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Research Article

A Comparative Study on the Effectiveness of Mouthwash Using Intelligent System and its Effect

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ABSTRACT

Although COVID-19 is no longer the primary public health threat, ongoing vigilance and preventive measures remain crucial. The pandemic highlighted the need for effective solutions to limit viral transmission, with mouthwash emerging as a promising tool due to its antibacterial and antiviral properties. Recent studies have shown that certain mouthwashes can reduce viral load in the mouth, potentially lowering the risk of infection. This study evaluates 64 mouthwash alternatives for their efficacy in combating COVID-19, using the fuzzy-Preference Ranking Organization Method for Enrichment Evaluation (f-PROMETHEE), a multi-criteria decision-making approach. The results indicate that Dentaid Perio-Aid Active Control is the most effective mouthwash, with the highest net flow of 0.0973, followed by Oroheks Plus Gargle (0.0033) and Kloroben Gargle (0.0021). These findings provide essential insights into the comparative effectiveness of mouthwash products, guiding both healthcare professionals and consumers in selecting optimal products for virus prevention. This study underscores the potential of mouthwash as an accessible, cost-effective solution for enhancing oral hygiene and reducing viral transmission.

1. INTRODUCTION

This Coronavirus disease-2019 (COVID-19) is a novel virus caused by the virus, severe acute respiratory syndrome corona virus 2 also identified as SARS-CoV-2. The disease was first identified in the People's Republic of China, in the Wuhan province in December 2019. On January 2020, the World Health Organization (WHO) officially recorded the disease as a pandemic. WHO, revealed that the virus has recorded mortality rate of about 5.62 million and of about 360 million cases as of 1st of January, 2022. However, so many ways are devised to curtail the spread and potentially weaken the virus [1].

The symptoms range from mild symptoms to deadly symptoms that may lead an intensive care. The most common symptoms include, dry cough, anorexia, fatigue and high body temperature (fever). The COVID-19 is transmittable when a person comes in contact with an infectious person or an infected object. These mainly occur if the contaminated body fluid reaches the body parts, such as from the mouth, nose and eyes. Similarly, a study by the WHO also revealed that infected persons can be contagious for 10 days and can transmit the virus easily. In addition, the diagnoses of the virus are done in many different ways, but it is most commonly done using the nucleic acid tests. The nucleic acid tests detect the presence of the infected RNA [2].

The nucleic acid process has the ability to determine the duration of the virus. This particular test is done using the nasopharyngeal swab. The common preventive measures taken include, vaccination, isolation, regular use of nose masks in public, good hygiene, ventilated place and many more. Similarly, individuals infected with virus are advised to take same precautions by self-isolating and getting the necessary treatments. The WHO approved numerous medications for the COVID-19. These include the application of broad-spectrum medications, which are applicable in treating similar diseases with the symptoms. For instance, in a study conducted on the evaluation of symptom of the disease to measure the most

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common symptom with the highest percentage. This experiment was done on some patients, which shows fever with the highest symptoms. Therefore, fever-based treatments are administered in some cases in treating the virus [3].

1.1 Symptoms

The symptoms of COVID-19 can vary depending on the individual characteristics and body formation. Hence, the most common symptoms are fever, cough, fatigue, headache, joint ache to mention a few. However, some individuals are asymptomatic, which means persons with no observable symptoms but are infected with the virus. These individuals can easily transmit the disease to other persons because they carry the virus. Those with observable symptoms such as, severe coughing, high body temperature, dyspnea and anorexia are the symptomatic characters [4].

1.2 Diagnosis

Scientists from different fields of study have shown interest in the study and diagnosis of COVID-19 in its different forms or variation. Hence, early detection of the virus is essential for the subsequent diagnosis such as self-isolation in curbing the spread of the disease at an early stage. Therefore, different novel methods of COVID-19 diagnosis are conceived using different approaches in different fields. Artificial intelligence-based diagnosis is introduced using smart techniques, such as smart devices that will diagnose, treat and detect the virus using machine learning computational approaches [5].

Medical imaging has recorded high performance in the detection and diagnosis of COVID-19 in many research studies as reported by Ozsahin et al 2020. The researchers separated two major categories to evaluate their results, which are laboratory and radiography approaches suing an AI-based chest CT, deep learning and neural networks were used in the computation of the results. Therefore, the results remarkably revealed about 99% symptom of pneumonia using the advanced machine. Other major diagnostic approaches of COVID-19 include the application of biosensing devices [6].

1.3 Treatment

The treatment of coronavirus requires a broad spectrum-approach, especially when it not first detected during the diagnosis. Therefore, at most cases due to the observable symptoms, the patient is administered medications based on the individual symptoms. In addition, many researchers, institutions and pharmaceuticals have applied broader approaches using both medications and vaccines in treating the virus. Similarly, herbal medicine in some cases was revealed to prevent and cure the virus as reported in Morocco, Japan and China [7].

Other novel approaches involve the administering of different vaccines such as, the Johnsons' and Johnsons, CoronaVac, Sinovac, and in using medications such as antiviral drugs such as favipiravir and merimepodib, dexamethasone, ivermectin, hydroxychloroquine and chloroquine. However, with the evolution of different variants of virus, attention is tilted towards the preventive measures due to the flawed capacities of most of the vaccines and medications used in treating the COVID-19 [8].

2. LITERATURE REVIEW

Mouthwash or mouth rinse is a watery-formed substance that is ingested orally in a form of a gargle. These substances are composed of antiseptic solutions that are essential in reducing microbial loads in the buccal cavity, although mouthwashes could be applicable for analgesic or antifungal characters in numerous forms using different ingredients. The common ingredients used in the mouthwashes include alcohol, benzoic acid, chlorhexidine, digluconate, cytylpridinium chloride, betamethasone, edible oil, fluoride, hydrogen peroxide, lactoperoxidase among a few ingredients [9].

Study by Cai et al revealed the compositional structure of the herbal mouthwash and its effect in acting like the synthetically formed mouthwashes. Relatively, their study showed a significant similarity between the synthetic and the herbal mouthwashes. In other words, the herbal mouthwash acted same as the synthesized form. The herbal mouthwash also targeted the loads of microbial formation in the oral cavity. The application of mouthwash in the mouth involves rinsing it with about 20-50 ml of the substance. This method takes about fifty seconds gargling without consumption. However, it is advisable not to use mouthwash immediately after brushing the teeth due to the benefits of the fluoride residue left on the teeth derived from the toothpaste [10].

2.1 History of mouthwash

The history of mouthwash could be referenced to the mouth rinsing method practiced in the Ayurveda mainly for treatment of gingivitis. Hence, it could also be traced to the Roman and Greek era, which are involved in the practice using mechanical methods by the upper class. Similarly, vinegar, salt and alum were also used in the mouth rinsing as recommended by Hippocrates [11].

Furthermore, the first mouthwash product invented by a German man named Richard Seifert in 1892, produced by Karl Auguust Lingner. Another evolution of this study was done by Harald Loe, who was a Professor at the Royal Dental Collegen, Denmark. Loe showed the demonstration of Chlorhexidine as a potential compound that could destroy any load of the dental plague. The aim of the research was the effectiveness of Chlorhexidine to retain its potency in the mouth with a high concentration [12].

2.2 Recent Findings

Vasudevan and Stahl experimented a study on the cannibinoids infused mouthwash, comparatively to measure its effectiveness with the Chlorhexidine against the bacterial contents of the dental plague. Two infused cannabinoid mouthwashes (CBD) and cannabigerol (CBG) were sampled. An in-vitro analysis was taken from samples collected from 72 individuals from the age 18 to 83 years, respectively. In their results, both the cannabinoids infused mouthwashes and chlorhexidine showed similar bactericidal efficacy [13].

With the distinct potentials of many products of mouthwash ingredients like the chlorhexidine against bacterial deposits in the mouth, it has become clear that mouthwashes have the potentials of disintegrating the bacterial activities in the mouth. However, due to the presence of chlorhexidine and other effective ingredients in the mouthwashes, it is revealed that it potentially has high effect in destroying the COVID-19 deposit in the mouth.

Research study by Eduardo and colleagues revealed the potentials of mouthwash in load reduction of the salivary SARS-CoV-2 using randomized pilot clinical trial. Eduardo et al. investigated three types of mouthwash solutions containing Cetylpyridinium chloride, zinc lactate, hydrogen peroxide and chlorhexidine gluconate to reduce the salivary SARS-CoV-2 deposition in the mouth. They used sixty samples of SARS-CoV-2 positive patients and randomly partitioned them into groups according to specific mouthwash, collecting their individual saliva samples. The results revealed that mouthwash containing chlorhexidine gluconate, zinc lactate and cetylpyridinum chloride significantly reduced the viral load in the saliva for up to 60 minutes, while the mouthwash containing hydrogen peroxide reduced the virus for up to 30 minutes after rinsing [14].

3 MATERIALS AND METHODS

3.1 Samples

Sixty-four samples of various mouthwash products were collected online, base on different searching engines at our disposal. The products collected were put under some criteria involved in their characterization and their potential effects against COVID-19.

3.2 Methods

The method applied in this study is the Multi-Criteria Decision-Making (MCDM) method, using the fuzzy-Preference Ranking Organization Methods for Enrichment Evaluations (f-PROMETHEE) technique. The study was covered by criteria such as, the dose number, dose schedule, storage and stability, contradiction, indication, allergic reaction, advantages, disadvantages, active ingredients, efficacy, approvals and side effects and four chemicals were defined as protective reagents against COVID-19 because of the ingredients they contained, such as Chlorhexidine gluconate, Cetylpyridinium chloride, povidone-iodine and hydrogen peroxide. The advantages and disadvantages of the options has been determined based on their ingredients, their usage for the range of age, their interactions with food, drink and medications, the amount of their usage and their possibility of the allergic reactions.

The PROMETHEE is regarded as one of the preferred MCDM techniques, which allow smooth evaluation and ranking of alternatives, based on the outline criteria. The PROMETHEE ranks desirable alternatives from the most preferred alternatives to the least preferred alternatives. When compared with other MCDM techniques, PROMETHEE is considered advantageous because of its capability to use different types of preference functions for every criterion. This technique simultaneously assists in analyzing both qualitative and quantitative data. The application of PROMETHEE technique is significant in the evaluation of alternatives. The use of linguistic scale with fuzzy logic assists this study for indicating the parameters where the crisp values are not available for the determination of the alternatives [15]. In this study Gaussian preference function is used for the criterion and equal importance levels are given.

4 RESULT AND DISCUSSION

The Table 1 shows the net flow, positive outranking flow and negative outranking flow of alternatives. The alternatives are all products of modern mouthwash reagents, formed by different chemical compounds from various manufacturing labels. When f-PROMETHEE was incorporated in the evaluation of the alternatives, the product Dentaid perio-Aid Active control recorded the highest net flow (0,0973), while prevident sodium fluoride recorded the least net flow (-0,0071). Positive

outranking flow is a measure of the strength of an option compared to other alternatives when all criteria are considered. And negative outranking flow is a measure of the weakness of an option compared to other alternatives when all criteria are considered.

TABLE 1: THE NET FLOW, POSITIVE OUTRANKING FLOW AND NEGATIVE OUTRANKING FLOW OF ALTERNATIVES

Rank	Alternatives	Net flow	Positive Outranking Flow	Negative Outranking Flow
1	Dentaid Perio·Aid Active Control	0,0973	0,0975	0,0029
2	Oroheks Plus Gargle	0,0033	0,0054	0,0021
3	Kloroben Gargle	0,0021	0,0045	0,0024
4	%0.15 Benzydamine HCl %0.12 Chlorhexidine digluconate (Geraks Mouthwash)	0,0018	0,0045	0,0027
4	Ecolab Chlorhexidine Gluconate Antiseptic Mouthwash Peppermint Flavored 0.2% Chlorhexidine	0,0018	0,0044	0,0026
4	Corsodyl Daily Rinse Alcohol Free	0,0018	0,0052	0,0035
7	Chlorhexidine gluconate 120 mg (0.12%) Benzydamine hydrochloride 150 mg (0.15%) (Geral Mouthwash)	0,0017	0,0044	0,0027
7	Chloroben	0,0017	0,0040	0,0023
7	Peroxyl Colgate1.5% hydrogen peroxide	0,0017	0,0043	0,0026
10	1% Food-Grade Hydrogen Peroxide	0,0014	0,0039	0,0024
11	Buco Bleu Kollutuvar	0,0010	0,0043	0,0033
11	Colgate® PerioGard®, Mint, 16 oz (Rx Only) - Alcohol Free	0,0010	0,0041	0,0032
13	(Klorhex Plus) %0.2 Chlorhexidine gluconate + Flurbiprofen	0,0009	0,0036	0,0027
14	Kloehex Plus 2.5 MG/ML + 1.2 MG/ML Gargle, 200 ML	0,0008	0,0032	0,0024
15	Alphadine 1% Gargle	0,0007	0,0044	0,0036
16	Corsodyl Mint Mouthwash	0,0003	0,0043	0,0040
17	Klorhex İrrigasyon Çözeltisi	0,0002	0,0032	0,0029
18	Betaisodona Mouthwash/Gargle	0,0000	0,0029	0,0028
18	ANDOREX GARGLE 120 m	0,0000	0,0036	0,0036
20	Oral B®	-0,0001	0,0028	0,0029
20	Hydrogen Peroxide 1.5%	-0,0001	0,0038	0,0039
22	UltraDex Oral Rinse + Fluoride Mouthwash 500ml	-0,0002	0,0036	0,0038

23	Sensodyne Promine Mouthwash	-0,0004	0,0038	0,0042
24	Listerine® Antiseptic	-0,0005	0,0037	0,0041
25	Chlorhexidine gluconate	-0,0006	0,0041	0,0047
26	Crest Pro-Health Multi-Protection Mouthwash	-0,0008	0,0022	0,0030
27	Chlorhexidine Mouthwash 300ml Original	-0,0010	0,0032	0,0042
27	VITIS Orthodontic Mouthwash 500 ml	-0,0010	0,0021	0,0030
29	2% Hydrogen Peroxide, Fresh Mint	-0,0011	0,0024	0,0035
30	Klorhex Gargle	-0,0014	0,0024	0,0038
30	Cepacol Antibacterial Mouthwash	-0,0014	0,0032	0,0046
32	Colgate Plax Tea & Limon mouthwash No alcohol	-0,0015	0,0020	0,0034
32	Benzydamine HCl %0.15 Chlorhexidine gluconate mouthwash %0.12 (Oroheks Plus)	-0,0015	0,0020	0,0035
34	Wokadine Germicide Gargle 2% with Menthol	-0,0016	0,0028	0,0044
35	Hydrogen Peroxide 1.5% (w/v), Mild Mint	-0,0019	0,0031	0,0051
36	Povisep – Povidone Iodine 1% Mouthwash/Gargle	-0,0020	0,0019	0,0039
37	Wisdom Chlorhexidine Mouthwash Mint 300 ml	-0,0020	0,0022	0,0041
38	Corsodyl Daily Defence Alcohol Icy Mint Free Mouthwash 500ml	-0,0022	0,0019	0,0041
38	%0.15 Benzydamine HCl %0.12 Chlorhexidine digluconate (Heksoben Mouthwash)	-0,0022	0,0019	0,0041
38	Wisdom Chlorhexidine Mouthwash Original 300 ml	-0,0022	0,0020	0,0042
41	Povisia 2% Gargle	-0,0025	0,0023	0,0048
42	Parodontax Daily Mouthwash	-0,0026	0,0023	0,0048
42	Cofsils Experdine Gargle	-0,0026	0,0018	0,0044
42	Peridex™ Chlorhexidine Gluconate 0.12% Oral Rinse from 3M	-0,0026	0,0037	0,0063
42	Arodin – Povidone Iodine 1% Mouth-Wash/Gargle Mouthwash	-0,0026	0,0018	0,0045
46	Povin Mouthwash	-0,0027	0,0021	0,0048

46	Cipladine gargle	-0,0027	0,0020	0,0047
48	Chlorhexidine Mouthwash 300ml Mint	-0,0028	0,0020	0,0048
49	Listerine® Smart Rinse® Kids Fluoride Mouthwash, Berry Splash Flavor	-0,0030	0,0015	0,0045
50	Corsodyl Daily Rinse Alcohol Free	-0,0031	0,0015	0,0046
51	Perio-Aid Mouthwash Intensive Care 500ml	-0,0032	0,0014	0,0046
52	Corsodyl (Alcohol Free Mint Flavour)%0.2 chlorhexididn	-0,0034	0,0014	0,0047
53	LISTERINE® COOL MINT® Antiseptic Mouthwash	-0,0036	0,0026	0,0062
54	VITIS Gingival Mouthwash 500ml	-0,0037	0,0009	0,0046
55	Betadine Gargle and Mouthwash 10mg/ml Oral Solution	-0,0039	0,0016	0,0055
56	Cordocyl Mint Mouthwash	-0,0040	0,0020	0,0060
57	Swish by Colgate® Antibacterial Mouthwash	-0,0047	0,0010	0,0057
57	Swish by Colgate® Antibacterial Mouthwash Mild Mint	-0,0047	0,0010	0,0057
57	Swish by Colgate® Antibacterial Mouthwash Refreshing Mint -	0,0047	0,0010	0,0057
57	Swish by Colgate® Antibacterial Mouthwash Invigorating Mint -	0,0047	0,0010	0,0057
61	Cipladine Povidone Iodine Mouthwash	-0,0050	0,0010	0,0060
62	GUM PAROEX Intensive Action Mouthrinse	-0,0053	0,0015	0,0068
63	LISTERINE TotalCare Sodium fluoride 0.02%	-0,0062	0,0009	0,0071
64	Prevident Sodium fluoride 1.1% (w/w)	-0,0071	0,0018	0,0090

5 CONCLUSION

This study concludes recording high significance of Dentaid Perio·Aid Active Control as the best alternative mouthwash against COVID-19, due to high efficacy, very low side effect, contraindication and allergic reactions. The use of fuzzy MCDM technique, fuzzy PROMETHEE, simplifies the decision maker's confusion in selecting safe mouthwash for human use. This study shows the strengths and weaknesses of the selected mouthwashes, which could also be very important and beneficial for the users and for the experts, working in this field. This study can be improved by including other mouthwashes and additional criteria based on individual priorities.

Conflicts of Interest

The authors declare no conflicts of interest.

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