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Analysing the Optimum Number of Cupping Points for Selected Diseases by Utilising Graph Colouring

Nur Atikah Aziz[1], Yuhani Yusof[1,*], Hazulin Mohd Radzuan[2], Wan Aliaa Wan Sulaiman[3], Viska Noviantri[4]

[1] Centre for Mathematical Sciences, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuh Persiaran Tun Khalil Yaakob, 26300 Kuantan, Pahang, Malaysia
[2] Department of Basic Medical Sciences, Kulliyyah of Medicine International Islamic University Malaysia, IIUM Kuantan Campus, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia
[3] Fakulti Perubatan Dan Sains Kesihatan, Universiti Putra Malaysia, 43400 UPM Serdang Selangor, Malaysia
[4] Mathematics Department, School of Computer Science, Bina Nusantara University, Jakarta, Indonesia

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ABSTRACT

An innovative methodology is proposed in optimizing the cupping points related to stroke, insomnia and back pain diseases through the utilization of a graph colouring method. Personalized treatment strategies and patient management heavily rely on the optimization of cupping points. By leveraging the powerful tools of graph theory and by the application of colouring approach, this study aimed to provide valuable insights into enhancing the optimum number of cupping points for selected diseases. According to the graphical model utilized in this study, this technique also saves time and money because it's imperative to acknowledge that the appliances of two vertices as the most effective nerve point for initial treatment is sufficient and highly efficient. This method is significant from previous methods that required the use of 10 nerve vertices for back pain, 14 for insomnia, and 14 for stroke treatment, thus could have a profound impact on patients' wellbeing, as well as various fields and industries.

1. Introduction

Wang *et al.,* [1] state that one of the traditional Chinese medicines (TCM) treatments for reducing chronic pain is cupping therapy. As described by Aboushanab *et al.,* [2] and Cao *et al.,* [3], the medicinal cupping technique involves using cups made of various materials, that are applied to the acupoint or painful location using a heating or vacuum device. It is used as a deep-tissue massage and to treat various disease, including pain, inflammation, poor circulation, pressure in blood vessel, and others [4].

Referring to Al-Bedah *et al.,* [5], wet cupping, movement or massage cupping, dry cupping, flash cupping, and medicinal cupping are just a few of the many varieties of cupping therapy available. According to Al-Bedah *et al.,* [6] currently, dry, and wet cupping are the two types of frequently used

* *Corresponding author.*
E-mail address: yuhani@umpsa.edu.my

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cupping. The specific underlying tissue is simply drawn into the suction cup during dry cupping. The process is the same in wet cupping, yet it incorporates the additional steps of bloodletting and scarification into the overall process. Ghods *et al.,* [7] mention that the medicinal cupping point will be chosen based on the patient's complaint or disease. Specific medicinal cupping points will be used for each different disease. The cup is heated first before being put on the body parts to induce suction. The point will then be cut, causing blood to spill. Several authors [8-10] state that the procedure is repeated until no more blood flows from the medicinal cupping points.

According to Xu *et al.*, [11] and Aboushanab *et al.*, [12], TCM has been developed for over thousands of years and is known for its diagnostic and therapeutic benefits for several diseases, including migraines, back pain, stroke, asthma, and diabetes. Numerous studies have been done on various diseases to show the effectiveness of medicinal cupping therapy has been shown by Uddin *et al.*, [13]. In this context, most research focuses on the techniques and the effectiveness of medicinal cupping through different approaches. Hence, this ongoing research aims to optimize the chosen medicinal cupping points.

In this study, back pain, insomnia, and stroke are the three diseases that are interesting to analyze due to some following justifications. The first disease that will be discussed in this paper is chronic back pain which leads to physical, psychological, and economic impact, as well as high consumption of medications and medical services as mentioned by Sielski *et al*., [14] and Gore *et al.*, [15]. According to the World Health Organization (WHO) [16], in 2020, around 619 million people worldwide had back pain. It is expected to increase to 843 million by 2050 due to more people and an aging population. Sita *et al*., [17] reported that TCM has been used in conjunction with allopathic pain management as part of the movement towards demedicalization. Among these methods, medicinal cupping therapy is suggested and used as one of the TCM approaches that help to alleviate chronic pain, as described by Wang *et al*., [18].

The second disease, insomnia, is the most typical sleeping issue. According to Cao *et al.,* [19], middle school students, employees, and soldiers are among 43.8% of people who report having trouble sleeping, with college students experiencing the worst cases of insomnia. Zhang *et al.,* [20] state that medicinal cupping therapy has a positive effect and demonstrates superiority in cases of mild insomnia with fewer treatments and higher rates of improvement and cure. There is a current paucity of studies describing how medicinal cupping, rooted in ancient traditions, emerges as a potential candidate for alleviating insomnia symptoms.

The last disease that will be discussed is stroke. The World Stroke Organization (WSO) [21] has declared that stroke continues to be the second most common cause of death and the third most common cause of death and disability combined (measured in disability-adjusted life-years lost - DALYs) worldwide. Many stroke survivors continue to experience residual disability even though stroke mortality is declining, as shown by Feiqin *et al*., [22]. As mentioned in Ovbiagele *et al.,* [23], the prevalence of stroke and the socioeconomic burden are anticipated to increase as there will be a growing aging population and a declining number of stroke deaths. Referring to Lee *et al*., [24] and Kim *et al*., [25], few studies have examined how cupping treatments were tested on stroke patients to study the effectiveness of cupping in the rehabilitating stroke.

According to West *et al.,* [26], graph colouring is one of the techniques used in graph theory. The chromatic number, $\chi(G)$ is the smallest number of colours needed to colour the vertices of a graph so that no adjacent vertices have the same colour. In planar graphs, the Four-Colour Theorem dictates that the chromatic number is at most 4, and bipartite graphs are always 2-colourable as stated by Appel *et al.,* [27]. Scheduling, map colouring, and wireless communication are examples of graph colouring applications. In the realm of alternative medicine, a novel application of graph colouring emerges in the optimization of medicinal cupping points. To date, very little attention has

been paid to this field. By leveraging the principles outlined by West *et al.,* [26], in graph theory, specifically the chromatic number, χ(*G*) practitioners can systematically determine the optimal selection of cupping points. This innovative approach, inspired by the Four-Colour Theorem and insights from Appel *et al.,* [27], brings a fresh perspective to alternative therapies, providing a structured method for cupping point selection. As the exploration of graph colouring widens its horizons, its adaptability to alternative medicine showcases potential advancements in therapeutic interventions.

Much research examines the efficacy of medicinal cupping. Meanwhile, not much research has been explored about the specific cupping points for the treatment of back pain, insomnia and stroke has yet to be explored. The research is geared towards identifying medicinal cupping points to assist practitioners during medication. This study proposes a graphical methodology that uses graph colouring perspectives to determine the optimal number of medicinal cupping points for treating back pain, insomnia, and stroke.

2. Methodology

The human nervous system, which comprised of central and human nervous systems, is connected as it comprises the brain and bundles of afferent and efferent nerves fibres. By identifying the medicinal cupping point as the vertices, a basic graph may be constructed, allowing for the use of graph theory. Referring to Al Bedah *et al*., [8] and Aziz *et al.,* [9], practitioners are currently continually cupping at random points, mostly due to patient preferences. Increasing the number of medicinal cupping points costs more time and money. In this regard, using a trustworthy simulation model based on graph colouring gives a more advantageous choice, allowing cupping practitioners to ascertain and effectively explain the appropriate and necessary number of medicinal cupping points. This preliminary investigation used graph colouring as the chosen method due to data accessibility challenges highlighted by Kim *et al.,* [28], despite the existence of alternative approaches such as multi-objective functions and multi-criteria decision-making. Some related definitions used in this article will first be defined.

Definition 1 [29]: Vertex
A vertex, V is a point where two lines intersect or meet.

The vertices of the generated graph are the cupping point employed in medicinal cupping. There must be a specified location and a specific number of cupping points for each disease.

Definition 2 [29]: Edge
The edge, E is a link or line between vertices, V.

The human nervous system will be represented by the edges connecting all the relevant cupping points (vertices) to create a basic graph.

Definition 3 [29]: Graph, *G*
A graph $G = (V, E)$ consists of V, a nonempty set of vertices or nodes and E, a set of edges.

The vertices and edges will be the cupping points and nerves, respectively. The definition of the approach method is then provided.

Definition 4 [30]: Graph colouring
Graph colouring is an assignment of colours to every vertex and if two vertices joined each other by an edge, they must have different colours.

The process will determine the optimal solution where the graph contains the fewest colours to be assigned.

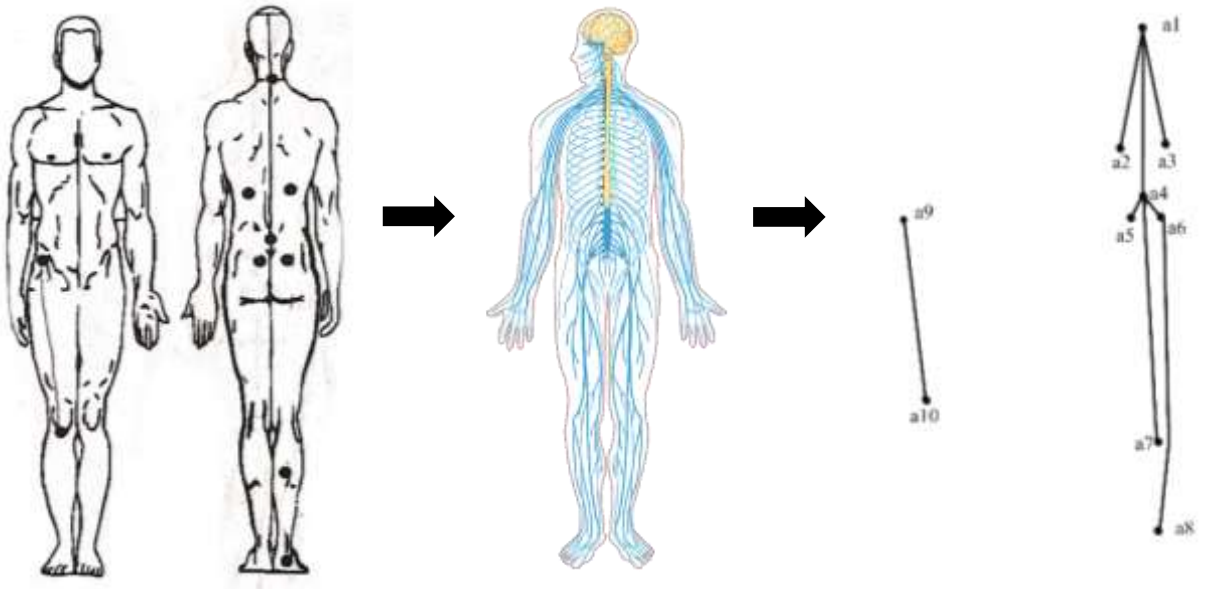
Definition 5 [30]: Chromatic number, χ(*G*)
The chromatic number, χ(*G*) of the graph is the least number of colours required for colouring a graph.

The chromatic number is determined by counting the total amount of colour utilized after assigning a colour to each vertex. The element with the smallest chromatic number will be selected to make the decision.

Graph colouring has significant practical applications in various domains, and its study has provided several theoretical issues. Graph colouring is widely utilized in practical applications such as compiler design, scheduling, wireless communication, and timetabling as several authors show in review paper [31-34]. This result suggests that graph colouring can be used as a different strategy for streamlining procedures. This article will use the graph colouring approach to determine the ideal number of medicinal cupping sites for back pain, insomnia, and stroke treatment. Since no research uses graph colouring for medicinal cupping, and there exists a relation between medicinal cupping and the basic graph, the graph colouring method is chosen as the most suitable approach that can be used in this research.

3. Results

A recent study by Jie *et al.,* [35] reports that the COVID-19 pandemic caused countries and organizations worldwide to revise their business operations. Some countries, such as Malaysia, imposed Movement Control Orders (MCO) to stop the virus from spreading. Healthcare professionals are faced with circumstances where patients may not be available for physical examinations due to the COVID-19 pandemic's problems. When presented with the situation, this research mainly depends on data obtained exclusively from interviews and medical opinions. According to consultations with specialists, each disease has unique cupping points in the human nervous system. These back pain, insomnia, and stroke cupping points have been applied and practiced by the cupping therapy expert from the Pusat Bekam Al-Yakin. The association of cupping point will then be discussed by a human anatomy specialist from International Islamic University Malaysia (IIUM) Kuantan, Pahang, viewed from a medical perspective. After that, a fundamental graph will be used to investigate the connection between medicinal cupping points and the human neurological system. A simple graph is developed to illustrate the connections between the cupping points via graph theory. Figure 1 shows the procedure for the basic medicinal cupping point.



Step 1: Basic cupping point are determined (Nerve vertex) [35]

Step 2: Mapped to human nerve body (Nerve edge)

Step 3: Simple graph obtain (Nerve graph)

Fig. 1. Mathematical model process for basic cupping points

As a result, the following definitions for nerve vertex, nerve edge, and nerve graph are presented.

Definition 6 [31]: Nerve Vertex, *NV*
Nerve vertex, NV is a vertex that represents medicinal cupping points for a unique disease based on the human nerves system.

Definition 7 [31]: Nerve Edge, *NE*
Nerve edge, NE is an edge that connects between the nerve vertex, $N\,V$ to form a simple graph based on the human nerves system.

Definition 8 [31]: Nerve Graph, *NG*
A nerve graph, NG consist a set of nerve vertex, NV that connected by nerve edges, NE . In other way, nerve graph represents as NG = (NV , NE).

Definition 9: Nerve Cupping, *NC*:
A nerve cupping, designated as *NC*, represents a specific medicinal cupping point strategically applied to be cupped during medicinal cupping treatment.

Ideally, the relation between cupping points and the mathematical model can be depicted as in Table 1:

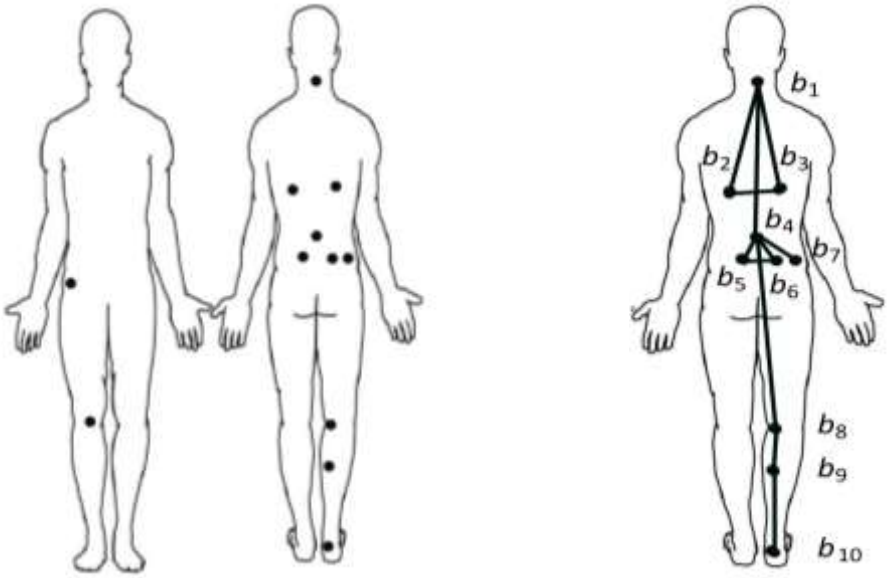
Table 1
The relation between cupping points and the mathematical model

Medicinal Cupping	Mathematical Model
Medicinal Cupping points	Nerve vertex
Human nerve	Nerve edge
Cupping points system	Nerve graph
Set of nerve vertex that will be cupped	Nerve cupping

By leveraging the powerful tools of graph theory and the application of colouring concepts, the process of the mathematical model will be tested toward back pain, insomnia and stroke on finding optimum number of cupping points as discussed in section 3.1, 3.2 and 3.3.

3.1 Graph Colouring Model for Back Pain

Figure 2 displays the ten nodes that represent the nerve vertex *(NV)* used by practitioners to treat back pain. The nerve edge *(NE)* of the graph in Figure 2(b) depicts the nerves connections between the ten nodes of the back pain nerve vertex *(NV),* which are renamed as vertices b_i, $1 \leq i \leq 10$ of a nerve graph *(NG)*. Figure 2(b) can be depicted as a nerve graph *(NG),* as seen in Figure 3.

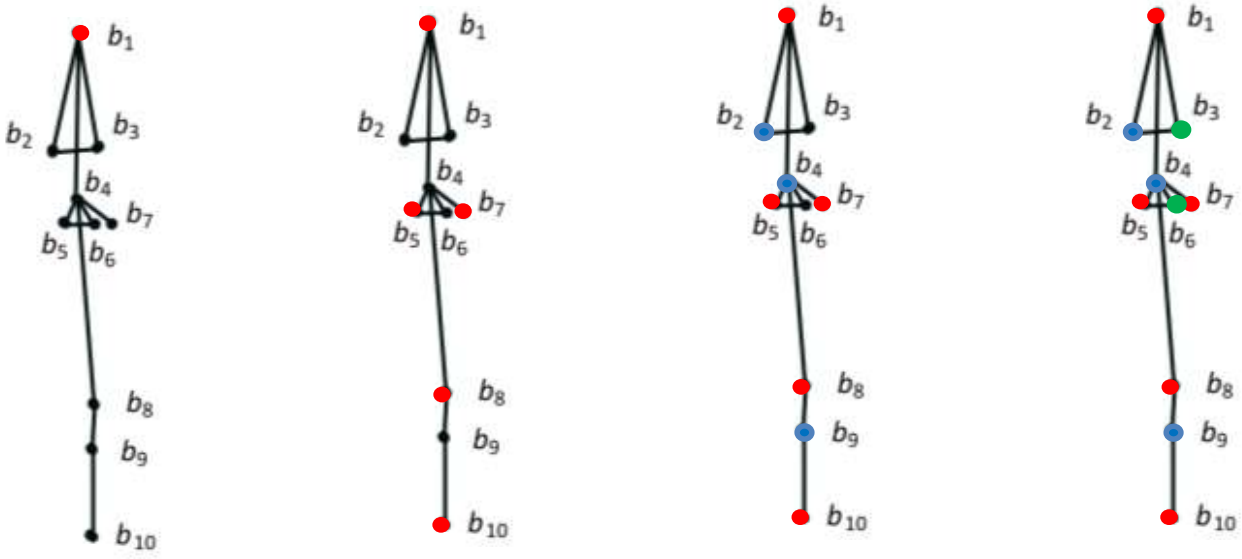


(a) Nerve vertex for back pain [36] (b) Nerve edge based on human nerve

Fig. 2. Nerve vertices and nerve edge for back pain

Fig. 3. Nerve graph, *NG*, for back pain

Figure 3 is derived from Figure 2(b). Due to the connection at the junction where the nervous system connects, the nerve vertices were found to match the human nervous system. Using graph theory, the connection of the nerve vertex generates a nerve graph, *NG*. The ideal number of nerve vertex for medicinal purposes is determined by applying the concept of graph colouring to the nerve graph *G*. Figure 4 shows the process of applying graph colouring to the nerve graph, *NG*:



Step 1 Step 2 Step 3 Step 4

Fig. 4. Steps for colouring the retrieved figure with graph colouring methods for back pain

First, a vertex was selected randomly. In this step, vertex b_1 was chosen and coloured with red. Second, all vertices that not adjacent to b_1, such as b_5, b_7, b_8, and b_{10}, were also coloured with red. When colouring all the vertices, the first colour chosen should be placed as the maximum on the single graph. Since b_2, b_3, and b_4 are adjacent to b_1, automatically b_2 was assigned a different colour, blue. Meanwhile, $b_3$and b_4 were assigned with green, respectively. All processes were repeated until all the vertices were coloured, as shown in Step 4. The result of this procedure is the chromatic number χ(*G*) = 3. Using a trial-and-error method, the precise results are obtained during the graph colouring processes. This iterative process is repeated until all vertices are coloured, allowing the chromatic number, χ(*G*), to be calculated. The outcomes of the trial and error method are shown in Table 1.

In accordance with Definition 4, Results 1 and 3 are the best options out of the three potential outcomes listed in Table 1. Results 1 and 3 are the best options because they achieve the highest number of vertices for red (which is 5 vertices) and the least number of vertices (which is 2 vertices; displayed in green) for Result 1, and the maximum number of vertices (which is 5 vertices; shown in blue) for Result 3. The details are as follows:

Result 1: χ(*G*) = 3
- : 5 nerve vertices, $\{b_1, b_5, b_7, b_8, b_{10}\}$
- : 3 nerve vertices, $\{b_2, b_4, b_9\}$
- : 2 nerve vertices, $\{b_3, b_6\}$

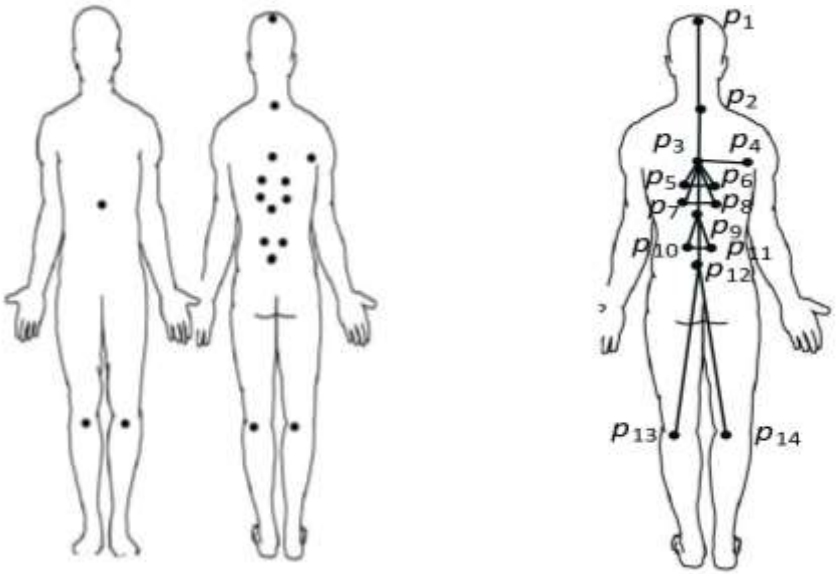
Result 1 and 3 shown in Table 2, that the graph's optimal colour arrangement meets the graph colouring criteria. The chromatic number χ(*G*) of this configuration is 3, which is the smallest number of colours needed to colour all the vertices without allowing adjacent vertices to share the same colour. Figure 4 shows that two vertices are the most effective nerve vertex (Result 1 and Result 3) for the first treatment, which is sufficient and effective. These results contrast to the previous method, which consisted of 10 nerve vertices [36]. For Result 1, the green point is the key element that offers the best solution and greatly lowers the quantity of nerve vertex needed for the procedure. The blue-marked points will take precedence over the red ones because fewer vertices need to be cupped if patients need another round of medicinal cupping treatment. Meanwhile in Result 3, The red-marked points will take precedence over the blue ones because there are fewer vertices that need to be cupped if patients need another round of medicinal cupping treatment.

Table 2
Results of graph colouring for nerve graph *NG* (back pain)

Colour	Result 1	Result 2	Result 3
Red	5	3	3
Blue	3	4	5
Green	2	3	2

3.2 Graph Colouring Model for Insomnia

The 14 nodes that corresponding to the nerve vertices (*NV*) that practitioners utilize to treat insomnia are shown in Figure 5. The nerve edge (*NE*) in Figure 5(b) displays the nerve connections between the 14 nodes of the insomnia nerve vertices, which are renamed vertices p_i, $1 \leq i \leq 14$, of a nerve graph (*NG*). As seen in Figure 6, Figure 5(b) can be represented as a nerve graph.



(a) Nerve vertices for insomnia [36] (b) Nerve edge based on human nerve

Fig. 5. Medicinal cupping points for Insomnia

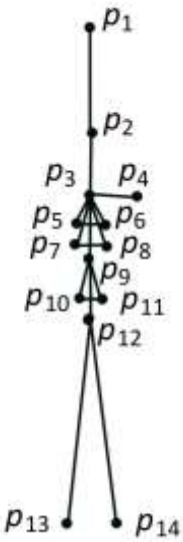
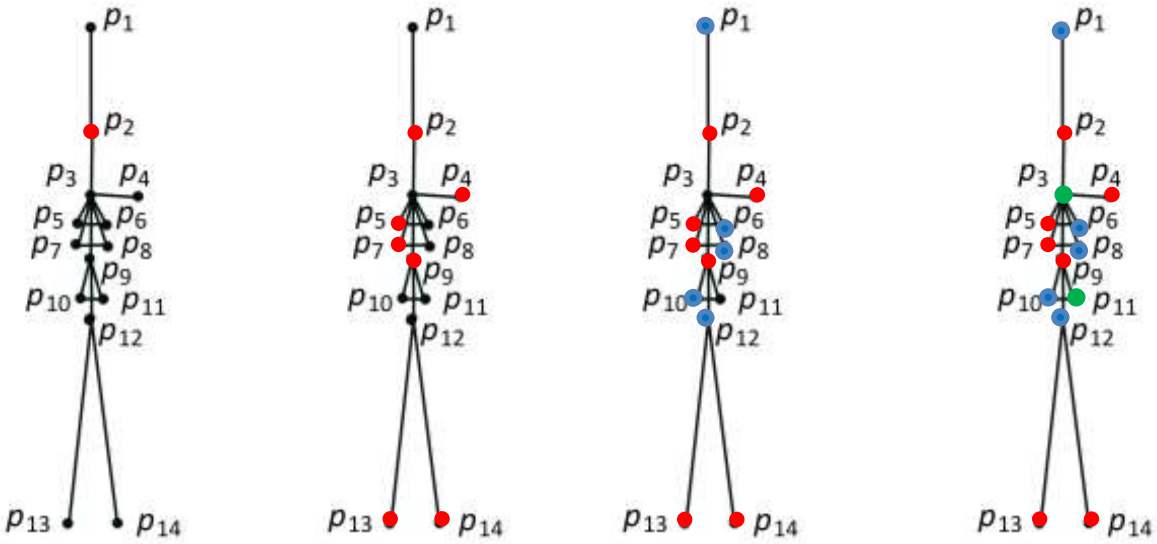


Fig. 6. Simple graph, *G*, for Insomnia

Figure 7 shows the process of applying graph colouring to the Nerve graph (*NG*):



Step 1 Step 2 Step 3 Step 4

Fig. 7. Steps for colouring the retrieved figure with graph colouring methods for insomnia

As the same steps undergo, the results obtain as follows as in back pain.

According to Definition 4, Result 1 is the best choice of the three possible outcomes in Table 3. There are three possible results. Results 1 is the best choice because it produces the most vertices for the colour red (7 vertices), as well as the fewest number of vertices (2 vertices; indicated in green). The details are as follows:

Result: $\chi(G) = 3$

- : 7 nerve vertices, $\{p_2, p_4, p_5, p_7, p_9, p_{13}, p_{14}\}$
- : 5 nerve vertices, $\{p_1, p_6, p_8, p_{10}, p_{12}\}$
- : 2 nerve vertices, $\{p_3, p_{11}\}$

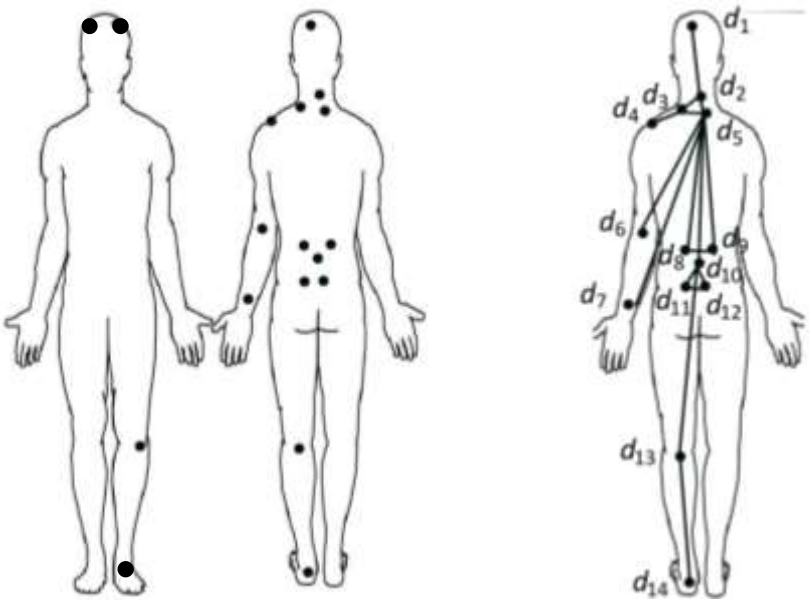
Table 3
Results of graph colouring for nerve graph, *NG* (insomnia)

Colour	Result 1	Result 2	Result 3
Red	7	4	7
Blue	5	7	4
Green	2	3	3

The most optimal colour arrangement on the graph that satisfies the requirements for graph colouring is shown in Result 1. This configuration's chromatic number, or $\chi(G)$, is 3, the fewest colours required to colour every vertex without letting adjacent vertices have the same colour. Figure 7 shows that two vertices are the most effective nerve vertex for the first treatment shown in Result 1, which is both sufficient and effective. This differs from the previous approach, which used 14 nerve vertices [36]. The green point is the key element that offers the best solution and greatly lowers the quantity of nerve vertices needed for the procedure. The points with blue markings will be given priority over those with red ones since fewer vertices require cupping in the case that patients require more medicinal cupping therapy points.

3.3 Graph Colouring Model for Stroke

The 14 nodes that correspond to the nerve vertices (*NV*) that practitioners use to treat stroke are shown in Figure 8. The nerve connections between the 14 nodes of the stroke nerve vertices (*NV*), which are renamed as vertices d_i, $1 \leq i \leq 14$, of a nerve graph (*NG*), are shown by the nerve edge (*NE*) of the graph in Figure 8(b). As shown in Figure 9, Figure 8(b) can be represented as a nerve graph.



(a) Nerve vertices for stroke [36] (b) Nerve edge based on human nerve

Fig. 8. Medicinal cupping points for stroke

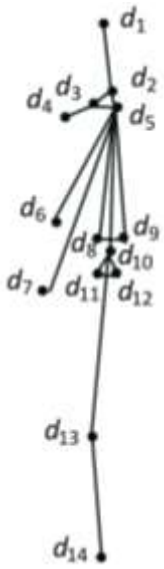


Fig. 9. Simple graph, *G*, for Stroke

The procedure of applying graph colouring to the nerve graph *(NG)* is depicted in Figure 10, as presented below:

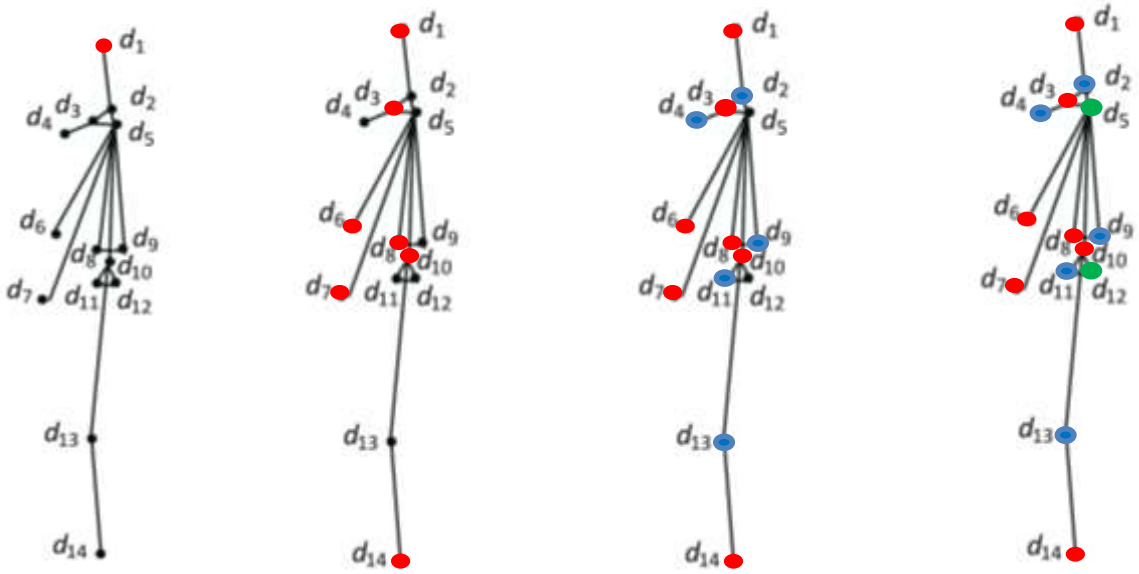


Fig. 10. Steps for colouring the retrieved figure with graph colouring methods for stroke

With the steps implemented as in back pain and insomnia, the following results hold for stroke.

Out of the three possible outcomes stated in Table 4, Results 1 is the best option, according to Definition 4. Table 4 illustrates the three possible results. Results 1 is the best option since it achieves the most vertices for red (7 vertices) and the fewest vertices (2 vertices; depicted in green). The details are as follows:

Result: $\chi(G) = 3$

- : 7 nerve vertices, $\{d_1, d_3, d_6, d_7, d_8, d_{10}, d_{14}\}$
- : 5 nerve vertices, $\{d_2, d_4, d_9, d_{11}, d_{13}\}$
- : 2 nerve vertices, $\{d_5, d_{12}\}$

Table 4
Results of graph colouring for nerve graph, *NG* (Stroke)

Colour	Result 1	Result 2	Result 3
Red	7	5	6
Blue	5	6	5
Green	2	3	3

The best colour arrangement on the graph that satisfies the requirements for graph colouring is shown in Result 1. The chromatic number $\chi(G)$, of this configuration is 3, which is the minimum number of colours required to colour every vertex without allowing adjacent vertices to share the same colour. The results presented in Figure 10 indicate that two vertices are the most effective nerve vertex for the first therapy shown in Result 1, which is both sufficient and effective. This result is not the case with the previous approach, which used 14 nerve vertices [36]. The green point is the crucial factor that provides the optimal solution and significantly reduces the number of nerve vertices required for the method. The points with blue markings will be given priority over those with red ones since fewer vertices require cupping in the event that patients require more medicinal cupping therapy slots.

3.4 Algorithm

The model is currently undergoing real-world trials in partnership with an industrial partner, Pusat Bekam Al-Yakin. Actual samples must be used during this trial process to confirm the model's efficacy. Researchers created an algorithm that was implemented in the C# programming language, as shown in Figure 11, to guarantee the authenticity of the results. This algorithm is essential for verifying the results produced by the graph colouring procedure. The model can handle the validation process effectively by using C#, enabling precise evaluations and insights. The algorithm plays a key role in assessing the model's effectiveness, enabling relevant inferences to be derived from the trial, and additional model improvements as necessary.

```
Begin
Read matrices from .txt file, M = NxN (V[x,y]),
For all node pairs [x,y] ∈ NxN do
if V[x, y] = 1, then colour x ≠ y; Colour 1, Colour 2, … Colour n
if V[x, y] = 0, then colour x = y;
χ(G) = ∑ Colour
Display ∑ Colour 1, ∑ Colour 2, … ∑ Colour n
End
```

Fig. 11. Algorithm on finding nerve vertex for selected diseases

The algorithm first reads the adjacency matrix M from a text file (.txt). As the study involves n vertices, the matrix M comprises elements of $V[x,y]$, where $1 \leq (x, y) \leq n$. In the algorithm, if vertices $[V_x][V_y] = 1$, it signifies that vertices x and y are connected, while a value of 0 indicates that the two vertices are not connected. The number of nerve vertices for treating back pain, insomnia and stroke are represented by the algorithm's output, which is shown in Figures 12, 13 and 14.

3.4.1 Back pain

First, this algorithm will be verifying the results produced by the graph colouring procedure for back pain. The number of nerve vertices for treating back pain is represented by the algorithm's output, which is shown in Figure 12. As demonstrated in Figure 11, it is evident that the optimal number of nerve vertices for the treating back pain is represented by two vertices, as indicated in green colour. Additionally, blue corresponds to five vertices, while red corresponds to three vertices. This output validates the results obtained by applying graph colouring and the concept of the chromatic number. The graph colouring process has successfully identified the most efficient distribution of nerve vertices, supporting the optimal treatment approach for back pain based on the chromatic number concept.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}
b_1	0	1	1	1	0	0	0	0	0	0
b_2	1	0	1	0	0	0	0	0	0	0
b_3	1	1	0	0	0	0	0	0	0	0
b_4	1	0	0	0	1	1	1	1	0	0
b_5	0	0	0	1	0	1	0	0	0	0
b_6	0	0	0	1	1	0	0	0	0	0
b_7	0	0	0	1	0	0	0	0	0	0
b_8	0	0	0	1	0	0	0	0	1	0
b_9	0	0	0	0	0	0	0	1	0	1
b_{10}	0	0	0	0	0	0	0	0	1	0

Fig. 12. Simulation result from algorithm constructed for backpain

3.4.2 Insomnia

Next, this algorithm verifying the results produced by the graph colouring procedure for insomnia disease. The number of nerve vertices for treating insomnia are represented by the algorithm's output, which is shown in Figure 13. Figure 11 shows that two nerve vertices, which are shown in green, are the best number of nerve vertices for treating insomnia. Furthermore, there are seven vertices for the colour blue and five vertices for the colour red. This result validates the findings from the chromatic number concept and graph colouring. Based on the chromatic number concept, the graph colouring procedure has successfully determined the most effective nerve vertex distribution, hence enabling the best possible treatment plan for insomnia.

	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}	p_{13}	p_{14}
p_1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
p_2	1	0	1	0	0	0	0	0	0	0	0	0	0	0
p_3	0	1	0	1	1	1	1	1	1	0	0	0	0	0
p_4	0	0	1	0	0	0	0	0	0	0	0	0	0	0
p_5	0	0	1	0	0	1	0	0	0	0	0	0	0	0
p_6	0	0	1	0	1	0	0	0	0	0	0	0	0	0
p_7	0	0	1	0	0	0	0	1	0	0	0	0	0	0
p_8	0	0	1	0	0	0	1	0	0	0	0	0	0	0
p_9	0	0	1	0	0	0	0	0	0	1	1	1	0	0
p_{10}	0	0	0	0	0	0	0	0	1	0	1	0	0	0
p_{11}	0	0	0	0	0	0	0	0	1	1	0	0	0	0
p_{12}	0	0	0	0	0	0	0	0	1	0	0	0	1	1
p_{13}	0	0	0	0	0	0	0	0	0	0	0	1	0	0
p_{14}	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Fig. 13. Simulation result from algorithm constructed for insomnia

3.4.3 Stroke

Lastly, the same process will go through with stroke. The number of nerve vertices for treating stroke are represented by the algorithm's output, which is shown in Figure 14. Two vertices, as shown in green in Figure 11, are the ideal number of nerve vertices for the treatment of stroke. Furthermore, there are seven vertices for the colour blue and five vertices for the colour red. This conclusion confirms the results obtained by applying the chromatic number concept and graph colouring. The graph colouring procedure successfully found the most efficient distribution of nerve vertices, supporting the best stroke therapy approach based on the chromatic number concept.

	d_1	d_2	d_3	d_4	d_5	d_6	d_7	d_8	d_9	d_{10}	d_{11}	d_{12}	d_{13}	d_{14}
d_1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
d_2	1	0	1	0	1	0	0	0	0	0	0	0	0	0
d_3	0	1	0	1	1	0	0	0	0	0	0	0	0	0
d_4	0	0	1	0	0	0	0	0	0	0	0	0	0	0
d_5	0	1	1	0	0	1	1	1	1	1	0	0	0	0
d_6	0	0	0	0	1	0	0	0	0	0	0	0	0	0
d_7	0	0	0	0	1	0	0	0	0	0	0	0	0	0
d_8	0	0	0	1	1	0	0	0	1	0	0	0	0	0
d_9	0	0	0	0	1	0	0	1	0	0	0	0	0	0
d_{10}	0	0	0	0	1	0	0	0	0	0	1	1	1	0
d_{11}	0	0	0	0	0	0	0	0	0	1	0	1	0	0
d_{12}	0	0	0	0	0	0	0	0	0	1	1	0	0	0
d_{13}	0	0	0	0	0	0	0	0	0	1	0	0	0	1
d_{14}	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Fig. 14. Simulation result from algorithm constructed for stroke

4. Conclusions

According to the graphical model utilized in this study, this technique also saves time and money because it's imperative to acknowledge that using two vertices as the most effective nerve point for initial treatment is sufficient and highly efficient. These methods significantly from previous methods that required the use of 10 nerve vertices for back pain, 14 for insomnia, and 14 for stroke treatment. The generated C# code also facilitates the validation of this particular outcome. This discovery aids society at large in deciding where to cup as well as researchers and practitioners in medical cupping. Although more research and clinical trials are required to confirm this finding and its applicability in the real-world, it's important to acknowledge that this discovery is significant for further development of cupping therapy. It could have a profound impact on patients' wellbeing, as well as various fields and industries. Based on the observations and analysis, shown that the properties of graph colouring hold.

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