <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> <div style="border: 1px solid #ccc; padding: 2px 10px;">Male</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Female</div> </div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Age Category</div> <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> <div style="border: 1px solid #ccc; padding: 2px 10px;">Baby</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Kid</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Teenage</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Adult</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Old</div> </div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Job Workload</div> <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> <div style="border: 1px solid #ccc; padding: 2px 10px;">Light</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Medium</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">Heavy</div> </div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Self-isolating Duration (week)</div> <div style="display: flex; justify-content: space-around; margin-bottom: 5px;"> <div style="border: 1px solid #ccc; padding: 2px 10px;">- 1</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">± 1</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">± 2</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">± 3</div> <div style="border: 1px solid #ccc; padding: 2px 10px;">+ 3</div> </div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">History of Illness (if any)</div> <div style="border: 1px solid #ccc; height: 20px; margin-bottom: 5px;"></div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Self-healing Therapy Recommendations</div> <div style="border: 1px solid #ccc; height: 20px; margin-bottom: 5px;"></div> <div style="border: 1px solid #ccc; height: 20px; margin-bottom: 5px;"></div> <div style="border: 1px solid #ccc; height: 20px; margin-bottom: 5px;"></div> <div style="background-color: #444; color: white; padding: 5px; text-align: center;">Send !</div>	<p>Age Category Baby = 0-1 year Kid = 2-11 years Teenage = 11-20 years Adult = 21 – 60 years Old = above 60 years</p> <p>Job Workload Light = 75% of the time spent sitting and 25% standing and moving. Example: students, teachers, office workers, etc. Medium = 25% of the time used is sitting or standing and 75% is a special activity in the field of work. Examples: housewives, factory employees, etc. Weight = 40% of the time spent sitting or standing and 60% for special work activities in the field of work. Examples: construction workers, farmers, field workers. etc.</p> <p>Source: https://kesmas.kemkes.go.id/</p> <p style="text-align: center;"><i>Let's heal together! Your recommendation means a lot to them...</i></p>
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Fig. 4. Crowdsourcing Platform of Questionnaire Form

- a. Self-healing Recommender System This self-healing recommendation system works to generate a list of requested recommendations according to the data entered. This system was created to get recommendations for healing from patients who have recovered from self-isolation. When a patient who has recovered through self-care and treatment fills in data according to the system, including gender, age, busyness, illness history, self-medication, and recovery time, the recommended data will automatically be processed with a crowdsourcing-based fuzzy system. And when people who are still in treatment fill in data according to the system, which includes gender, age, and occupation, the S-hRS subsystem will generate a list of appropriate recommendations for patients who are still in self-isolation. If additional data is entered into the S-hRS system, the S-hRS system will rearrange the list of recommendations based on the new self-isolation data.
- b. Fuzzy Enrichment based on Crowd Resources This fuzzy system consists of two subsystems, including a crowdsourcing platform and a fuzzy integrator. In the crowdsourcing section, this platform functions to collect data from Covid-19 patients. This section consists of:
 - 1) Database
The database contains data information from patients registered into the system. This database accommodates all data from patients who have recovered from self-isolation or who are still undergoing self-isolation.
 - 2) Questionnaire Design
This questionnaire design contains several predetermined questions about name, gender, age, occupation, length of recovery, history of illness, and recommendations for self-therapy. And this set of questions will be sent to the client, who will answer.
 - 3) Data Aggregation
In collecting data on answers sent by Covid-19 patients regarding self-medication, several ways are used to ensure the correctness of the recommendations that must be applied to each patient. By looking at the data entered by the client in the questionnaire, it will be accommodated into a database, which will then be processed into a data aggregator. The data aggregator will provide the results of the processing according to the data entered by the client. Fig. 4 is a membership function in the ShR system.
 - 4) Input/output Variables

This research used three input variables for our fuzzy systems, namely gender, category, and job workload. The fuzzy membership functions for each of the variables are shown in Fig. 4(a), 4(b), and 4(c), respectively. The output of the fuzzy systems is a new score of the potential of patient recovery time, and its fuzzy membership function is shown in Fig. 5.

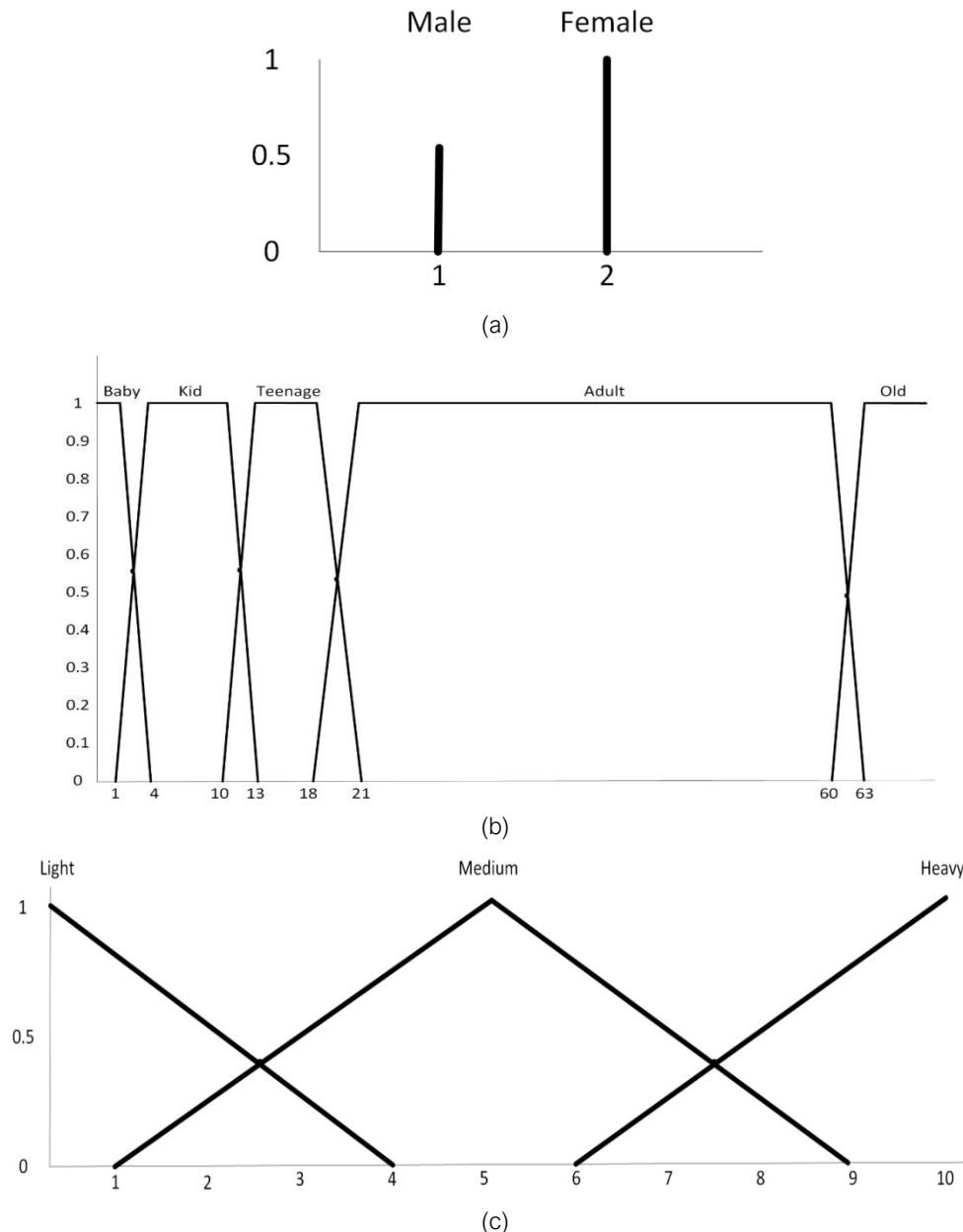


Fig. 5. Membership functions of input variables: (a) Gender, (b) Category of age, and (c) Job workload

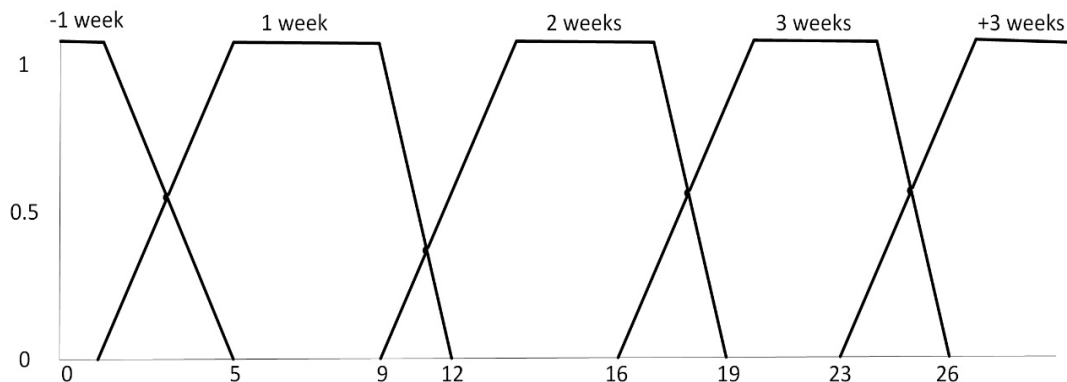


Fig. 6. Membership functions of output variable: Potential recovery time in weeks

3. Results

In this section, this research presents a sample of fuzzy logic rules used for the implementation. A set of 30 fuzzy if-then rules is designed intuitively for our system. Some of the rules are shown in Fig. 6.

3.1. Implementation

In order to show the feasibility of the proposed system, a prototype of the proposed information enrichment system is implemented. ShRS combines crowdsourcing platforms and fuzzy integrators on the server-side. The web-based application is developed to simulate a crowded platform using the laravel and Vue framework Javascript programming language is used for applying interoperability, and MySQL database is used for storing the data.

The registered resource Covid-19 patients recovered from self-healing, then filled in the questionnaire form to contribute their experiences during self-healing, including therapy conducted and the person profile. The systems then compute the data to provide the best recommendations of the treatment along with its potential recovery time based on the data from recovered patients. Table 1 is the sample of the results generated by ShRS.

Table 1. Sample result generated by ShRS

Patient ID	Top-2 Recommended Therapies by ShRS	
	Therapy-1 (potential recovery time in days)	Therapy-2 (potential recovery time in days)
04	11.1	18.4
07	13.2	22.2

3.2. Results

The S-hRS using the fixed data input can also accommodate data which later the new patient will enter data which data aggregator will then process. The sample result for patients ID-04 and ID-07 are shown in table 2. New self-healing patients recover faster because they have a way of treatment more appropriate self-healing so that the old potential heals faster. Assuming the data with no history of illness, the recommendations are only for therapy appear for patients who have a history of illness.

Table 1. Information enrichment from the sample results

Patient ID-04	
ShRS rank based on the fastest recovery time:	<p>Therapy-1 (11.1 days) Consumption: <i>Take vitamins every day</i> <i>Drink enough warm water</i> Activity: <i>Sunbathing every morning</i></p> <p>Therapy-2 (18.4 days) Consumption: <i>Get cough medicine</i> <i>Take antibiotics</i> Activity: <i>Put small rolled tissue with eucalyptus oil into nose</i> <i>Always positive thinking</i></p>
Patient ID-07	
ShRS rank based on the fastest recovery time:	<p>Therapy-1 (13.2 days) Consumption: <i>Consume coxavit</i> <i>Drink bear brand milk</i> <i>Eat dates if any</i> Activity: <i>Do light exercise</i> <i>Sunbathing at 10.00 am for 15 minutes</i></p> <p>Therapy-2 (22.2 days) Consumption: <i>Eat lots of vegetables</i> <i>Drink fruit juice</i> <i>Drink pocari sweat</i> Activity: <i>Sunbathing in the morning</i></p>

Table 2 shows the recommended therapy from the whole collected crowd resource data. By aggregating the input profile of the self-isolating patient, the ShRS provides a ranking of the best therapy from the successfully recovered patient. There are kinds of consumptions and activities made by the

recovered patients. Then, the system is able to suggest which consumption and activity are the best for the new patient. It is hoped that the proper treatment therapy will cure the healing of Covid-19 patients who are self-isolating.

4. Conclusions

The purpose of this study is to accelerate the healing of Covid-19 patients who undergo self-isolating. The method we propose uses a fuzzy system crowdsourcing because it is known that the human immune system is different due to several factors. This method is used to provide recommendations for Covid-19 patients. As an overview of this system, work starts from crowdsourcing, then processed with fuzzy data obtained from recovered covid patients. The system will recommend a way to heal someone by looking from the system's current immunity regarding age, gender, and job workload. Therefore, the fuzzy method is appropriate in providing recommendations. This research has great potential to be realized because the data crowdsourcing can be processed easily using fuzzy to achieve the ideal recommendation for covid patients who do self-healing. Further research can use other algorithms such as Sugeno, Tsukamoto, and so on to be more varied and use five data, namely by adding input data on nutritional and genetic conditions from parents as contained in the literature. We suggest to use location-based crowdsourcing Fuzzy system regarding the importance of knowing patients' location in the problem context of Covid-19 for further research.

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