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Optimizing Diabetes Cupping Point from Graph Colouring Perspective

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ABSTRACT

Nowadays, diabetes has become one of the most common chronic diseases that lead to mortality around the world. Managing diabetics patients require multidisciplinary approach, in which the patient must maintain a healthy lifestyle, take specific medications for recuperation, and receive specialized medical care. However, apart from conventional medication that are being prescribed nowadays, the ancient therapy of cupping can help in the healing process and provide benefits for diabetes. Medicinal cupping is a specific technique that involves applying cups to specific points on the body to stimulate healing and improve health. Each disease possesses distinct locations that require cupping and practise. The practitioner will apply the cups randomly or based on the patient's complaint, which will have an impact to the cost of therapy. In addition, no mathematical method has been done previously to ensure that this practical procedure is optimized. This paper proposes a graph model to identify the optimal number of cupping points for diabetes using a graph colouring approach based on the perspective of human nerves.

1. Introduction

Mehta *et al.,* [1] state that cupping therapy is one of the oldest traditional remedies used by the Egyptians, Chinese and Greeks since ancient times for various conditions. During cupping therapy, suction or fire creates negative pressure in a cupping glass. This negative pressure is then put on the affected skin area, which is thought to increase the energy flow. People use it as a deep-tissue massage and to treat pain, inflammation, poor circulation, tension, and other diseases as described by Kim *et al.,* [2].

Refer to Al-Bedah *et al.,* [3], numerous forms of cupping therapy exist, encompassing wet cupping, movement or massage cupping, dry cupping, flash cupping, and medicinal cupping. Al-Bedah *et al.,* [4] indicates that, in cupping therapy, both wet and dry cupping is commonly implemented. Wet cupping requires lacerating the skin in order to pull blood into the cup, but dry

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cupping draws the skin into the cup without scarification. According to researchers Ghods *et al.,* [5], applying cups to specific places on the skin while creating a sub-atmospheric pressure using heat or suction is known as cupping. The point selection will be based on these three conditions. First, practitioners will follow the patient's complaint. Second, when there's no complaint, the treatment will be based on the patient's disease, and each disease have particular cupping points. Lastly, treatment will start with basic points than randomly as patient request as shown by Al-Bedah *et al.,* [6]. The cup heated first and placed on specific points in the human body to create suction. Then the point will be cut to shed blood. Umar *et al.,* [7] state that the process repeat until no more blood comes out from the point [7].

According to Aboushanab *et al.,* [8] and Uddin *et al.,* [9], there is a belief that this ancient practice provides numerous advantages to the human body, including improved blood circulation, strengthened immune systems, and the removal of toxins. Previous research has shown that cupping therapy is effective in treating several diseases, including migraines, back pain, stroke, asthma, and diabetes. Many research have been conducted on various illnesses to demonstrate the efficacy of cupping therapy as mention by Rahmadi *et al.,* [10].

This paper is focusing on one of the most common metabolic disorders, which is diabetes. Diabetes has been highlighted by several authors [11-13] as Malaysian's most deadly disease. Besides, the effectiveness of diabetes medicinal cupping has been shown by Akbari *et al.,* [14]. According to Akbari *et al.,* [14], cupping therapy is a worthwhile therapy that helps improves blood circulation and claims to be a very good treatment for pain relief.

As far as our current understanding goes, there hasn't been any specific research conducted regarding the identification of specialized cupping points for treating diabetes. This research will have a significant impact on the community, economy, and nation as a whole. In addition to encouraging healthy living, the newly developed mathematical model is anticipated to identify the optimum number of diabetes cupping points in this society that impact society at a lower cost. New concepts of theorem, lemma, corollary and proposition on selected disease cupping treatments characteristics using adjacency matrix approach will be presented and proof. These results are perhaps to open the eyes of society towards their perspective on the alternative medicine, especially medicinal cupping (that practiced by Prophet Muhammad S.A.W). This research is in line with The Twelfth Malaysia Plan (2021-2025). The developed simulation model for this research is also useful for cupping practitioners presented as a new software as parallel with IR 4.0 needs. This approach will be highlighted as one of the alternative medicines without drug involvement. From the perspective of graph colouring, a graphical model is proposed in this study to determine the optimal number of medicinal cupping points for diabetes.

2. Methodology

For Increasing the number of cupping points results in higher time and cost requirements. Currently, practitioners frequently use cupping at random, primarily due to patient preferences, shown by Al-Bedah *et al.,* [6]. In this regard, using a reliable graph-colouring simulation model offers a more advantageous option, allowing cupping practitioners to identify and effectively convey the optimal and essential quantity of cupping points. Refer to Hanafi *et al.,* [15], while other approaches like multi-objective functions and multi-criteria decision-making exist, this preliminary study adopts graph colouring due to data accessibility limitations. In this context, a graph is defined as follows:

Definition 1 by Rosen [16]: Graph, *G*
In the context of graph theory, a graph *G* = (*V, E*) is composed of a non-empty set of vertices (or nodes), represented by *V*, and a set of edges, denoted by *E*. Each edge in the graph is associated with either one or two vertices, known as endpoints, and it is through these endpoints that the edges establish connections between them.
Every edge in a simple graph connects two distinct vertices; no two edges connect the same vertices. In this study, the edges will be the cupping points, and the vertices will be the nerves. The approach method's definition is then given.

Definition 2 by Rosen [16]: Graph colouring
Each vertex in a graph has a colour, and any two vertices connected by an edge must have a distinct colour. This process is known as "graph colouring." The process will determine the optimal number of problems where the graph contains the fewest colours. This minimum number of colours is known as the chromatic number, denoted as $\chi(G)$.

Definition 3 by Rosen [16]: Chromatic number, $\chi(G)$
The chromatic number $\chi(G)$ of a graph represents the minimum number of colours needed to colour the vertices of the graph, ensuring that no adjacent vertices have the same colour. Once all vertices have been coloured, the overall amount of colour utilized will be counted and shown as a chromatic number. The decision will then be made based on the element with the lowest chromatic number.

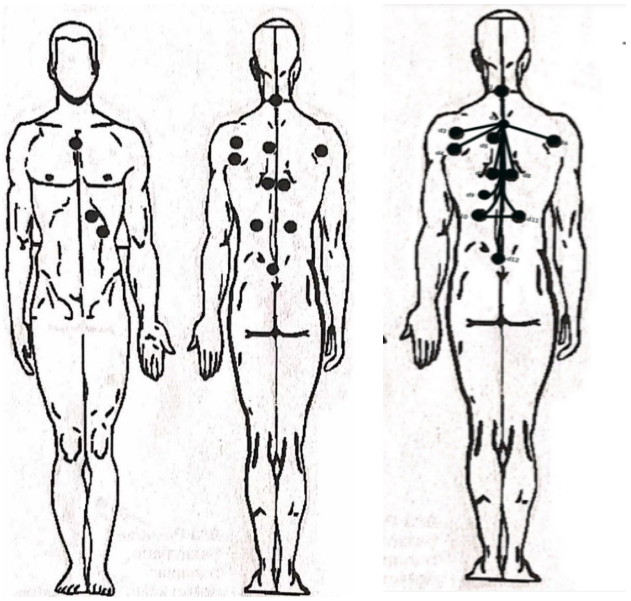
Graph colouring has found numerous practical applications in various fields, and its study has also presented several theoretical challenges. In practical applications, graph colouring is utilised extensively for tasks such as register allocation in compiler design, scheduling in computer science, frequency assignment in wireless communication, and timetabling in education as mentioned by several authors [17-20]. This indicates that graph colouring serves as an alternative approach to simplifying processes. The present paper will employ the graph colouring method to ascertain the optimal number of medicinal cupping points for treating diabetes.

3. Results

3.1 Graph Colouring for Back Pain

According to Jie *et al*., [21], the COVID-19 pandemic had a significant impact on nations' and organizations' global business practices. Several countries implemented Movement Control Orders (MCO) as an additional effort to impede the disease's spread. Comparable to Malaysia, the period of MCO witnessed the closure of all non-essential businesses, the restriction of interstate travel, and the limited availability of daily necessities. Due to the pandemic, Malaysians were confined to their residences. Amidst the challenges posed by the COVID-19 pandemic, healthcare practitioners are confronted with situations where patients may remain unavailable for physical examinations. When faced with the situation, this research heavily relies on information obtained solely through discussions and medical views. Based on discussions with experts, the nervous system of the body has specific cupping points for each disease. These points are used in medicinal cupping. A specialist in Islamic cupping therapy from Pusat Bekam Al-Yakin, will first verify the diabetes cupping points. After that, a human anatomy expert from IIUM Kuantan, Pahang, will confirm the cupping points from a medical standpoint. Subsequently, a basic graph inspired by graph theory will be employed to explore the relationship between cupping points and the human nervous system. Utilising the

principles of graph theory, a simple graph is constructed to represent the connections among the cupping points. The process can be seen in Figure 1.



(a) (b)

Fig. 1. Medicinal cupping points for diabetes, (a) Medicinal cupping points for diabetes [22], (b) Connected cupping points based on human nerve

Figure 1 displays the 12 nodes representing the diabetes cupping points, denoted as vertices i, $1 \leq i \leq 12$, implemented by medicinal cupping practitioners. These vertices are represented by the graph *G*, whereas the nerve connections between the cupping points are depicted as edges in Figure 1(b). Subsequently, Figure 1(b) can be represented as a simple graph, depicted in Figure 2.

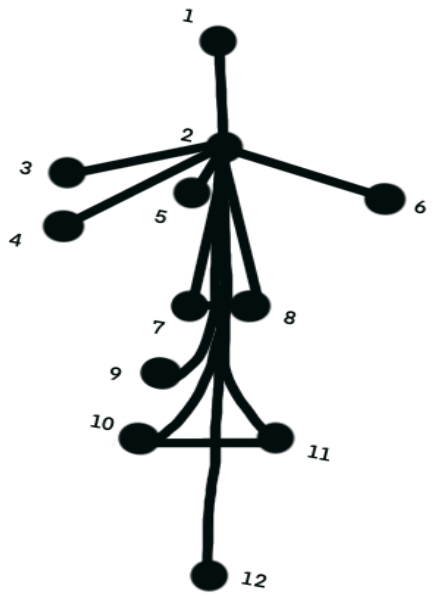


Fig. 2. Simple graph, *G*, for diabetes

Figure 2 is based on Figure 1(b). The cupping points corresponded to the human nervous system because the points are connected at the point where the nervous system joins. Graph theory has been utilised to establish a simple graph, denoted as *G*, from the connections between the cupping points. By applying the concept of graph colouring to the simple graph *G*, the optimal number of medicinal cupping points can be determined. The procedure of applying graph colouring to the simple graph *G* is depicted in Figure 3, as presented below:

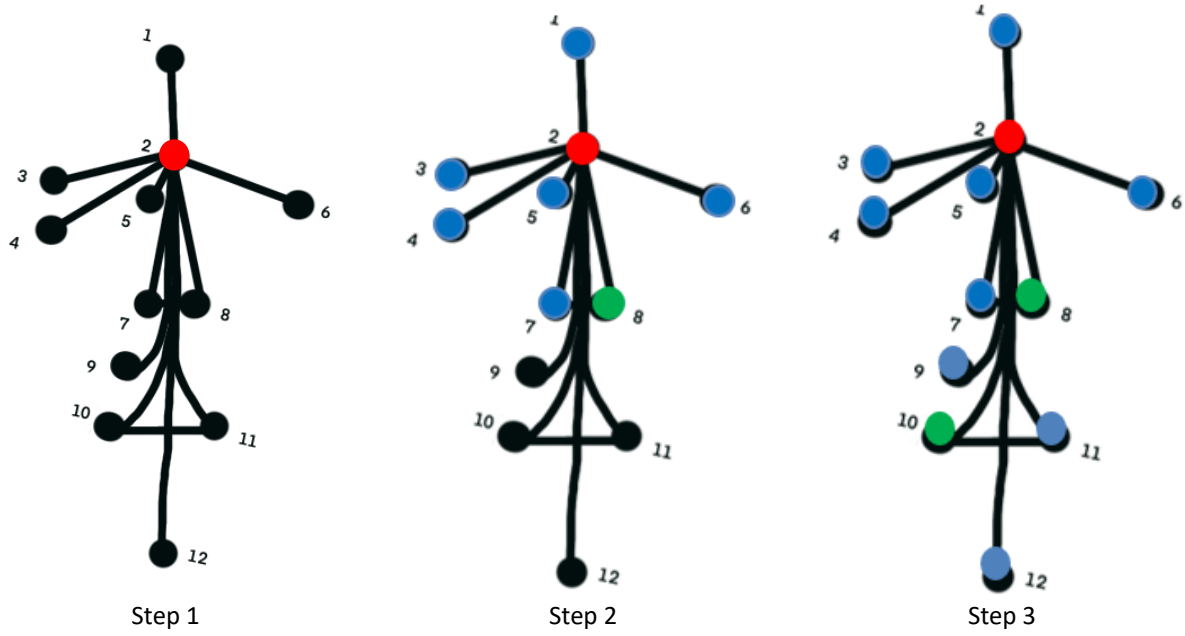


Fig. 3. Steps of using graph colouring methods in colouring the extracted figure

The first step in graph colouring is to pick a random point and give it a colour. For instance, in Step 1, vertex 2 is coloured red. Next, from vertex 2, the adjacent vertices are identified (in this case, vertices 1, 3, 4, 5, 6, 7, and 8) and coloured with different colours (Step 2). Similar actions are taken for other vertices adjacent to 2. It is recommended to reuse colours that adhere to the graph colouring properties, as demonstrated in Steps 2 and 3. This process continues until all vertices are coloured (Step 3). After completing this process, the obtained chromatic number is $\chi(G) = 3$. The precise results are attained using a trial-and-error approach, which is applied during the graph colouring steps. This iterative process continues until all vertices are coloured, allowing the determination of the chromatic number, $\chi(G)$. Table 1 displays the results obtained from the trial-and-error method.

According to Definition 2, the best solution among the three possible results presented in Table 1 is Result 1. This solution achieves the maximum number of vertices coloured in blue, which is 9, and the least number of vertices coloured in red, which is 1. This result optimally satisfies the graph colouring properties. The details of the best solution are as follows:

Result: $\chi(G)= 3$

: 1 medicinal cupping points, {2}
: 9 medicinal cupping points, {1, 3, 4, 5, 6, 7, 9, 11, 12}
: 2 medicinal cupping points, {8, 10}

Table 1
Results of graph colouring for simple graph *G*

Colour	Result 1	Result 2	Result 3
Red	1	1	1
Blue	9	8	6
Green	2	3	5

Result 1 illustrates the optimal arrangement of colours on the graph, satisfying the criteria for graph colouring. This arrangement leads to a chromatic number denoted as $\chi(G)$ of 3, indicating the smallest quantity of colours necessary to colour all vertices while ensuring that no adjacent vertices share the same colour. According to the findings from Figure 3, the optimal cupping point for the first treatment is identified as a single vertex, proving to be sufficient and efficient. This is in contrast to the original approach, which involved considering 12 cupping points. The red point is the key element that provides the optimum solution, significantly reducing the number of cupping points required for the treatment. In the event that patients require a repeat medicinal cupping treatment, the green-marked points will be prioritized over the blue ones because there are fewer vertices that need to be cupped.

3.2 Algorithm

At present, the model is undergoing real-world trials in collaboration with Pusat Bekam Al-Yakin, an industrial partner. This trial process requires the use of actual samples to verify the model's effectiveness. To ensure the validity of the results, researchers have developed an algorithm implemented in the C# programming language, as depicted in Figure 4. This algorithm plays a vital role in validating and confirming the outcomes obtained from the graph colouring process. By using C#, the model can efficiently handle the validation procedure, allowing for accurate assessments and insights. The algorithm serves as a crucial step in evaluating the model's performance, facilitating meaningful conclusions to be drawn from the trial, and enabling further enhancements to the model as needed.

```
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. 4. Algorithm on finding diabetes medicinal cupping points

The algorithm initiates by reading an adjacency matrix M from a .txt file. As the study involves 12 vertices, the matrix M comprises elements of V[x, y], where $1 \leq x, y \leq 12$. In the algorithm, if vertices V[x, y] = 1, it signifies that vertices x and y are connected, while a value of 0 indicates that the two vertices are not connected. As a result of running the algorithm, a chromatic number of 3 is determined, providing the optimal number of diabetic medicinal cupping points. The algorithm's output, as illustrated in Figure 5, clearly represents this optimal number of cupping points for diabetes treatment.

As demonstrated in Figure 5, it is proved that the optimal number of medicinal cupping points for the treatment of diabetes is represented by a single vertex (2), as indicated in red colour. Additionally, the colour blue corresponds to nine vertices, while the colour green corresponds to two vertices. This output serves as validation for the results obtained through the application of graph colouring and the concept of the chromatic number. The graph colouring process has successfully identified the most efficient distribution of cupping points, supporting the optimal treatment approach for diabetes based on the chromatic number concept

$$M = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{array} \begin{array}{c} \begin{array}{cccccccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \end{array} \\ \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

Fig. 5. Simulation result from algorithm constructed

4. Conclusions

Twelve vertices are discovered to be cupped as standard procedures for diabetes conditions. In this study, the graphical model demonstrates that the best and optimized method in cupping therapy for diabetic patient is by using only one vertex, which it will save time and money. Moreover, the C# code that was developed serves to validate this particular outcome. This finding helps practitioners or researchers in the field of medical cupping, and society at large to determine the best points to cup. To find out if this result works in the real world, though, further research and clinical trials need to be done to support this finding.

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