

The Level of Comprehension of Medical Information Presented in Flowchart versus Standardised Text: A Randomised Controlled Trial

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ABSTRACT

Emergency medical guidelines allow rapid assessment and decision-making during emergency medical scenarios. Therefore, the presentation of medical management protocols should be concise, illustrative, and user-friendly using flowcharts. This study aimed to determine the level of comprehension of medical information and the time taken to make accurate decisions during medical emergency scenarios when presented in a flowchart compared to standardised text format among undergraduate medical students. A randomised controlled trial was conducted among medical students at a private medical university in Malaysia. A total of 60 students were recruited by purposive sampling and randomised equally into control and intervention groups. Flowchart and standardised text versions of "Immediate Management of Diabetic Ketoacidosis (DKA)" were given, followed by a validated case-based scenario questionnaire. The data was analysed using Epi Info Software version 7.2.5.0 and SPSS software. The statistical tests used were Chi-square test, independent sample T-test and Fischer exact test. Based on the grading system, the level of comprehension was statistically significant ($p = 0.043$) among the groups. There was no significant difference in the time taken for correct answers among the two groups ($p = 0.145$). Based on the feedback form, medical students chose the flowchart as their preferred mode of medical information presentation (strongly agree) as it is a fast decision ($p = 0.002$) and agreement on understandability ($p = 0.006$ for agree, $p = 0.001$ for strongly agree). Using flowchart to analyse medical information enhanced the level of

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comprehension of students. The level of comprehension of medical information was significantly higher when using flowcharts compared to standardised text. Therefore, we recommend using flowcharts for future medical instruction, guidelines, and publications.

INTRODUCTION

Around the world, millions of patients require medical attention in emergencies [1]. An emergency medical condition is defined as an illness, symptom, or condition at a level of severity requiring immediate medical attention to avoid potential severe harm to the individual [2]. Medical management protocols, guidelines and care pathways issued by global or local medical authorities allow rapid, accurate assessment and decision-making in these scenarios [3].

Medical management protocols provide concise instructions regarding correct choices of diagnostic and screening tests, ways to provide medical or surgical services, length of hospital stay, or other details required in clinical practice [4]. Clinical guidelines allow the assessment of the risk-benefit ratio in all therapeutic options available and decide accordingly on the most suitable one for the patient to improve the quality of healthcare delivery [5]. Healthcare professionals must be able to rapidly extract and comprehend relevant information from such medical protocols in any given situation. Therefore, publications must outline the medical management protocols follow more concise, illustrative, and user-friendly modes for data presentation like “Flowcharts” [6].

A flowchart is a presentation of information in a sequential manner with a diagrammatic approach [7]. It is well known that flowcharts provide substantial advantages like ease of communication, efficiency analysis and adequate documentation of data [8]. Text is an important element for comprehension in reading and learning [9]. A writer’s intended meaning is influenced by the text’s readability, which relates to the text’s features and layout [9]. The font type needs to be standardised for a standardised text and ensure its clarity and readability [10].

Comprehension is defined as a higher mental function that enables us to process information received via different sensations and to understand its meaning. Three levels of comprehension are described in the literature: Literal, Inferential and Critical. Each level of comprehension which allows a greater and deeper understanding than the other influences the reader’s competency in terms of comprehension [11]. Decision-making using flowcharts was superior in comprehension accuracy and speed compared to paragraph instructions [12].

A case study conducted in Hong Kong analysed the decision-making skills among students and revealed that students made better strategic decisions with creative collaboration when flowcharts were implemented into the decision-making model [13]. A Randomised Controlled Trial (RCT) among respiratory therapists in the United States pointed out that the use of both flowcharts and text-based tools can equally achieve dissemination of information of the newly developed complex medical protocol and decided to include both formats to allow better comprehension of the said algorithm [14]. A study conducted in South Korea concluded that physicians preferred having

newly developed asthma guidelines presented in a flowchart to facilitate better comprehension and rapid decision-making [15]. Similarly, flowcharts are frequently used in school settings to aid students' learning process [16-19].

A qualitative study conducted in Cambridgeshire, UK, in 2009 developed flowcharts simplifying cancer diagnosis processes, criteria for discharging patients, and care for patients with diabetes [20]. The study found that flowcharts and various other process modelling diagrams were preferred among healthcare workers to understand complex processes compared to text-based versions and flowcharts in particular were found to be the most favored type of model [20].

In the clinical setting, medical errors can occur in case of insufficient comprehension and intervention measures are needed to bridge the gap in comprehension and minimize the number of medical errors [21]. Although previous studies have reported the effect of flowcharts as a method of information presentation, there are limited studies conducted measuring the level of comprehension of flowcharts both globally and in the Asian region, specifically on healthcare professionals. Therefore, our study aimed to assess the level of comprehension of medical information, the time taken to make the decision, and the participants' perception when presented in a flowchart compared to standardised text among future medical professionals in Malaysia with the determination to discover a pragmatic approach to aid rapid and precise decision making in emergency medical scenarios.

METHODS

Study Design

This study was a pilot parallel randomised controlled trial to assess the level of comprehension of medical information when presented in a flowchart in comparison to standardised text among clinical year students of a private medical university in Malaysia.

Study Setting, sample size, and sampling

This study was conducted between February 2023 and April 2023. We invited 60 participants from clinical-year medical students to participate in this study. The reference study yielded a mean difference of 2.62 and a standard deviation difference of 0.199 between the intervention group (flowchart base diagrams) and control group (textual) with a power of 80% [22] and the sample size was estimated by using OpenEpi version 3.01 software [23]. A minimum sample size of 32 was calculated with 16 participants per intervention and control groups. Considering the availability and willingness of participants to participate in the study and the necessity to increase the reliability and validity of the collected data, we invited 60 participants to the study. The 60 participants were grouped 30 each to the intervention (flowchart) and the control group (standardised text) to evaluate the comprehension level of medical information in the respective forms. After that, the study sample was screened per inclusion and

exclusion criteria to determine the participants' eligibility to participate in the study. Inclusion criteria were (i) MBBS students from clinical years, (ii) Participants of any age, gender, ethnicity, or nationality and (iii) Participants who provided informed consent. Exclusion criteria were (i) Students who are on sedative medications, (ii) Students who have history of head injuries and trauma, (iii) Students who have central nervous system disease, and (iv) Students who are ill on that particular day.

Intervention

The final 60 participants were randomly assigned into two groups (intervention group=flowchart and control group=standardised text). A flowchart and a standardised text about "Immediate Management of Diabetic Ketoacidosis (DKA)" was prepared [24]. The flowchart was printed in black and white on 2 sheets of plain white A4 (210 x 297mm) in portrait orientation. No additional colours were added. The standardised text version of the same flowchart was printed on two sheets of plain white A4 in portrait orientation. Bold, underlined, italicised, highlighted or coloured text were not used. The fonts used for both flowchart and standardised text version were Times New Roman, size 12 with 1.15-line spacing.

Prior to the study, a written Informed Consent Form was obtained from all the participants. The intervention group was given the flowchart while the control group was given standardised text at the same time. A time period of 10 minutes was allocated for both groups to review the given material. At the end of 10 minutes an online questionnaire (Quizizz) was shared with all the participants via a QR code. Through Quizizz application, the number of correct answers along with the average time taken to answer each question were measured for each participant. The total time allocated to answer all the ten questions was ten minutes. Participants were allowed to answer the question at their own pace however the test should be completed within ten minutes. Participants were allowed to refer to the given material throughout the online test (open-book test format). A feedback form regarding our research and their preference for flowchart and standardised text was given at the end of the session.

Data collection

The participation registration form included an introduction to the study and questions regarding the demographic profile of the participants. Quizizz was used to administer the questionnaire to determine the level of comprehension. Ten case-based scenario questions were given with 4 multiple choice answers for each question. Content validation was done for the scenario-based questions by using the experts' ratings and suggestions.

Participants had to choose a single best answer for each question. Participants were allowed to answer the questions in accordance to their own pace however the test should be completed within ten minutes. Using the Quizizz app we measured the number of correct answers, time taken to solve each question along the total time spent on the questionnaire.

At the end of the trial, a feedback form was distributed among the participants. A 5-point Likert scale was used to assess the participants' stress level, their subjective assessment of level of comprehension of the material and their preference of information presentation.

Data analysis

The data obtained from the participants were collected and tabulated in Microsoft Excel spreadsheet and analysed using Epi info 7.2.5.0 software and SPSS (Version 27). The data was analysed accordingly for descriptive statistics, T-test, Chi-square test and Fisher's Exact test. The number of correct answers (total score) and the time taken to answer each question and the entire questionnaire and compared for two groups. The feedback survey with the 5-point Likert scale was used to assess the level of stress, user friendliness, understandability (comprehension), the ability of rapid decision making and preference towards the given material. The skewness and kurtosis of total score and total time were found to be normally distributed [25].

Ethical consideration

All participants in this study were given an informed consent form to decide their participation in this study. The participation of the students was voluntary, and the data collected from the participants were kept confidential. No incentives were given to attract the medical students to participate in our study. Participants were acknowledged that they had the right to quit the study at any time during the study period if they wanted to. The research proposal was then submitted and approved by the Research Ethics Committee, Faculty of Medicine, Manipal University College Malaysia (MUCM), Malaysia.

RESULTS

Table 1 compares demographic data between flowchart group (intervention) and standardised text group (control). There was no significant difference between the participants in two groups in terms of age, gender, ethnicity, and nationality (Table 1).

Table1. Comparison of Demographic data between flowchart and standardised text group participants (n=60)

Variables	Flowchart (n=30)	Standardised Text (n=30)	<i>p</i>
Age			
Mean (SD)	22.50 (1.38)	22.07 (1.01)	0.172 ^a
Median (Q1, Q3)	22 (22, 23)	22 (22, 22)	
Gender			
	n (%)	n (%)	
Male	11 (36.67%)	9 (30%)	0.584 ^b
Female	19 (63.33%)	21 (70%)	
Ethnicity			
Malay	0 (0%)	2 (6.67%)	-
Chinese	7 (23.33%)	6 (20%)	-
Indian	15 (50%)	14 (46.67%)	0.899 ^b
Sri Lankan	8 (26.67%)	8 (26.67%)	0.837 ^b
Nationality			
Malaysian	22 (73.33%)	22 (73.33%)	1.000 ^b
International	8 (26.67%)	8 (26.67%)	

^a- Unpaired t- test

^b- Chi-square

The total scoring of the flow chart group and standardised text group were compared and presented in the Figure 1. The mean and standard deviation of the flow chart group was 76 (15.67), while the standardised text group was 69.33 (19.11).

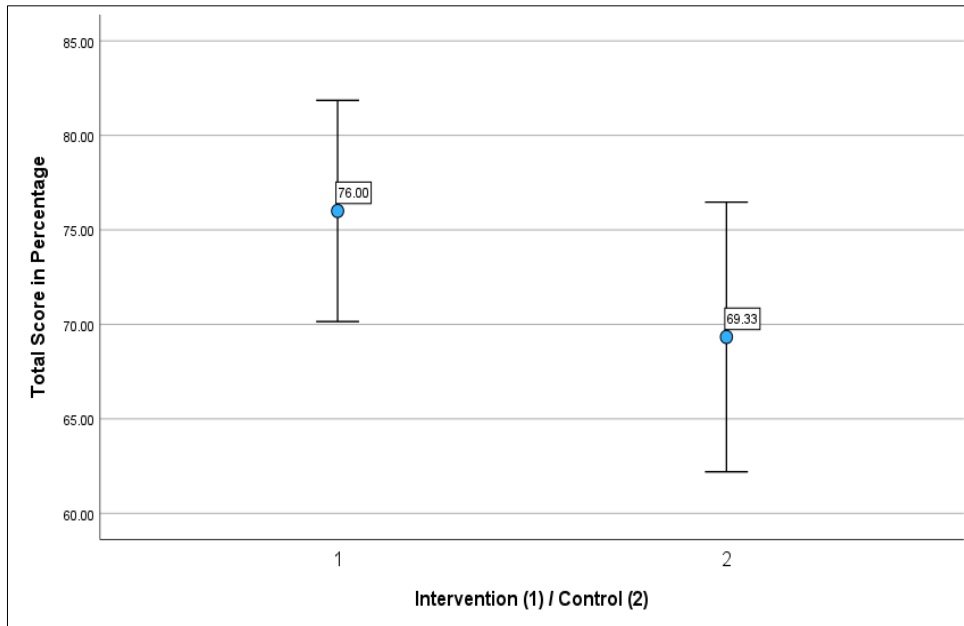


Figure 1. Total score percentage (%) between flowchart and standardised text groups

Table 2 shows the level of comprehension in grades between the flowchart (intervention group) and standardised text (control group). The grading categories are based on the standard scoring intervals for the respective levels of comprehension [26]. The grading is categorised as 86-100 (very good), 71-85 (good), 56-70 (fair), 41-55 (poor), 0-40 (very poor) [26]. Based on the case-based questionnaire, 17 students (56.66%) from the intervention group managed to secure the scores above 70% but only 13 students (43.33%) from the control group were capable of doing (Table 2).

Table 2. Level of comprehension in Grades between flowchart and standardised text

Grades	n (%)					p
	Very Good	Good	Fair	Poor	Very Poor	
Flowchart	10 (33.33)	7 (23.33)	9 (30)	4 (13.33)	0 (0)	0.043 ^c
Standardised text	6 (20)	7 (23.33)	13 (43.33)	0 (0)	4 (13.33)	

^c Fisher's Exact

Figure 2 presents the mean and standard deviation of time taken for the correct answers to the case based questions. The mean and standard deviation for the flowchart group is 4.30 (1.77) for the standardised text group is 4.59 (1.95) respectively. The mean difference between standardised text and flowchart group is 0.29 (17.4 seconds), which indicates that the flowchart group took a shorter average duration to answer accurately (Figure 2).

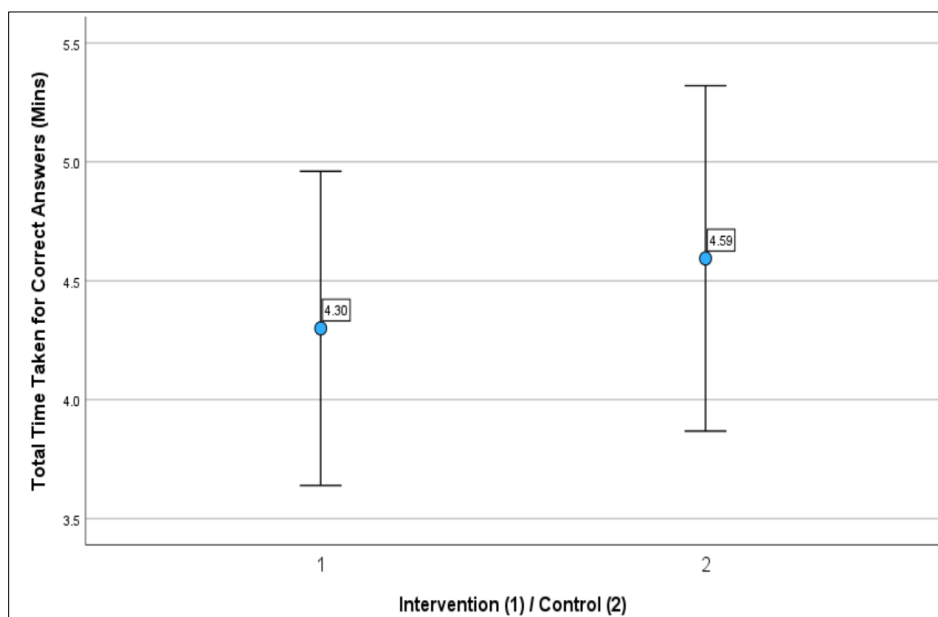


Figure 2. Total time taken for correct answers of questionnaire between flowchart and standardised text groups.

Table 3 shows the data on participants' perception on utilisation of flowchart vs standardised text to comprehend medical information obtained from the participant feedback form. The first 5 questions on the feedback form were based on personal perception of different categorical variables, allowing participants to grade the answer using a 5-point Likert scale. And the final question inquired regarding the personal preference of material among the two groups. All data were analysed using the Chi-square test due to the categorical nature of the independent and dependent variables.

The first question allows the participants to grade the level of stress encountered using a five-point Likert scale. 6 participants agreed and 18 disagreed that flowchart is stressful, while in the standardised text group 8 participants agreed and 11 disagreed that standardised text is stressful. When the "user friendliness" of the given material was assessed using the second question, in the flowchart group, 30 participants agreed while none of them disagreed on the user friendliness of the flowchart. 18 participants agreed and 5 disagreed while another 7 was uncertain on the user friendliness of the standardised text. It was evident that all 30 participants in the flowchart group made a clear choice and either agreed or strongly agreed on the user friendliness of the material while the 30 participants on the standardised text group had differences of opinions which ranged from strongly disagree to strongly agree. The third question is targeted on assessing the ability to make "fast decisions" using the five-point Likert scale. 28 participants agree and 2 participants disagree that flowchart is helpful in making fast decisions. In the standardised text group 15 participants agreed, 8 participants disagreed while 7 participants were uncertain on whether standardised text was helpful for fast decision making. The fourth question was aimed to assess the personal preference of material for "future references". 28 participants agreed while only 1 disagreed on the use of flowcharts for future reference. 15 participants disagreed while none agreed for the use of standardised text for future reference.

The fifth question assesses the perception of the participant on the level of understanding (Comprehension) using the five-point Likert scale. Out of 30 participants in the flowchart group 29 agreed on the higher level of understanding (comprehension) when using the flowchart while only 1 was uncertain. 17 participants agreed and 3 participants disagreed with 10 uncertain on the level of understanding for the standardised text. Relative Risk (RR) was calculated using values for "uncertain" as the reference group. It resulted in a RR value of 6.39 and 8.07 along with the p values of 0.006 and 0.001 for the "Agree" and "strongly agree" groups respectively.

When inquired on the participant's "preferred method of presentation", flowchart was preferred by 27 participants of the flowchart group and 24 participants of the standardised text group. Which shows that 51 participants out of 60 (85% of the total sample) agreed on the flowchart as the preferred method of presentation irrespective of the group they were assigned. 6 participants from the standardised text group and 2 participants from the flowchart group preferred standardised text as the preferred method of presentation which was only 15% of the total sample (Table 3).

Table 3. Participants' perception on utilisation of flowchart vs standardised text format to comprehend the medical information

Variable	n (%)		p
	Flowchart (n=30)	Standardised Text (n=30)	
Stress			
Strongly disagree	7 (23.33)	3 (10.00)	0.510
Disagree	11 (36.67)	8 (26.67)	0.571
Uncertain	6 (20.00)	11 (36.67)	1.000
Agree	5 (16.67)	6 (20.00)	1.000
Strongly agree	1 (3.33)	2 (6.67)	-
User friendly			
Strongly disagree	0 (0.00)	2 (6.67)	-
Disagree	0 (0.00)	3 (10.00)	-
Uncertain	0 (0.00)	7 (23.33)	-
Agree	16 (53.33)	14 (46.67)	0.09
Strongly agree	14 (46.67)	4 (13.33)	
Fast decisions			
Strongly disagree	0 (0.00)	2 (3.33)	-
Disagree	1 (3.33)	6 (20.00)	-
Uncertain	1 (3.33)	7 (23.33)	1.000

Agree	14 (46.67)	13 (43.44)	0.103
Strongly agree	14 (46.67)	2 (6.67)	0.002

Future reference

Strongly disagree	0 (0.00)	4 (13.33)	-
Disagree	1 (3.33)	11 (36.67)	1.000
Uncertain	1 (3.33)	5 (16.67)	-
Agree	10 (33.33)	8 (26.67)	0.166
Strongly agree	18 (60.00)	2 (6.67)	0.002

Understandability

Strongly disagree	0 (0.00)	0(0.00)	-
Disagree	0 (0.00)	3 (10.00)	-
Uncertain	1 (3.33)	10 (33.33)	-
Agree	18 (60.00)	13 (43.33)	0.006
Strongly agree	11 (36.67)	4 (13.33)	0.001

Preferred method of presentation

Flowchart	27 (90.00)	24 (80.00)	0.142
Standardised text	2 (6.67)	6 (20.00)	
Mind map	1 (3.33)	0 (0.00)	-

Chi-square test

DISCUSSION

A randomised controlled trial was conducted among a group of medical students to determine the level of comprehension, decision-making accuracy, and the participants' perception when medical information is presented in a flowchart compared to standardised text. In order to achieve our set research target, the trial was designed and conducted by presenting the same medical protocol material in both flowchart and standardised text versions to the intervention and control groups respectively. At the end of the trial the level of comprehension was assessed using a validated case based questionnaire while the time taken to determine the correct answers along with the total time for completion were also measured using an online software application called "Quizizz". All data generated from the trial was analysed using appropriate statistical tools and measures.

The study concluded that the graded level of comprehension was greater in the flowchart group compared to the standardised text group and the exhibited difference was statistically significant. The mean total score percentage (%) was comparatively higher in the flowchart group than in this study's standardised text group. Therefore, based on these results we could successfully reject the null hypothesis of the research. Both the findings were consistent with a previously conducted Quasi experimental study among 57 participants in University of Iowa, which indicated that flowchart was the better data presentation method to improve comprehension, particularly for tasks with high levels of complexity [28]. But when reviewing past literature on similar themes, it was evident that some research pointed a contrary point of view.

For instance, in a quasi-experimental study conducted among 149 psychology students in University of New Hampshire showed that though programmed instructions can score better in tests compared to standardised text formats the difference of level of comprehension was insignificant [29]. Another study conducted among 30 respiratory therapists in Cleveland Clinic, Ohio, United States tested the dissemination of information in a newly developed protocol using flowcharts and test formats and concluded that both the formats yield significant knowledge acquisition and pointed out that some participants may have struggles deciphering the material in flowcharts due to the unfamiliarity to the format [14]. The reasoning for the differences in findings of the above-mentioned studies to our study is difficult to pinpoint. Although the study designs and the fact that these studies measured the level of comprehension by the means of memory retention and follow up, rather than focusing on a "open-book" test concept which would allow to exclusively measure the level of comprehension without the involvement of the "memory" component might be factors that would contribute to the difference in findings.

When considering the measurement of time to complete the questionnaire and the time taken to approach each question, the data generated was statistically insignificant. But the flow chart group managed to secure a less mean total time than the standardised text group, proving that flow charts allowed the participants to approach answers faster than the control group. The above findings partially agree with a key research paper published based on a randomised control trial on the level of comprehension of flowcharts versus printed instructions by R. Kammann of University of Otago, New

Zealand in 1975. Kammann pointed out that flowcharts are superior in compression accuracy and speed compared to standardised text [12].

Another study conducted with 64 undergraduate psychology students in the California state university pointed out that students in the flowchart group required an overall less view time to study the material and find the answers to the given questions [27]. During the literature review, there is a lack of studies that have been conducted focusing on the speed advantage that can be gained from using flowcharts in decision-making scenarios. Therefore, with the existing literature it is difficult to make comparisons and draw conclusions for the “time” and “speed” factors for using flowcharts and standardised text.

The data obtained using the five-point Likert scale on participants’ perception of utilisation of flowcharts versus standardised text, participants overwhelmingly agreed on three key areas: Fast decision-making, Understandability and use for future references. For the perception of “Stress” the difference between the two groups was statistically insignificant. Also, majority of the participants in both groups agreed on the user-friendliness of flowcharts while selecting it as their preferred method of presentation. Most of these findings are compatible with previous studies conducted. A study conducted in Queensland, Australia among senior high school students on the use of flowcharts in procedural mathematics, showed that 81% preferred flowcharts and 94% believed it improved teaching and learning process [18].

Another similar study conducted among health care workers in a hospital in Cambridgeshire, England showed that the majority of participants preferred modelling diagrams to simplify complex procedural tasks while flowcharts were the most favoured type of model [20]. During the study we conducted, stress encountered by the participants when handling the given material was not significant. This finding is also in accordance with a study conducted among 144 accounting students, which concluded that stress among the two groups was not significantly different [22].

The observed discrepancy between the studies cited in the literature review and this study could be explained by the limitations discussed below. In this study, the blinding was not conducted. Another limitation that we had was our sample size being small, our study time coincided with the end of posting examinations of other batches, making them unavailable to join our study as they needed to focus on their studies.

CONCLUSION

In conclusion, the study results show that the mean of the total score percentage between the flowchart group (intervention group) and standardised test (control group) is higher in the flowchart group than in the standardised group. Despite the fact that the data is not statistically significant, this indicates that the average of the flowchart group scores is higher than the standardised group. The frequency of the correct answers between flowchart and standardised text had significant findings. The level of comprehension in grades in the flowchart group was greater when compared to the standardised text group. The total time taken to complete the questionnaire was

shorter in flowchart compared to standardised text. However, the data obtained was not statistically significant.

According to the data gathered from the feedback form, a majority of the participants agreed that the utilisation of flowcharts was more user friendly and understandable, reduced stress, and enabled them to make fast decisions. 90 percent of the participants chose flowcharts as their preferred method of information presentation. In general, our study concludes that flowcharts are the preferred method of information presentation in comparison to standardised text.

RECOMMENDATION

For future research, it is recommended to have a larger sample size involving not only medical students, but also medical professionals who are involved in making emergency decisions so as to have stronger evidence. Besides that, participants from other colleges of different education programs should be recruited and evaluated flowchart vs standardised text as a method of information presentation.

We would recommend flowchart for medical students as a way of understanding medical topics particularly concerning management. This is particularly helpful for students to understand the complex management of a disease that is created based on multiple criteria of a patient. There are countless management guidelines created for the vast diseases of the medical field. Hence, we recommend assessing the comprehension of management guidelines using flowchart method vs standardised text again with a bigger sample size.

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