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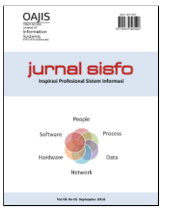

Stroke Expert System for Personalized Risk Prediction and Adviser: A Preliminary Study of Stroke Risk Factors

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Abstract

World Stroke Organization states that one in six people worldwide will have stroke in their lifetime. Thousand studies about stroke are conducted in worldwide and its number is increasing every year. This means that health scientists still working on stroke and the knowledge about stroke (and its risk factors) is still developing. A project develops an expert system that has two objectives. First, to educate people about stroke by delivering their personalized stroke risk prediction. Further, this expert system will also provide some advice to reduce their risk based on the modifiable risk factors that they have. Second, the expert system aims to acquire and encode stroke risk factors knowledge as it develops. Thus, the risk prediction result is continuously updated based on the newest knowledge. This paper provides preliminary information about people knowledge about stroke. Do they know if stroke is the first leading cause of death in Indonesia? Do they know about the stroke risk factor? Do they know about how to reduce their stroke risk factor (if they have the risk)? What kind of electronic media do they want to get acknowledged about stroke? The expert system is offered as one option in the last question. From 259 individuals we draw the conclusion that 40% respondents aged from 15-75 do not know that stroke is the first leading cause of death in Indonesia. In average, the respondents only know three out of nine mentioned stroke risk factors. Those three are high level of cholesterol, related to heart disease, and age. 56% respondents do not know how to reduce the stroke risk factor, and they do want to know more about it. 63% respondents want an expert system to predict their stroke risk and give them more knowledge to reduce the stroke risk. From this result, we are confident that the expert system is wanted and can educate people more about the stroke risk factors, also, its personalized advisor can acknowledge them about how to reduce the risk.

Keywords: Expert Systems, Risk, Prediction, Stroke, Questionnaire

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1. Introduction

World Stroke Organization states that one in six people worldwide will have stroke in their lifetime. Stroke is also the leading causes of long-term disability worldwide [1]. In Indonesia, stroke is the first leading cause of death in Indonesia [2]. In US, stroke is the third cause of death and long-term disability [3]. Thus, study about stroke are common and information about stroke is available on health-based websites. Even though information about stroke is accessible in any form of media (printed or electronic), people may have different depth of knowledge about stroke. In this research, we tried to seek how deep the knowledge of the people -in a country- about stroke. We chose Indonesian people to measure how far they know about stroke knowledge because stroke is the first leading cause of death in this country.

Stroke is a sudden death of brain cells caused by a clot in artery supplying blood to the brain (i.e. ischemia) or a burst vessel causes blood to leak into the brain (i.e. hemmoragic) [1]. They divided stroke risk factors into two categories: modifiable and non-modifiable [4]. Non-modifiable risk factors for stroke are age, sex, ethnicity, and genetics. Modifiable risk factors for stroke are hypertension, smoking, waist-to-hip ratio, diet, physical activity, hyperlipidemia,

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diabetes mellitus, alcohol consumption, and cardiac causes. A study about stroke risk factor establishes 8 main stroke risk factors, for both ischemic and hemmoragic: hypertension, diabetes mellitus, hyperlipidemia, heart disease, family history, smoking, overweight, and physical exercises. These risk factors were summarized from 167 articles [5].

This research aims to increase people awareness by providing an expert system that capture the knowledge of stroke, as the knowledge develops. Further, this knowledge will be turned into a personalised prediction for the people and acknowledge them about their risk for stroke. An appropriate suggestion about how to reduce the risk, which is inferred from their modifiable risk factors, will also be provided at the end of the stroke risk prediction result. Existing expert systems related to diseases has been published, for example chronic kidney disease [6], uveitis [7], and cattle disease [8], but, none of them are related to stroke.

Thus, there are two targets of stroke knowledge which are important for people to know and needed to build the expert system. First target is the stroke knowledge to supply stroke risk calculation. Second target is the knowledge to advise people in order to reduce their (predicted) stroke risk.

As a preliminary study, this research is started with gathering people awareness about stroke. A questionnaire was composed with aim to get people knowledge about (1) the fatality of stroke in Indonesia, (2) stroke risk factors, (3) how to decrease risk for stroke. Lastly, this questionnaire also contained a question about their preferred media to get acknowledged about stroke. We include the expert system as the option in this question and let them decide whether they prefer it or not. Thus, the goal of this research as a whole is to build an expert system as a media to educate Indonesian people about stroke risk factor. The expected impact of using this expert system continuously is a reduction in stroke cases specifically in Indonesia.

2. Previous Research

Expert systems in the disease diagnosing area are widely recognized. They used several knowledge representations such as rule-based [6], [9], frames [10], case-based [11], probabilistic [12]. Many of them use vary forms of knowledge-base to store knowledge elicited from expertise. A personalized risk prediction is one of the knowledge-bases that are used in expert systems as the main diagnoses reasoning.

Personalized risk prediction has been previously developed using a statistical methods (i.e. Bayesian Network) and a knowledge repository (i.e. ontology) [13]. But it is developed for infectious diseases that contains risk factor knowledge for 234 infectious disease in the world. Thus, the content of the knowledge cannot be reused for developing stroke risk factor knowledge. However, the structure of knowledge still can be reused [14]. This is because the common knowledge for risk factors in any diseases provided in health articles is still the same. The knowledge for risk factors is provided in a numeric form namely risk ratio and a string for the risk factor.

Calculating risk for stroke is not a new thing in the context of medicine. Several articles and web applications established their works online to help people measure their stroke risk [15][16][17][18]. However, none of them that allow modification of the calculation base. They used scoring questionnaire and divided them with total number of scores. They put certain weights for certain risk factor that they feel crucial for determining stroke risk. As we know that the experts and scientists continuing their study about stroke (and its risk factors), it means that the knowledge can be updated in any time, as the knowledge develops.

From collected stroke risk calculator above, only two that provide further knowledge on how to reduce stroke risk [19], [20]. But the provided knowledge not based on their risk prediction results. They are composed for people in general, thus, it may less relevant for several people who does not have particular risk factors. For example, the provided knowledge is about alcohol drinker and smoker, but some people who are not alcohol drinker nor smoker are not relevant to this kind of knowledge.

Therefore, based on the previous knowledge, we will reuse the basic algorithm for risk calculation, knowledge structure, and improving the data structure of the previous algorithm to provide a new stroke risk prediction. Also, we will extend the expert system to a personalized advisor that gives relevant information for the user based on their predicted risk result and risk factors.

3. Methodology

This paper aims to answer preliminary research: (1) to what extent this kind of expert system will educate Indonesian people about stroke (and its risk factors), and (2) whether it is needed or not. To answer the first question, we composed a questionnaire with three points. First point is the basic knowledge of stroke fatality, especially in Indonesia. Second point is the stroke risk factors. Third point is how to reduce stroke risk. To answer the second question, we added a question about several types of electronic media, the expert system is included here. The methodology can be seen in a Fig. 1.

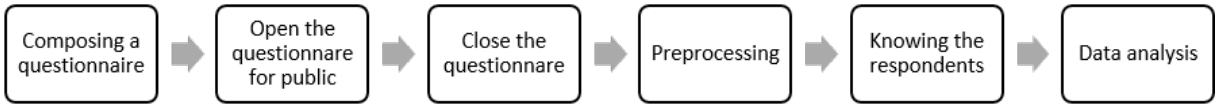

Fig. 1. Research Methodolody

Table 1. The questionnaire designs

Number	Points	Question	UI Design
1	Respondent's identity	How old are you now? (in years)	Text field
2		What is your gender? (male/female)	Radio button
3	Basic knowledge about stro-ke fatality	Have you ever heard about stroke before? (Yes/No)	Radio button
4		What is your stroke knowledge source? (inner circle/friends/electronic or printed media/other)	Check list
5		Do you know that stroke is the first leading cause of death or long-term disability in Indonesia? (Yes/No)	Radio button
6	Stroke risk factors	What is in your mind when you hear about stroke? (it is related to heart disease/it is related to diabetes/people with high cholesterol have it most/elderlies have it most/stroke risk in women is higher than men/stroke risk in smokers is higher than non-smokers/stroke risk in alcohol drinkers is higher than non-alcohol drinkers/obese people has higher stroke risk/stroke risk is genetic)	Check list
7	How to reduce stroke risk	Do you know how to reduce stroke risk? (Yes/No)	Radio button
8		Do you want to know more about it? (Yes/No)	Radio button
9	Preferred electronic media	What kind of electronic media do you want to be acknowledged from? (Youtube video/online article/infographic/an expert system that predicts your stroke risk and deliver personalized knowledge on how to reduce that predicted risk)	Radio button

3.1. Composing a questionnaire

At first, there are few questions about the respondent's identity (e.g. age and gender). Then, several main questions derived from three points that explained before. Table 1 shows the points of questions provided in the questionnaire.

3.2. Open questionnaire for public and close it

This preliminary survey used a convinience sampling because participants are selected based on their availability and willingness to take part. There is no sample size setting and volunteer bias may occur. Therefore, we include the participants' profile as additional information of this research conclusion. There is no inclusion or exclusion in this research. We used Google Form feature to publish this questionnaire. At first, we only targeted about 30 respondents in one day. So, we planned to open it for seven days. This questionnaire opened from 19th November 2019 to 26th November 2019. There are 262 anonymous responses; we got around 50 respondents extra from the previous expectations.

3.3. Preprocessing

Activities included in this process are eliminating blank row(s) and standardizing age field. Blank rows occurred because someone opened it but doesn't answer any question. There were three blank rows in 262 responses, thus, we removed them. A standardization is needed in age field. This is because the design of the questionnaire is text field. Sometimes respondents filled their age with '19 years' or '19 yrs', while we expect only numbers. Thus, we trimmed 'years' or 'yrs' in that field. If we did not perform this trimming, the effect is '19 years' and '19 yrs' are considered different from '19'. In fact, they are stating the same age.

3.4. Knowing the respondents

This questionnaire is given without requiring a name (i.e. anonymous), however, we still asked about age and gender of the respondents. Age and gender are required because both are risk factors of stroke. We, somehow, measure the extent of the stroke risk factor knowledge based on their identity. We also expect that people that hold the risk factors will know more about their status of stroke risk. For example, people aged above 30 will acknowledge more about stroke risk than people aged below 30. Same thing goes for women. In this step, we performed a descriptive analysis to both age and gender.

Table 2. Age description

Age (in years)	Frequency
<18	8
18-20	59
21-25	10
26-30	43
31-35	84
36-40	15
41-45	14
46-50	6
>50	7
N/A	13
Total	259

3.5. Data Analysis

This step is describing answers of seven questions (question #3 to #9) and categorizing them based on age and gender. This categorization aims to seek to what extent the respondents know or doesn't know about stroke knowledge. Then, the expert system will be expected to fill the gap by educating them with knowledge that they do not know before.

4. Results and Discussion

From preprocessing step, 259 respondents are obtained. Therefore, this section only discusses the results of section 3.4 and 3.5.

4.1. Knowing the respondents

From 259 respondents[1], the youngest respondent is 15 years old and the eldest is 75 years old. There are 13 respondents who left the age field blank. The respondents are 130 men and 129 women. This survey has even ratio for men or women, thus, any information revealed from this survey do not represent one majority gender, unless it is being categorized on purpose. Table 2 shows age description of the respondents.

4.2. Data Analysis

Question *#3: Have you ever heard about stroke? (Yes/No)*

257 respondents have heard about stroke before. 2 respondents did not answer. From this answer, we conclude that stroke is a well-known health condition in Indonesia.

Question *#4: What is your stroke knowledge source? (inner circle/friends/electronic or printed media/other)*

From 257 respondents who have heard about stroke before, 187 of them heard from parents or their close relatives (e.g. inner circle). 140 of them heard from their friends or neighbours. 192 of them read from printed or electronic articles.

Question *#5: Do you know that stroke is the first leading cause of death or long-term disability in Indonesia? (Yes/No)*

From 259 respondesnts: 163 respondents know that stroke is the first leading cause of death or long-term disability. 96 do not know this basic information.

A) Classified by age

We classified whether a person knows this information or not based on age: below 30 and above 30. This classification based on the first stroke sometimes found on people age 30, so we expect that respondents in class above 30 will know more about this information. The result shows that people age above 30 are more acknowledged about this information than people age below 30. Table 3 shows age classification towards stroke fatality information.

B) Classified by gender

[1]Full responses can be accessed in https://is.gd/fullResponses

Table 3. Stroke fatality information classified by age

Age <= 30	Total = 120	Percentage
Know	72	60%
Do not know	48	40%
Age >30	Total = 126	
Know	91	65,46%
Do not know	48	34,53%
N/A	Total = 13	
Know	10	76.92%
Do not know	3	23.08%

Table 4. Stroke fatality information classified by gender

Men	Total = 130	Percentage
Know	64	49,23%
Do not know	66	50,76%
Women	Total = 129	
Know	99	76,74%
Do not know	30	23,25%

Then, we classified this information based on gender: men and women. There are slight differences between men and women who have stroke. This is because women have two risk factors for stroke that are not owned by men. Those two are pregnancy and birth-controlling pills consumption. Note that, all female respondents are above 16 years old which already has period and possible to get pregnant or consume birth-controlling pills. Thus, we expect that women are more acknowledge than men because they hold more risk factors than men.

The results are there is significant differences between men and women. More men do not know if stroke is the first leading cause of death in Indonesia. But, three out of four women already know this information. From this result, it can be concluded that women are more acknowledged about the fatality of stroke than men. Table 4 shows gender classification towards stroke fatality information.

Question *#6: What is in your mind when you hear about stroke? (it is related to heart disease/it is related to diabetes/people with high cholesterol have it most/elderlies have it most/stroke risk in women is higher than men/stroke risk in smokers is higher than non-smokers/stroke risk in alcohol drinkers is higher than non-alcohol drinkers/obese people has higher stroke risk/stroke risk is genetic)*

259 respondents know about stroke risk factors. They can choose any risk factors they know more than one options. The result is given in Table 5.

The Table 6–Table 15 explains the respondents who understand stroke risk factors classified by gender and age. More respondents age above 30 aware that high cholesterol is risk factor for stroke than respondents age below 30. Women are more acknowledged about high cholesterol, heart disease, and diabetes than men. For heart disease, there is no difference between respondents age below 30 and above 30.

Respondents age below than 30 years old seems to know that risk factor for stroke is increasing with age than respondents age above 30 years old. In contrast with previous risk factors (high cholesterol and heart disease), in these risk factor (elderly and obesity) men know this information rather than women.

Then, we want to know how many of the provided risk factors are known for each category of age and gender. In all categories, respondents knew 3 out of 9 risk factors for stroke.

Question *#7: Do you know how to reduce stroke risk? (Yes/No)*

Table 5. Respondents' knowledge about stroke risk factor

Risk Factors	Frequency	Percentage
Related to high cholesterol	186	71.80%
Related to heart disease	157	60.60%
Most of the sufferers are elderly (>50)	121	46.70%
Most of the sufferers are obese	114	44%
Most of the sufferers are smoker	73	28.20%
Related to diabetes	65	25.10%
Most of the sufferers are alcohol drinker	59	22.80%
Can be passed to the next generation	44	17%
Most of the sufferers are women	13	5%

Table 6. Risk factor = high cholesterol

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	78	78/186 = 41.9%	78/120 = 65%
Above 30 (Total = 126)	98	98/186 = 52.7%	98/126 = 77.78%
N/A (Total = 13)	10	10/186 = 5.4%	10/13 = 76.92%
Gender			
Men (Total = 130)	89	89/186 = 47.85%	89/130 = 68.46%
Women (Total = 129)	97	97/186 = 52.15%	97/129 = 75.19%

Table 7. Risk factor = heart disease

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	73	73/157 = 46.5%	73/120 = 60.83%
Above 30 (Total = 126)	74	74/157 = 47.2%	74/126 = 58.73%
N/A (Total = 13)	10	10/157 = 6.3%	10/13 = 76.92%
Gender			
Men (Total = 130)	74	74/157 = 47.13%	74/130 = 56.92%
Women (Total = 129)	83	83/157 = 52.86%	83/129 = 64.34%

Table 8. Risk factor = elderly (¿50 years old)

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	60	60/121 = 49.58%	60/120 = 50%
Above 30 (Total = 126)	55	55/121 = 45.45%	55/126 = 43.65%
N/A (Total = 13)	6	6/121 = 4.95%	6/13 = 46.15%
Gender			
Men (Total = 130)	71	71/121 = 58.67%	71/130 = 54.61%
Women (Total = 129)	50	50/121 = 41.33%	50/129 = 38.76%

Table 9. Risk factor = obesity

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	49	49/114 = 42.98%	49/120 = 40.8%
Above 30 (Total = 126)	56	56/114 = 49.12%	56/126 = 44.44%
N/A (Total = 13)	9	9/114 = 7.89%	9/13 = 69.23%
Gender			
Men (Total = 130)	60	60/114 = 52.63%	60/130 = 46.15%
Women (Total = 129)	54	55/114 = 48.24%	54/129 = 41.86%

Table 10. Risk factor = smoker

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	26	26/73 = 35.61%	26/120 = 20.63%
Above 30 (Total = 126)	40	40/73 = 54.79%	40/126 = 31.74%
N/A (Total = 13)	7	7/73 = 9.6%	7/13 = 53.84%
Gender			
Men (Total = 130)	41	41/73 = 56.16%	41/130 = 31.54%
Women (Total = 129)	32	32/73 = 43.83%	32/129 = 24.8%

Table 11. Risk factor = diabetes

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	23	23/65 = 35.38%	23/120 = 19.16%
Above 30 (Total = 126)	38	38/65 = 58.46%	38/126 = 30.15%
N/A (Total = 13)	4	4/65 = 6.15%	4/13 = 30.77%
Gender			
Men (Total = 130)	22	22/65 = 33.84%	22/130 = 16.92%
Women (Total = 129)	43	43/65 = 66.15%	43/129 = 33.33%

Table 12. Risk factor = alcohol drinker

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	24	24/59 = 40.68%	24/120 = 20%
Above 30 (Total = 126)	30	30/59 = 50.85%	30/126 = 23.81%
N/A (Total = 13)	5	5/59 = 8.47%	5/13 = 38.46%
Gender			
Men (Total = 130)	34	34/59 = 57.62%	34/130 = 26.15%
Women (Total = 129)	25	25/59 = 42.37%	25/129 = 19.38%

Table 13. Risk factor = genetic

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	21	21/44 = 47.72%	21/120 = 17.5%
Above 30 (Total = 126)	19	19/44 = 43.18%	19/126 = 15.08%
N/A (Total = 13)	4	4/44 = 9.1%	4/13 = 30.77%
Gender			
Men (Total = 130)	15	15/44 = 34.09%	15/130 = 11.54%
Women (Total = 129)	29	29/44 = 65.91%	29/129 = 22.48%

Table 14. Risk factor = gender

Age	Frequency	Percentage (divided by all frequencies)	Percentage (divided by row)
Below 30 (Total = 120)	6	6/13 = 46.15%	6/120 = 5%
Above 30 (Total = 126)	7	7/13 = 53.84%	7/126 = 5.55%
N/A (Total = 13)	0	0/13 = 0%	0/13 = 0%
Gender			
Men (Total = 130)	3	3/13 = 23.07%	3/130 = 2.3%
Women (Total = 129)	10	10/13 = 76.92%	10/129 = 7.75%

138 respondents do not know how to reduce the risk for stroke. 120 respondents know. 1 respondent abstain. From Table 16, it can be seen that respondents age above 30 know how to reduce the stroke risk than respondents age below 30. Also, women tend to know how to reduce the stroke risk than men.

Question *#8: Do you want to know more about it? (Yes/No)*

252 respondents have concern to know more information about stroke, while only 6 respondents do not want to know more about stroke. 1 respondent abstain.

Question *#9: What kind of electronic media do you want to be acknowledged from? (Youtube video/online article/infographic/an expert system that predicts your stroke risk and deliver personalized knowledge on how to reduce that predicted risk)*

We provide four options of media for disseminating information about stroke in the questionnaire. Those four are Youtube video, online article, infographic, and expert system application. 158 respondents opt for Youtube video, 131 for online article, 111 for infographic, and 161 for expert system application. 1 respondent abstain.

From the Table 17, there are difference at media preference of dissemination information about stroke or health in general. Respondents age below 30 prefer Youtube Video rather than an expert system application. But, respondents age above 30 prefer an expert system application rather than mass media like Youtube video. Between men and women, men prefer Youtube video, women prefer an expert system.

This preliminary finding can be used to enrich the user experience in the stroke expert system by mentioning their common understanding about stroke risk factor. Then, the expert system will add new knowledge that are new to the user. Thus, they may have some better understanding about stroke risk factor after using this expert system.

5. Conclusion

This section explains conclusion of this research and the possibility of the further research.

5.1. Conclusion

From 259 individuals we draw the conclusion that 40% respondents aged from 15-75 do not know that stroke is the first leading cause of death in Indonesia. In average, the respondents only know three out of nine mentioned stroke risk factors. Those three are high level of cholesterol, related to heart disease, and age. 56% respondents do not know how to reduce the stroke risk factor, and they do want to know more about it. 63% respondents want an expert system to

Table 15. Summary of number risk factors known for each category age and gender

Age	Mean of number of risk factors
Below 30 (Total = 120)	3
Above 30 (Total = 126)	3.3
N/A (Total = 13)	4.2
Gender	
Men (Total = 130)	3.14
Women (Total = 129)	3.27

Table 16. Summary of stroke risk reduction knowledge classified by age and gender

Age	Do not know (Total = 158)	Know
Below 30 (Total = 120)	72	48
Above 30 (Total = 126)	62	64
N/A (Total = 13)	4	9
Gender		
Men (Total = 130)	76	54
Women (Total = 129)	62	67

Table 17. Preferred electronic media classified by age and gender

Age	Youtube Video	Online Article	Infographic	Expert System
Below 30	81	61	57	72
Above 30	66	64	49	83
N/A	11	6	5	6
Gender				
Men	95	66	63	78
Women	63	65	48	83

predict their stroke risk and give them more knowledge to reduce the stroke risk. From this result, we are confident that the expert system is wanted and can educate people more about the stroke risk factors, also, its personalized advisor can acknowledge them about how to reduce the risk.

5.2. Further Research

Next research will be literature review about the existing stroke risk calculator and its methods. Then, the collection of stroke risk factor from various literature and knowledge source will be conducted. This aims to build a knowledge-base that will be used as knowledge perseverance to generate stroke risk prediction. The knowledge about advice to reduce stroke risk will be also collated.

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