Pre-Medicine Program as a Factor Influencing Residency Specialization Options of Pre-Medicine Students of University of Perpetual Help System Dalta – Las Piñas Campus

Kisses P. Eusebio, Geram M. Mugol, Yuri Louis N. Taduran, Lian Mei S. Terania,
Phoemela Crystal G. Tumala and Gwyneth Ardee E. Villalino
University of Perpetual Help System DALTA, Las Piñas City

Abstract: Pre-medicine program is the first step on one's medical journey. Choosing the best pre-medicine program may give one prerequisite skill that are likely needed during medical school as well as in residency training. Different programs offer different subjects and competencies to meet, so it gives several advantages and disadvantages for the student with respect to their performance in medical school and residency training. This leads researchers to think that choosing the right pre-medicine program is crucial to be competent enough in the professional field. The study is conducted to know if there is a significant relationship between the chosen pre-medicine program and residency specialization options of pre-medicine students of University of Perpetual Help System DALTA - Las Piñas Campus. In order to find answers to this, the researchers conducted a semi-unstructured interview on 10 pre-medicine students of UPSHD that are categorized into two categories: 5 for BS Nursing and 5 for BS Medical Technology, via MS Teams or Messenger call. The results showed that respondent's current pre-medicine program does not affect their specialization options. Most of them did not have a hard time choosing their current pre-medicine program since it is their already their top choice without considering specialty. They reasoned out that pre-medicine program is independent from the residency training itself. The researchers concluded that there is no significant relationship between pre-medicine program and residency specialization options of pre-medicine students of UPHSD – Las Piñas Campus.

Key Words: pre-medicine program; residency specialization; medical school; nursing; medical technology

1. INTRODUCTION

The field of medicine requires adequate competencies in order to rightfully serve the duty it partakes, given the fact that medical professionals basically hold a patient's life on a daily basis. Along with this is the time it consumes to finally enter the field, as well as the several choices that one can encounter throughout its medical journey. This will all begin on choosing the most suitable pre-medicine program in order to earn an undergraduate degree that is required upon entering a medical school.

"There is not actually a major called 'pre-med'; pre-med is just a term to let people know you have plans to be a doctor" (Sakiras, 2020). While it is actually true, it is important to have a clear goal in mind because "It is a vocation as much as it is a learning experience" (Mapa, 2018). Without entering medical school, a pre-medicine program is a career by itself which opens work opportunities if by any chance that one will not proceed to get a medical degree.

Weighing specialization options is one of the major decisions that a medicine student should look thoroughly before coming to the professional field. Pre-medicine program greatly sets medicine student's future in that field of specialization as their knowledge and several skills acquired upon taking this will determine how well they can perform as a resident and eventually, as a doctor (Pan Afr Med J. et al, 2014).

Various pre-medicine program gives upcoming medicine students prerequisite skills in preparation for their medical journey. According to Mappa (2020), skills like scientific processing, analytical thinking, problem solving, and memorizing well is vital for a medicine student. Since different program have different sets of subjects to take as well as competencies to meet, they all have their edge over one another. Thus, choosing the right pre-medicine program help students to perform better upon choosing specialization in residency training that may affect their future, especially into that profession in which they wish to be proficient in.

This study may benefit aspiring doctors who are still in high school, pre-medicine students and, mostly, medical students, since they are already one

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step away in taking their residency. Moreover, this study can generate information and recommendations that can be used to respond to the challenges of choosing the most suitable pre-medicine program which would ideally help them excel in residency training as well as in the actual professional field.

This aims to know if there is a significant relationship between the chosen pre-medicine program of pre-medicine students of University of Perpetual Help System DALTA – Las Piñas Campus and their residency specialization options. It also aims to give high school students an idea on what pre-medicine program suits them best based on their residency preference, if they already have one in mind. Ultimately, to produce medicine students that can excel in their residency training as well as medical professional who have the competencies to better serve the nation.

2. METHODOLOGY

The researchers decided to do a survey-interview as their data gathering tool, specifically a semi structured type of interview, that refers to an interview concept that does not strictly follow a formalized list of questions. With this the researchers have prepared at least 7 questions to be given to the interviewee. As it allows for a discussion with the interviewee rather a straightforward question and answer format.

2.1 Data Gathering tool

The researchers decided to do a survey-interview as their data gathering tool, specifically a semi structured type of interview, that refers to an interview concept that does not strictly follow a formalized list of questions. With this the researchers have prepared at least 7 questions to be given to the interviewee. As it allows for a discussion with the interviewee rather a straightforward question and answer format.

2.2 Sampling Design/Respondents

The sampling that will be used in the study is stratified random sampling. Respondents will be categorized based on the pre-medicine program that they took mainly BS Nursing, BS Medical Technology. From a population of 10 students, the researchers will only get 5 respondents per category which will sum up to 10 respondents as the sample.

2.3 Data Gathering Procedure

The researchers will be using a one-on-one interview for collecting the data from respondents. One researcher will be assigned per correspondent. The researcher will be recording the phone call to document the interview process. The length of the

interview process that has taken place was around 8 minutes at max.

2.4 Data analysis Plan

The researcher will be using descriptive statistical tools, specifically the measures of central tendency to analyze the data that was gathered. It enables the researchers to summarize the statistic that quantitatively describes or summarizes features from a collection of the said information and enables to evaluate, and interpret how the respondents will answer the asked questions. Therefore, through the evaluated data the researchers will be able to generate conclusions that will answer the research questions from the overall topic. With this method, it will show the average based on the questions asked during the interview. It allows the researchers to describe the response of the respondents if their chosen pre-medicine program will affect their specialization.

3. RESULTS AND DISCUSSION

3.1 What general and specific skills would you hope an ideal pre-medicine course experience would give you?

Figure 1. *Did you have a hard time choosing your pre-medicine program?*

	BSN	BSMT	f	%
Yes				
Considering what is the easiest program	1	1	2	20%
Too many pre-medicine program choices	0	1	1	10%
Program choice/s shifted due to pandemic	1	0	1	10%
No				
Interest and Top Choice	3	3	6	60%
TOTAL:	5	5	10	100%

Most of the respondents answered no with a frequency of 6 or 60%. While 4 or 40% of the respondents answered yes to the question. most of the respondent's reason for answering no is because a certain pre-medicine program is their interest and top choice, with a frequency of 6 or 60%. While 2 or 20% of the respondent's reason for answering yes is because they are considering the easiest program to take, whether as for pre-medicine or not. One of the respondents had a hard time choosing his pre-medicine since she originally planned that she would take pre-law program be lawyer. But then, after the declaration of COVID-19 pandemic, she decided that she now wanted to pursue BS Nursing. "It is one of the most needed here," she reasoned out.

Most of the respondents answered no with a frequency of 8 or 80% while 2 or 20% of the

Figure 2. *Did your choice of pre-medicine program affect your specialization you plan to take?*

	BSN	BSMT	f	%
Yes				
Skills and Subjects offered by pre-medicine program	0	2	2	20%
No				
Pre-medicine program is independent from residency specialization	5	0	5	50%
Already have specialization interest	0	3	3	30%
TOTAL:	5	5	10	100%

respondents answered yes. most of the respondent's reason for answering no is because they believed that a pre-medicine program is independent from residency specialization that they want to take, with a frequency of 5 or 50%. While the remaining 2 or 20% who answered yes reasoned out that a pre-medicine program has a set of skills and subjects to offer that can be useful in medical school or upon taking specialization. One of the respondents think that every pre-medicine program that everyone takes can have an effect in choosing a specialization in the future because before someone can have a final choice, he/ she must have gone to a medical school first. She said that some courses are being tackled already, especially in BS Medical Technology that will be taught again in medical school. Example for this is the subject bacteriology.

3.2 What pre-medicine program corresponds to a certain residency specialization?

Table 1. *What general and specific skills would you hope an ideal pre-medicine course experience would give you?*

	BSN	BSMT	f	%
Through hand-on experiences that the program offers	2	5	7	70%
Through learning adaptability	2	0	2	20%
Through learning communication skills	1	0	1	10%
TOTAL:	5	5	10	100%

Most of the respondents expected several skills that they want to develop including communication skills and critical thinking that will help them provide the right diagnosis with a frequency of 7 or 43.75% and 5 or 31.25% respectively.

Table 2. *What qualities do you look for in a pre-medicine course?*

	BSN	BSMT	f	%
Yes	4	3	7	70%
No	1	2	3	30%
TOTAL:	5	5	10	100%

Most of the respondents answered adaptability as the quality they look for when they

have chosen their pre-medicine course, given that medicine students can encounter various scenarios in their everyday work, with a frequency of 9 or 60%. While 1 or 6.67% of the respondents answered communication. One on the respondents from BS Medical Technology said that she does not look for the qualities in a pre-medicine program because she wanted pre-medicine that is comfortable and the one that she really likes. "Because regardless of the course, I think that if I really want what I am doing, I can really do something even though it contradicts my attitudes," she added.

3.3 What are the factors being considered by the medicine students in choosing their residency specialization

Table 1. *Did you consider Medical School as a factor in your residency specialization?*

	BSN	BSMT	f	%
Yes				
Overall quality of the Medical School as means of foundation for future specialization	4	3	7	70%
No				
Not an entire factor for specialization	1	0	1	10%
Multiple factors aside from medical school	0	2	2	20&
TOTAL:	5	5	10	100%

Most of the respondents considered medical school as a factor in their residency specialization with a frequency of 7 or 70% while 3 or 30% of them did not. most of the respondent's reason for answering yes is because they believe that the overall quality of the medical school like reputation and facilities is the foundation of their future specialization, with a frequency of 7 or 70%. While 1 or 10% of the respondents answered that medical school is not a factor in their future specialization. One of the respondents in BS Medical Technology said that at first, she considered medical school as a factor in their residency specialization but after reflecting in our situation we had, she changed her mind.

Table 2. *Does your financial status affect your choice of residency specialization?*

Factors	BSN	BSMT	f	%
Family	0	3	3	30%
Location of School	0	1	1	10%
Passion	2	1	3	30%
Mental Health	1	0	1	10%
Time	1	0	1	10%
None	1	0	1	10%
TOTAL:	5	5	10	100%

Most of the respondents answered that their choice of residency specialization is affected by their financial status due to it being really expensive to study, with a frequency of 8 or 80%. In contrast to this, 2 or 20% of the respondents answered that their financial status does not affect their choice of residency specialization. One of the respondents think that financial stability will definitely a specialization. She emphasized that, "To be a doctor, it takes many years of education and tuition fees. Other than that, there will be miscellaneous fees and expenses that are included in the tuition." The respondent concluded that if your financial status is not really great, it will definitely have an effect.

Table 3. What other factors did you consider in taking your residency specialization that the researchers did not mention?

	BSN	BSMT	f	%
The Influence of Parental suggestion	0	2	2	23%
Influenced by family background	0	1	1	11%
Location of the said institute	0	1	1	11%
Self interest in the program	3	1	4	33%
The given time of completion for finishing the program	1	0	1	11%
None	1	0	1	11%
TOTAL:	5	5	10	100%

Most of the respondents believed that family and passion is what they consider as a factor in taking their residency specialization, with a frequency of 3 or 30%. By passion and family are the two factors considered by the respondents other than the Medical school and their financial statuses. The respondents considered their passion since self-interest is important for them in choosing their specialization. Also, the family, especially the respondent's parental suggestion to them significantly affect their choices.

With the data collected, analyzed, interpreted and presented, the researchers therefore conclude that most of the respondents did not have a hard time choosing their pre-medicine program as most of the respondents answered positively to the question. The respondents' choice of pre-medicine program is based on their interest and their top choice. This is because they believed that a pre-medicine program is independent from the residency specialization that they plan to take. Therefore, pre-medicine programs do not affect the specialization that they are going to take in the future.

4. ACKNOWLEDGMENTS

5. REFERENCES

Aboshady, O., Zenhom, M., & Nasr, A. (2015, November 23). What should medical students do to choose thei specialty. The Pan African MEdical Journal. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4765349/

Chang, P.-Y., Hung, C.-Y., Wang, K.-I., & Huang, Y.-H. (2006, July). Factors Influencing Medical Studen'ts Choice of Specialty. ResearchGate. https://www.researchgate.net/publication/6983675_Factors_Influencing_Medical_Students%27_Choice_of_Specialty

Dossajee, H., Obonyo, N., & Ahmed, S. (2016, January 11). Career preferences of final year medical students at a medical school in Kenya-A cross sectional study. BMC Medical Education. https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-016-0528-1

Karkowsky, C. (2013, October 31). Third-Year Medical School: Deciding on Your Specialty. The Doctor's Tablet blog. http://blogs.einstein.yu.edu/third-year-medical-school-deciding-on-your-specialty/

Mapa, B. (2018, October 31). Want To Be a Doctor? Here Are the 7 Best Pre-Med Courses! Edukasyon.ph. https://portal.edukasyon.ph/blog/want-to-be-a-doctor-here-are-the-best-pre-med-courses

Medical & Healthcare Courses offered at UPHSD Las Piñas. (n.d). FIND UNIVERSITY. https://www.finduniversity.ph/universities/university-of-perpetual-help-dalta/courses/medical-healthcare/

Mehmood, S., Kumar, A., Al-Binali, A., & Borleffs, J. (2012, March 12). Specialty preferences: Trends and perceptions among Saudi undergraduate medical students. Taylor & Francis Online. https://www.tandfonline.com/doi/full/10.3109/0142159X.2012.656753?scroll=top&needAccess=true

Nicodemus, L., Tabios, I., & Tabios, B. O. (2018, October). Medical Students Career Choices and Perceptions in Family Medicine and Primary Care. ResearchGate. https://www.researchgate.net/publication/328281251_Medical_Students_Career_Choices_and_Per

ceptions_in_Family_Medicine_and_Primary_Car
e

Sawonik, S., Kazlowiec, M., Kolodynska, A., Domagala, A., Aftyka, Milanowksa, J., . . . Samardekiewicz, M. (2019, March 12). Do medical students have problem with choosing the specialty? Preliminary report of the medical students population based study. Sciendo. https://content.sciendo.com/view/journals/pjph/128/3/article-p115.xml?language=en

What to Look for When Choosing Pre-Med College Programs. (2017, November 29). Peterson's. https://www.petersons.com/blog/what-to-look-for-when-choosing-pre-med-college-programs/

A Review on the Application of Voltammetry in the Determination of Activity of Vitamins and Antioxidants in Fruit Juices

Erika Mae T. Borres, Ashley Mae T. Juan-Sing, Mike Dane A. Pararuan
and Erika Leanne R. Tined
De La Salle University Integrated School, Manila

Dr. Allan N. Soriano,
De La Salle University, Manila

Abstract: Voltammetry is preferred amongst other techniques for antioxidant and vitamin component detection because of its selectivity, sensitivity, ease of access, and inexpensive instrumentation. This study aims to assess and evaluate existing studies revolving around voltammetric determination of vitamins and antioxidants of fruit juices, seeing as they are a rich source of vitamin and antioxidants, to find commonalities and trends over the years. Articles reviewed found differential pulse voltammetry and square wave voltammetry to be the most utilized method for vitamin and antioxidant determination, respectively. Electrode performance was also compared between bare and modified electrodes by comparing the limit of detection (LOD) and recovery rate (RR) of each. A bare electrode was found to have the highest LOD value in vitamin determination, but modified electrodes seemed to display enhanced performance when compared to its bare self. Though, usage of modified electrodes in antioxidant determination displayed a much more distinguishable improvement. Optimal pH value of the supporting electrolyte in vitamins is $5.0 \leq pH \leq 7.0$, while it was found that the optimal pH value for antioxidants was $2.0 \leq pH \leq 6.0$. In conclusion, voltammetric determination is highly dependent on the combination of the method, the composition of the electrode, and the pH of the supporting electrolyte solution.

Key Words: voltammetry; vitamins; antioxidants; fruit juices; electrodes

1. INTRODUCTION

Food component detection is essential in ensuring the quality, safety, and nutrition of the food products distributed to the public. Voltammetry is the preferred method for the determination of such due to its cheap instrumentation, excellent sensitivity, rapid analysis, and simultaneous determination (Gulaboski & Pereira, 2008). With that, these methods have proven to be advantageous for analyzing a wide range of compounds found in food and beverages (Pisoschi, 2015). Additionally, these methods are also used to study different interactions between chemical components such as contaminants, antioxidants, and vitamins. Among the vitamins, ascorbic acid (AA) is frequently determined for its reductive and water-soluble properties allowing its participation in various biochemical reactions (see Figure 1).
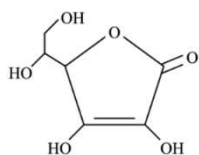

Figure 1. Chemical Structure of Ascorbic Acid

Given that a number of the aforementioned detectable food components with proven electrochemical properties are commonly possessed by fruit juices, voltammetry has been a highly recognized technique used for the said beverage. Fruit juices are associated with health benefits as they are rich sources of antioxidants and vitamins. Both constituents enhance the defense of the body against free radicals by preventing cells from being damaged, making the quantification of such crucial (Leonard et al., 2002).

Methods and electrode compositions were found to be factors that affect the behavior of voltammetric analysis (Pisoschi, 2015). This entailed a considerable number of studies to focus on antioxidant and vitamin determination using various combinations of electrodes and voltammetric methods. With this prominence, this systematic literature review aims to provide an extensive analysis and comparison of the existing literature in order to gauge the current state of voltammetry in food analysis, specifically for fruit juices. Particularly, this paper focuses on investigating its performance in vitamin and antioxidant determination, mainly in terms of the

specific methods, electrodes, and parameters utilized for food component detection in fruit juices. The reviewed literature was limited to research articles which have evaluated the technique solely in fruit juices and were published within the year 2000 to 2021.

2. METHODOLOGY

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was utilized for the data collection procedure of the study, with records identified from two scientific databases, i.e., ScienceDirect and Scopus, using the keywords "voltammetry" AND "fruit juices". A total of 38 articles was formally included in the review as seen in Figure 2; however, only the section of the original manuscript, which solely focuses on voltammetric applications in vitamin and antioxidant determination, was presented in this paper. Particularly for the said focus, only 20 articles were reviewed.
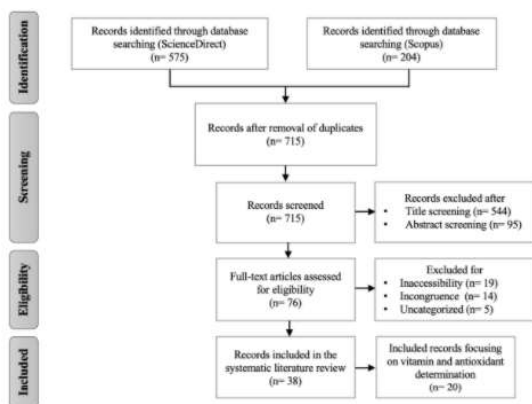

Figure 2. Adapted PRISMA Diagram Used in the Study

The extracted data from each study included the method of determination, performance of the electrode, and parametric study of pH employed in vitamin and antioxidant analysis. For electrode performance, the limit of detection (LOD) and recovery rate (RR) were also included for further examination of the effectiveness of the electrodes in fruit juice samples. The data obtained for each aspect were tabulated and sorted, depending on the availability and pertinence of the variables for examination. Common trends and outliers on the prevalence of particular voltammetric techniques, effects of electrode modifications, and optimal pH levels for supporting electrolytes were identified. Possible developments and researches on less covered areas of the field of study were also established.

3. RESULTS AND DISCUSSION

3.1. Method of Determination

As seen in Figure 3, Differential Pulse Voltammetry (DPV) is the most exploited method in vitamin determination, specifically AA, due to its exemplary precision, sensitivity, and speed. It can detect micromolar amounts of chemical components, making it convenient for detection in low concentration samples (Abdelrahim et al., 2013). Verifying its accuracy, most studies have found that the acquired AA levels corresponded with the reference data obtained from the standard titration methods (Ijeri et al., 2001; Gopalakrishnan et al., 2018; Gheibi et al., 2013). This congruence implies that DPV is comparable to the performance of conventional techniques and can be used as a reliable alternative.
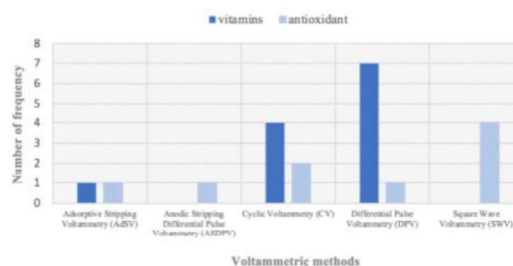

Figure 3. Usage Frequency of Voltammetric Methods Among Reviewed Literature

Despite the existence of successful studies utilizing other electrochemical techniques such as CV and AdSV, most of the reviewed literature found DPV to be more advantageous than others due to its higher current sensitivity, better resolution, and capability to eliminate capacitive charging currents (Gheibi et al., 2013; Intarakamhang et al., 2011). Hence, it can be concluded that DPV is the most suitable voltammetric technique for AA determination.

Voltammetric methods CV, DPV, and AdSV were also found to be applicable in quantifying antioxidants. However, unlike CV that was regarded by Bordonaba & Terry (2012) as the usual method choice in antioxidant analysis, further research utilizing DPV and AdSV is necessary for an in-depth establishment of their usefulness for the said purpose. SWV was observed to be the most applied in antioxidant determination due to its superior detection performance compared to conventional methods (see Figure 3). No interference was reported in polyphenol detection, unlike the traditional colorimetric method (Abdel-Hamid & Newair, 2016). SWV was also observed to perform better than CV in antioxidant assays. This technique exhibits the best characteristics of several voltammetric methods

which, besides sharing similar advantages with CV, includes easy identification of reversible oxidation reaction and easy obtainment of redox peaks (Bordonaba & Terry, 2012). These findings substantiate the effectiveness of SWV as the most favored method for antioxidant determination. Descriptions, advantages, and disadvantages of each method were summarized in Table 1.

Table 1. Summary of Voltammetric Techniques and Functions

Technique	Description	Advantage	Disadvantage
CV	Studies electrochemical behaviors and relationships	Provides easy qualitative analysis	Average quantitative analysis
SWV	Evaluates electrode kinetics and mechanisms	Fast and sensitive pulse technique	Low currents from irreversible systems
DPV	Discriminates Faradaic currents with small pulses	Rapid analysis and good selectivity	Slower than SWV
AdSV	Spontaneously strips and absorbs species on the electrode's surface	Detects low concentrations	Prone to interferences

3.2. Comparison of Electrode Performance

Among the studies reviewed, carbon paste electrode (CPE) is the most exploited working electrode, especially in older studies (Intarakamhang et al., 2011; Tadese et al., 2014; Pisoschi et al., 2011). However, modification of electrodes in more recent studies was observed to become more prevalent. All reviewed literature reported that modifications have yielded sharpened electrode performances. Abdel-Hamid and Newair (2016) applied PGA/MWCNT/GCE for gallic acid (GA) determination and has proven its capability to enhance electrode kinetics and GA oxidation. Frequently used modified screen-printed carbon electrodes (SCPEs) have also shown great performance for detecting both antioxidants and vitamins, as these were found to be capable of preventing phenolic coupling-induced electrode deactivation which results from polymeric film formation, a common problem in electrochemistry (Bordonaba & Terry, 2012). This corresponded to that of Gopalakrishnan et al. (2018), which emphasized the advantage of CdO/SPCE over other electrodes in terms of reproducibility, selectivity, and sensitivity. Generally, these substantiate the prominent observation that modifications made for bare solid electrodes is an effective factor that enhances electrode performance. Hence, there is a large potential for further exploration and development of modified electrodes to bring forth new benefits for voltammetry in vitamins and antioxidant determination.

Effects of electrode modification on its performance were further investigated by comparing the LODs and the RRs obtained from spiked fruit juice (see Table 2). Among the studies utilizing CPE for AA determination, a lowest LOD value of 2.2×10^{-11}M with an RR of 93.4%-105% was acquired by Tadese et

al. (2014), when paired with CV. Presently, this electrode-method combination is found to be the most promising and effective for AA determination amidst the development of new modified electrodes. The CdO/SPCE used with DPV has exhibited superior performance with an LOD of 5.4×10^{-8}M and an RR of 98.6% over CPEs utilized with the same method (Gopalakrishnan et al., 2018). Despite the establishment of CPEs over other electrodes, there is still no apparent reason behind its prevalence for AA determination. Although a range of 99.9%-101% was found to be closest to the ideal rate of 100%, a significant difference in LOD values were observed when utilized alongside DPV. Hence, not completely establishing the highest degree of sensitivity (Intarakamhang et al., 2011); this could possibly be attributed to its suitability in the specific sample.

Table 2. Electrode Performance in Determination of Vitamins and Antioxidants in Juices

Method	Component	Working Electrode	Limit of Detection (M)	Recovery Rate (%)	Reference
DPV	AA	CdO/SPCE	5.4×10^{-8}	98.6	Gopalakrishnan et al. (2018)
CV	AA	Pt	9.0×10^{-4}	94.4-104	Pisoschi et al. (2008)
DPV	AA	AuSNPS/CeO/SNGC	2.9×10^{-6}	88.8-108	Abdelrahim et al. (2013)
DPV	AA	CPE	5.0×10^{-5}	99.9-101	Intarakamhang et al. (2011)
CV	AA	CPE	2.2×10^{-11}	93.4-105	Tadese et al. (2014)
CV	AA	Pt	7.5×10^{-5}	94.9-103	Pisoschi et al. (2011)
CV	AA	CPE	1.8×10^{-5}	95.1-105	Pisoschi et al. (2011)
DPV	AA	CPE	2.0×10^{-5}	94.9-103	Pisoschi et al. (2011)
DPV	AA	Pt	8.7×10^{-6}	94.7-105	Pisoschi et al. (2011)
DPV	AA	CuO/GCE	1.0×10^{-6}	96.3-105	Buledi et al. (2020)
DPV	Rutin	GCE	1.0×10^{-7}	105.8	Blasco et al. (2004)
SWV	Rutin	CoFe$_2$O$_4$NPs/ILs/CPE	3.0×10^{-11}	97.6-102	Yola et al. (2017)
SWV	GA	PGA/MWCNT/GCE	3.2×10^{-9}	101	Abdel-Hamid & Newair (2016)
AdSV	Quercetin	BDDE	4.4×10^{-10}	94.7-106	Abdullah et al. (2018)
ASDPV	Quercetin	PGE	3.0×10^{-10}	93.2-94.7	Vu et al. (2015)

*CdO/SPCE - cadmium oxide screen-printed carbon electrode; AuSNPs/CeO/SNGC - gold-studded cerium oxide nanoparticles modified sonogel-carbon material; CuO/GCE - copper oxide nanoparticles modified glassy carbon electrode; GCE - glassy carbon electrode; CoFe$_2$O$_4$NPs/ILs/CPE - CoFe$_2$O$_4$ nanoparticles ionic liquid nanocomposite modified carbon paste electrode; PGA/MWCNT/GCE - poly(gallic acid)/multiwalled carbon nanotube modified electrode; BDDE - boron-doped diamond electrode; PGE - pencil-graphite electrode

In contrast to AA determination, a significant difference in electrode performance between the bare GCE and modified electrodes was observed. The CoFe2O4NPs/ILs/CPE utilized with SWV for rutin determination had an LOD value of 3.0×10^{-11}M and RR of 97.6%-102%, and exhibited superior electrode performance among all electrodes used for antioxidant detection (Yola et al., 2017). Meanwhile, a relatively higher LOD value of 1.0×10^{-7}M and deviated RR of 105.8%, were observed for the bare GCE (Blasco et al., 2004). Generally, these still validate how electrode modifications can increase its performance; however, it can be speculated that electrode-method relationships could be a factor that induces the slight discrepancy observed in the determination of AA.

3.3. Parametric Study of pH on Electrochemical Determination

Optimal electrolyte pH is a common parameter that was investigated by several studies (see Table 3). For AA detection, Tadese et al. (2014) investigated the effect of pH using CV and CPE, where the optimal pH value obtained was at pH 5.0. This suggests that using an electrolyte with a slightly acidic pH is favorable for AA determination using the given electrode. Meanwhile, Gheibi et al. (2013) assessed the effect of pH on peak currents and peak potentials in AA determination using APMCNTPE and obtained a rather neutral optimal value at pH 7.0. Despite the discordance of the aforementioned studies, it was found that AA in apple juice can also be determined at a pH level of 6.9 as utilized with a AuSNPS/CeO/SNGC, which directly falls between the optimal values mentioned prior (Abdelrahim et al., 2013). Although some researches have also utilized highly acidic electrolytes at a pH range 1.5-3.5, such levels of acidity come as a minority (Yilmaz et al., 2008; Ijeri et al., 2001). Hence, it can be concluded that AA is preferably determined using acidic electrolytes, commonly within a pH range of 5.0-7.0.

Similarly, several studies have also established optimal pH levels for antioxidant determination; all of which were also observed to be at an acidic range. Abdullah et al. (2018) investigated the redox behavior of quercetin using AdSV with a BDDE; its optimal pH is found to be at an acidic range with the pH levels of 2.0-5.0. Additionally, there are a number of studies that observed optimal pH values that fall within the said range. General polyphenol detection was obtained using highly acidic electrolytes at pH 2.6 using PGA/MWCNT/GCE, while ellagic acid (EA) and rutin were determined with electrolytes with a higher pH value of 5.5 and 6.0, respectively (Abdel-Hamid & Newair, 2016; Cuartero et al., 2011; Yola et al., 2017). It is evident that an abundant number of studies determine antioxidants at a pH range of 2.0-6.0; hence concluding that antioxidants in fruit juices are favorably determined with an acidic supporting electrolyte, regardless of the electrode used.

Table 3. Obtained Optimum pH Values

Method	Component	Working Electrode	Optimal pH Value	Reference
CV	AA	APMCNTPE	7.0	Gheibi et al. (2013)
DPV	AA	AuSNPS/CeO/SNGC	6.9	Abdelrahim et al. (2013)
CV	AA	CPE	5.0	Tadese et al. (2014)
DPV	AA	GCE	3.5	Yilmaz et al. (2008)
DPV	AA	CPE	1.5	Ijeri et al. (2001)
SWV	Rutin	CoFe$_2$O$_4$NPs/ILs/CPE	6.0	Yola et al. (2017)
SWV	GA	PGA/MWCNT/GCE	2.6	Abdel-Hamid & Newair (2016)
SWV	EA	GCE	5.5	Cuartero et al. (2011)
SWV	Rutin	GCE	6.0	Cuartero et al. (2011)
AdSV	Quercetin	BDDE	2.0-5.0	Abdullah et al. (2018)
ASDVP	Quercetin	PGE	3.0	Vu et al. (2015)
CV	Phenol	Pt	3.0	Piljac-Žegarac et al. (2009)

*APMCNTPE - p-aminophenol modified carbon nanotubes paste electrode

4. CONCLUSIONS

Voltammetry has proven to be an effective technique for antioxidant and vitamin determination in fruit juices. The performance of the technique was found to be highly dependent on the specific voltammetric method, electrode, and optimal pH of the electrolyte used. For vitamin determination, DPV is the most utilized due to its exceptional sensitivity and resolution. Despite a bare electrode exhibiting the best LOD value for AA determination, enhancements in performance in modified electrodes were still observed. As for the studied parameter, enhanced selectivity was also displayed when utilizing pH at slightly acidic to neutral levels. Meanwhile, antioxidant detection favored SWV because of its superior performance. Unlike in vitamin determination, there is a distinct improvement in performance of modified electrodes in contrast to the one with a considerable RR. The optimal pH of the supporting electrolyte for better selectivity was found to be at generally acidic levels. It can be concluded that the performance of voltammetry in detecting components in fruit juices may be further improved by ascertaining the compatibility of the method, electrode, and the pH of the electrolyte solution with one another. Further studies for thorough investigation between method-electrode modification relationships are also recommended.

5. ACKNOWLEDGMENTS

6. REFERENCES

Abdel-Hamid, R., & Newair, E. F. (2016). Voltammetric determination of polyphenolic content in pomegranate juice using a poly (gallic acid)/multiwalled carbon nanotube modified

electrode. Beilstein Journal of Nanotechnology, 7, 1104–1112. https://doi.org/10.3762/bjnano.7.103

Abdelrahim, M., Benjamin, S., Cubillana-Aguilera, L., Naranjo-Rodríguez, I., de Cisneros, J., Delgado, J., & Palacios-Santander, J. (2013). Study of the Electrocatalytic Activity of Cerium Oxide and Gold-Studded Cerium Oxide Nanoparticles Using a Sonogel-Carbon Material as Supporting Electrode: Electroanalytical Study in Apple Juice for Babies. Sensors, 13(4), 4979–5007. https://doi.org/10.3390/s130404979

Abdullah, A. A., Yardım, Y., & Şentürk, Z. (2018). The performance of cathodically pretreated boron-doped diamond electrode in cationic surfactant media for enhancing the adsorptive stripping voltammetric determination of catechol-containing flavonoid quercetin in apple juice. Talanta, 187, 156–164. https://doi.org/10.1016/j.talanta.2018.05.016

Baś, B. ł., Jakubowska, M. ł., & Górski, Ł. (2011). Application of renewable silver amalgam annular band electrode to voltammetric determination of vitamins C, B1 and B2. Talanta, 84(4), 1032–1037. https://doi.org/10.1016/j.talanta.2011.03.006

Blasco, A. J., González, M. C., & Escarpa, A. (2004). Electrochemical approach for discriminating and measuring predominant flavonoids and phenolic acids using differential pulse voltammetry: towards an electrochemical index of natural antioxidants. Analytica Chimica Acta, 511(1), 71–81. https://doi.org/10.1016/j.aca.2004.01.038

Bordonaba, J. G., & Terry, L. A. (2012). Electrochemical behaviour of polyphenol rich fruit juices using disposable screen-printed carbon electrodes: Towards a rapid sensor for antioxidant capacity and individual antioxidants. Talanta, 90, 38–45. https://doi.org/10.1016/j.talanta.2011.12.058

Buledi, J. A., Ameen, S., Khand, N. H., Solangi, A. R., Taqvi, I. H., Agheem, M. H., & Wajdan, Z. (2020). CuO Nanostructures Based Electrochemical Sensor for Simultaneous Determination of Hydroquinone and Ascorbic Acid. Electroanalysis, 32(7), 1600–1607. https://doi.org/10.1002/elan.202000083

Cuartero, M., Ortuño, J. A., Truchado, P., García, M. S., Tomás-Barberán, F. A., & Albero, M. I. (2011). Voltammetric behaviour and square-wave voltammetric determination of the potent antioxidant and anticarcinogenic agent ellagic acid in foodstuffs. Food Chemistry, 128(2), 549–554. https://doi.org/10.1016/j.foodchem.2011.03.064

Gheibi, S., Karimi-Maleh, H., Khalilzadeh, M. A., & Bagheri, H. (2013). A new voltammetric sensor for electrocatalytic determination of vitamin C in fruit juices and fresh vegetable juice using modified multi-wall carbon nanotubes paste electrode. Journal of Food Science and Technology, 52(1), 276–284. https://doi.org/10.1007/s13197-013-1026-7

Gopalakrishnan, A., Sha, R., Vishnu, N., Kumar, R., & Badhulika, S. (2018). Disposable, efficient and highly selective electrochemical sensor based on Cadmium oxide nanoparticles decorated screen-printed carbon electrode for ascorbic acid determination in fruit juices. Nano-Structures & Nano-Objects, 16, 96–103. https://doi.org/10.1016/j.nanoso.2018.05.004

Gulaboski, R., & Pereira, C. M. (2008). Electroanalytical Techniques and Instrumentation in Food Analysis. In S. Oltes (Eds.). Handbook of Food Analysis Instruments (pp. 379–402). Amsterdam University Press.

Ijeri, V. S., Jaiswal, P. V., & Srivastava, A. K. (2001). Chemically modified electrodes based on macrocyclic compounds for determination of Vitamin C by electrocatalytic oxidation. Analytica Chimica Acta, 439(2), 291–297. https://doi.org/10.1016/s0003-2670(01)00989-8

Intarakamhang, S., Leson, C., Schuhmann, W., & Schulte, A. (2011). A novel automated electrochemical ascorbic acid assay in the 24-well microtiter plate format. Analytica Chimica Acta, 687(1), 1–6. https://doi.org/10.1016/j.aca.2010.11.023

Leonard, S. S., Cutler, D., Ding, M., Vallyathan, V., Castranova, V., & Shi, X. (2002). Antioxidant properties of fruit and vegetable juices: more to the story than ascorbic acid. Annals of clinical and laboratory science, 32(2), 193–200.

Makhotkina, O., & Kilmartin, P. A. (2012). The phenolic composition of Sauvignon blanc juice profiled by cyclic voltammetry. Electrochimica Acta, 83, 188–195. https://doi.org/10.1016/j.electacta.2012.07.101

Piljac-Žegarac, J., Valek, L., Martinez, S., & Belščak, A. (2009). Fluctuations in the phenolic content and antioxidant capacity of dark fruit juices in

refrigerated storage. Food Chemistry, 113(2), 394–400. https://doi.org/10.1016/j.foodchem.2008.07.048

Pisoschi, A. M. (2015). Voltammetry as Analytical Technique in the Study and Quantitation of Several Food and Beverage Components: An Editorial. Biochemistry & Analytical Biochemistry, 04(02). https://doi.org/10.4172/2161-1009.1000e156

Pisoschi, A. M., Danet, A. F., & Kalinowski, S. (2008). Ascorbic Acid Determination in Commercial Fruit Juice Samples by Cyclic Voltammetry. Journal of Automated Methods and Management in Chemistry, 1–8. https://doi.org/10.1155/2008/937651

Pisoschi, A. M., Pop, A., Negulescu, G. P., & Pisoschi, A. (2011). Determination of Ascorbic Acid Content of Some Fruit Juices and Wine by Voltammetry Performed at Pt and Carbon Paste Electrodes. Molecules, 16(2), 1349–1365. https://doi.org/10.3390/molecules16021349

Tadese, A., Subramanian, P. A., Woldu, A., & Pal, R. (2014). Electrochemical determination and comparison of ascorbic acid in freshly prepared and bottled fruit juices: A cyclic voltammetric study. Journal of Chemical and Pharmaceutical Research, 6(5), 880-888.

Vu, D. L., Žabčíková, S., Červenka, L., Ertek, B., & Dilgin, Y. (2015). Sensitive Voltammetric Determination of Natural Flavonoid Quercetin on a Disposable Graphite Lead. Food Technology and Biotechnology, 53(4), 379-384. https://doi.org/10.17113/ftb.53.04.15.4176

Yilmaz, S., Yagmur, S., & Sadıkoğlu, M. (2008). Determination of Ascorbic Acid in Table Dosage Forms and Some Fruit Juices by DPV. International Journal of Electrochemical Science, 3, 1534-1542.

Yola, M. L., Göde, C., & Atar, N. (2017). Determination of rutin by CoFe2O4 nanoparticles ionic liquid nanocomposite as a voltammetric sensor. Journal of Molecular Liquids, 246, 350–353. https://doi.org/10.1016/j.molliq.2017.09.072

Spatial Mapping and Modeling of Reported Dengue Incidences in Luzon

Nicole M. Hernandez, Carla Katrine P. Lucero, Dianne C. Yumol
and Jericho Manuel A. Zulueta
De La Salle University Integrated School, Manila

Shirlee R. Ocampo
De La Salle University, Manila

Abstract: Dengue, the most rapidly spreading mosquito-borne viral infection, has significantly spread worldwide in recent decades - flourishing both in affluent and impoverished locations of tropical and subtropical countries. In 2012, the Philippines ranked fourth out of the ten Association of the Southeast Asian Nations (ASEAN) countries in having the highest number of dengue cases. The following study intends to analyze the spatial distribution of dengue incidences across all Luzon provinces in 2018. It aims to determine significant correlates that affect dengue incidences, map the incidence rate of dengue cases, and explore the clustering of recorded dengue cases. Poisson and Negative Binomial (NB) regression analyses and Multiple Linear Regression Models (MLRM) were applied to determine the significant correlations affecting dengue incidence rates. Simultaneously, spatial mapping was utilized to visualize and detect clustering in the provinces through dengue count, incidence ratios, and standard incidence ratios (SIR). MLRM and NB showed that rainfall and poverty incidence are significant correlates of dengue counts and incidence, and Nueva Ecija and Tarlac were observed to be provinces with distinct dengue count and SIR greater than 1, as well as provinces found in clusters. With the provided results, health organizations can provide health programs and allocate more funds in areas with SIR greater than 1 to prevent dengue spreading.

Key Words: spatial mapping; regression modeling; dengue incidence; correlation; Aedes aegypti

1. INTRODUCTION

Dengue is the most quickly spreading mosquito-borne virus in the world. According to WHO (2020a), dengue's global incidence rate has increased in recent decades, wherein about half of the world's population is now at risk, with 100-400 million infections occurring each year. In 2016, more than half of the 375,000 reported cases in the Western Pacific region were solely from the Philippines.

In the first half of 2019, the Philippines experienced a dengue outbreak which accounted for 146,062 dengue cases and 600 casualties. By the end of 2019, the total cases went up to 429,409 - which is higher compared to 241,707 cases revealed during 2018 (WHO, 2020b). Studies on dengue incidence usually delve into environmental factors in a particular region. However, factors such as dengue count per province have not been recorded in previous papers, making it crucial to address other contributing factors affecting dengue incidence.

Therefore, the following study aims to identify the significant correlates that affect dengue incidences across Luzon's provinces in 2018, map the percentages of dengue incidence rates in Luzon, and explore the clustering of recorded dengue cases to identify high-risk areas on a broad geographical scale. The study will focus on the spatial mapping and regression modeling of dengue across all provinces of Luzon.

2. METHODOLOGY

The complete available DENC data set from the provinces of Luzon in 2018 was requested and utilized from the Department of Health (DOH) Regional Offices by coordinating with their epidemiology units. Data for the variables relative humidity (RH), rainfall (RF), and temperature (TMIN, TMAX, and TMEAN) were obtained from PAG-ASA Synoptic Stations; and population (POP) and poverty incidence (POVINC) were retrieved from DOH and the Philippine Statistics Authority; all of which were summarized upon collection. Microsoft Excel, Statistica, SAS, and GeoDa were utilized to perform Standardized Incidence Ratio (SIR), MLRM, Poisson and NB regression models, and Spatial Mapping respectively.

2.1. Theoretical Framework and Analysis

2.1.1. Standardized Incidence Ratio (SIR)

SIR determines if the occurrence of a disease in a relatively small population is high or low. It predicts if the number of observed cases in a particular geographic area, i = 1,2,..., m, is higher or lower than expected (Natividad et al., 2019).

The common risk, r, or incidence rate of a region is computed by
$r = \frac{y}{N}$
where,
y= total count of the disease, and
N= total population exposed to risk in the region
SIR is obtained by:
$SIR_i = \frac{y_i}{e_i}$
where,
y_i= observed number of cases
e_i= expected number of cases
The expected number of cases, e_i, can be calculated using indirect standardization
$e_i = rN_i$
where,
N_i= the population in the region
r = common risk

2.1.2. Multiple Linear Regression Model

MLRM distinguishes the relationship between two or more independent variables and a dependent variable. It determines if changes in the independent variables can alter the dependent variable and approximate the variables' association. The dependent variable Y_i is considered to be a function of p-1 independent variables, $X_{1i}, X_{2i}, ...,X_{(p-1)i}$, and their association can be written as:
$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_{p-1} X_{(p-1)i} + \epsilon_i$ i=1,2,...,n
where,
Y_i= the value of the dependent variable
of observation i,
$X_{1i}, X_{2i}, ...,X_{(p-1)i}$= the values of p-1 predictors or independent variables, and
ϵ_i = corresponds to the random error.

2.1.3. Poisson Regression Model

The Poisson regression model is used when Y_i is a count variable. It assumes that the response variable is following Poisson distribution with parameter , $Y_i \sim Poisson(\lambda)$.
$E[Y] = e^{\beta_0 + \beta_1 X_1 + ... + \beta_{p-1} X_{p-1}} = e^{X'\beta}$
where,
Y is the dependent variable,
is the p x 1 vector of regression parameters
X is a p x 1 vector of independent variables.

2.1.4 Negative Binomial Regression Model

The NB model has the same mean structure as Poisson regression and is considered a generalized Poisson regression model. It contains an extra parameter to model overdispersion - narrowing the confidence intervals. NB is expressed as:
$f_Y(y) = \frac{\Gamma(y + r^{-1})}{\Gamma(r^{-1})\Gamma(y+1)}(r^{-1})^{r^{-1}}(1 - r^{-1})^y$ y=0,1,2,...
where,
$\mu_i = exp\{X_i\beta\}$
r= dispersion parameter
(.)= usual gamma function

The following distribution has a mean equal to μ_i and a variance equal to $\mu_i + r\mu_i^p$.

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistics and Standardized Incidence Ratio (SIR)

The SIRs of dengue for the provinces of Luzon for 2018 were computed and summarized. In Table 3.1, 18 provinces and one district have an SIR greater than 1, implying that more dengue cases were observed than expected. Batanes had the highest relative risk of infection, followed by Apayao and Quirino. Meanwhile, the remaining 17 provinces and three districts experienced lesser cases of dengue. Clustering can be observed in provinces shaded in the same color, implying that the nearness of the values between dengue cases, incidence rates, and SIR of nearby provinces display a high dengue risk.

Table 3.1. Dengue Count and the Population Exposed to Risk in Each Province with Corresponding Incidence Ratios and Standard Incidence Ratios

Provinces	Annual Dengue Count	Population exposed to risk	IR	SIR
Ilocos Norte	1886	607,454	0.003105	1.0838
Ilocos Sur	2014	707,531	0.002847	0.9936
La Union	2474	812,620	0.003044	1.0627
Pangasinan	8486	3,059,609	0.002774	0.9682
Batanes	1151	17,613	0.065349	13.716
Cagayan	2743	1,242,768	0.002207	0.4632
Isabela	7657	1,654,287	0.004629	0.9714
Nueva Vizcaya	3375	470,408	0.007175	1.5058

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Table 3.1. (cont.) Dengue Count and the Population Exposed to Risk in Each Province with Corresponding Incidence Ratios and Standard Incidence Ratios

Province	Count	Population	IR	SIR
Quirino	2137	196,119	0.010896	2.2869
Aurora	917	221,966	0.004131	1.5923
Bataan	2409	804,530	0.002994	1.1541
Bulacan	6476	3,515,504	0.001842	0.7100
Nueva Ecija	7062	2,268,553	0.003113	1.1999
Pampanga	6329	2,772,276	0.002283	0.8799
Tarlac	6657	1,420,364	0.004687	1.8065
Zambales	940	864,368	0.001087	0.4192
Batangas	2,757	2,887,957	0.000955	0.5288
Cavite	6,948	4,051,031	0.001715	0.9500
Laguna	5,647	3,258,735	0.001733	0.9598

Table 3.1. (cont.) Dengue Count and the Population Exposed to Risk in Each Province with Corresponding Incidence Ratios and Standard Incidence Ratios

Province	Count	Population	IR	SIR
Masbate	286	926,118	0.000309	0.5253
Sorsogon	512	823,469	0.000622	1.0577
Abra	1,095	244,800	0.004473	1.2543
Apayao	1,866	122,978	0.015173	4.2549
Benguet	1,344	832,635	0.001614	0.4526
Ifugao	851	209,611	0.004060	1.1385
Kalinga	1,582	219,077	0.007221	2.0250
Mountain Province	315	154,814	0.002035	0.5706
NCR-D1	29,618	2,899,200	0.001991	0.9060
NCR-D2	13,367	5,274,265	0.002534	1.1536
NCR-D3	5,802	3,015,062	0.001924	0.8759
NCR-D4	4,678	2,292,509	0.002041	0.9288

Table 3.1. (cont.) Dengue Count and the Population Exposed to Risk in Each Province with Corresponding Incidence Ratios and Standard Incidence Ratios

Province	Count	Population	IR	SIR
Quezon	3,841	2,202,097	0.001744	0.9661
Rizal	6,850	3,132,745	0.002187	1.2111
Marinduque	168	238,317	0.000705	0.2883
Occidental Mindoro	1,155	507,630	0.002275	0.9304
Oriental Mindoro	1,891	878,330	0.002153	0.8804
Palawan	3,787	1,170,905	0.003234	1.3225
Romblon	573	297,808	0.001924	0.7868
Albay	306	1,362,255	0.000225	0.3821
Camarines Norte	551	606,997	0.000908	1.5442
Camarines Sur	1,829	2,028,696	0.000902	1.5337
Catanduanes	53	269,469	0.000197	0.3346

Figure 3. Standard Incidence Ratios of Dengue Count and Population per Province
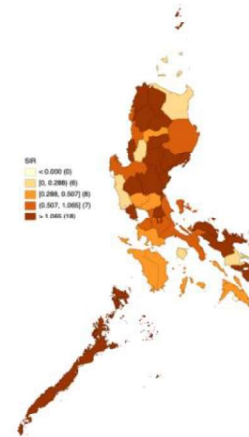

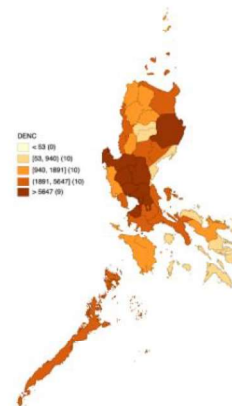Figure 1. Plot Map for the Accumulated Dengue Count per Province

Figure 2. Map of the Incidence Rate of Dengue Count and Population per Province
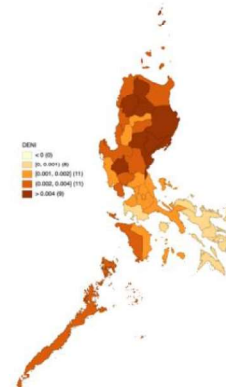
Figure 1 shows the map for the variable DENC, wherein provinces around the center of Luzon are reported to have a high dengue count in 2018.

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Clustering is observed, revealing that dengue cases occurring in these areas may be due to spreading. In Figure 2, dengue incidences were derived from dividing DENC by the total population in each province, and it revealed that provinces in the northeastern part of Luzon had high incidence rates. Lastly, Figure 3 shows the SIR of dengue cases and the total population of each province, where provinces located in Region 2 and 3 are observed to have high reported SIRs of dengue. Despite Batanes having the highest SIR, Cagayan did not have a high SIR in 2018. However, provinces that have a clustering of SIR greater than 1 were observed in Central Luzon.

3.2. Multiple Linear Regression Model

MRLM was applied to dengue cases and incidences but did not satisfy all assumptions. Thus, three transformations were utilized - namely arcsin(y), ln(y), and ln(1-yy). Only ln(y) for DENC satisfied all the assumptions. Stepwise selection procedure was utilized in selecting variables that fit the model. Figure 4 shows that all p-values are greater than 0.05, thus, the residuals are normally distributed.

Figure 4. Normality Test
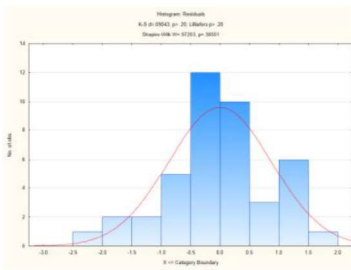
The homogeneity of variances was checked through a scatterplot of residuals versus predicted values. No clear pattern should be in the distribution or the data would be heteroscedastic. From Figure 5, since there is no cone-shaped pattern, the assumption has been satisfied.

Figure 5. Predicted vs Residual Scores
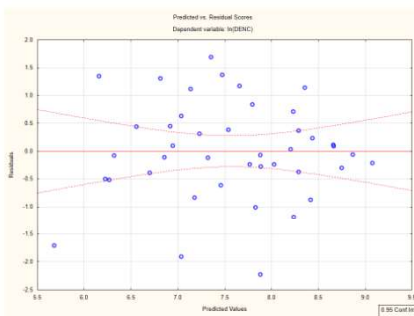
The next assumption checked was the independence within the residuals through the Durbin-Watson test. In Table 4 (see appendix), as the serial correlation is approximately 0, there is no correlation between the observations. Additionally, since the Durbin-Watson statistic falls between 1.5 and 2.5, there is no first order correlation.

Lastly, there should be no multicollinearity, which occurs when the independent variables are highly correlated with each other. Since the tolerance limits on Table 5 (see appendix) are greater than 0.01, there is no multicollinearity. The errors are also normally distributed with mean 0 and constant variance.

The following output was generated following a 5% level of significance with % = 0.39828405. Table 3.2.1 shows the simplified summary of results while Table 3 (see appendix) shows the full summary.

Table 3.2.1. Simplified Summary of Results of MLRM for ln(dengue count)

Variables	b*	Stnd. Err. of b*	b	Stnd. Err. of b	t(39)	p-value	e^b
Intercept			15.25959	4.760606	3.20539	0.002826	
RF	-0.35336	0.149695	-0.00381	0.001615	-2.36053	0.023786	0.70232
POVINC	-0.35716	0.143864	-0.08164	0.032885	-2.48261	0.017840	0.69966

The summary of results shows that there are two significant dengue correlates: POVINC (r = -0.35716, p < 0.05) and RF (r = -0.35336, p < 0.05). A possible explanation for the negative correlation is when POVINC decreases in a certain area, people would flock there for more job opportunities, resulting in more chances for dengue to spread.

Moreover, studies showed that heavy rainfall can possibly lessen dengue fever transmission by reducing the survival rate of mosquitoes. Thammapalo et al. (2005) analyzed the independent effects of rainfall in Thailand, and they suggested that dengue cases have a slightly negative correlation with the precipitation in some provinces.

3.3. Poisson Regression Model

The GENMOD procedure was utilized to obtain the Poisson regression model because it can fit a wide range of generalized linear models. The log(pop) function was specified as an offset to account for possible different observation periods. Additionally, the DSCALE function was utilized due to overdispersion. The simplified results are seen in Table 3.3.1. while Table 6 (see appendix) shows the full analysis. Table 3.3.1. shows that the POP variable has a p<0.05 (p=0.0184), which indicates that POP is a significant correlate of DENC as expected because

the bigger the population, the greater the chance of getting infected.

Table 3.3.1. Simplified Analysis of Maximum Likelihood Parameter Estimates of Poisson Regression with DSCALE Function

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	3.1095	2.7332	-2.2474	8.4664	1.29	0.2553
POP	1	0.0000	0.0000	0.0000	0.0000	5.56	0.0184

3.4. Negative Binomial Regression

Due to the overdispersion in Poisson regression, NB was used. The full results are in Table 7 (see appendix). On Table 3.4.1., the independent variables RF (p=.0028) and POVINC (p=.0007) show a p<0.05, meaning that RF and POVINC are statistically significant predictors of DENC.

Table 3.4.1. Simplified Analysis of Maximum Likelihood Parameter Estimates of Negative Binomial

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	3.5627	3.1367	-2.5851	9.7104	1.29	0.2560
RF	1	-0.0033	0.0011	-0.0054	-0.0011	8.94	0.0028
POVINC	1	-0.0650	0.0192	-0.1027	-0.0273	11.43	0.0007

Based on Table 5 (see Appendix), the NB model is,

$$\log\{E[Y]\} = 3.5627 - 0.0033\ RF + 4.3856\ TMAX + 4.0906\ TMIN - 8.5210\ TMEAN - 0.0038\ RH - 0.0650\ POVINC$$

while the model with the significant correlates is,

$$\log\{E[Y]\} = 3.5627 - 0.0033\ RF - 0.0650\ POVINC$$

where E[Y] is the expected DENC per province.

Results showed that the provinces with the highest expected DENC are Tarlac (E[Y] = 2.055) and Nueva Ecija (E[Y] = 2.249), which are in areas with clustering of SIR greater than 1. RF and POVINC may be attributed as factors for high clustering in Central Luzon as the two provinces have previously recorded about 7,000 raw dengue cases with a poverty incidence of 7.73 and 6.57, respectively. Although some provinces have high DENC, POVINC must also be considered since it is an important factor in the NB model. Thus, Tarlac and Nueva Ecija are the only provinces with notable expected DENC due to high DENC and POVINC values.

The results of this study are consistent with a 2008 study by Sia-Su about the relationship of climatic factors and dengue prevalence in Metro Manila. Through MLRM, the results show that there is a significant correlation between rainfall and dengue incidence (r = 0.614, p < 0.05). It proved that dengue incidence in the region varies as rainfall patterns change. Moreover, this study explored the statistical procedures Poisson and NB regressions which led to an additional significant correlate, POVINC, of dengue counts and incidences in the Luzon provinces.

4. CONCLUSIONS

The Philippines remains one of the countries reporting high dengue cases globally. In practice, dengue surveillance relies mainly on disease reporting units. However, the illness limits reporting accuracy, leading to a multitude of unrecorded and under-reported dengue episodes. In this paper, significant dengue correlates were obtained and adapted into a MLR and Poisson Regression model. However, due to overdispersion in Poisson Regression, NB was used instead. Both MLRM and NB results revealed that POVINC and RF significantly correlate to DENINC. Although both showed similar significant correlates, the NB model has higher adjusted predictors.

DENC, IRs, and SIRs were mapped in Luzon provinces. The heat maps display hotspots in a specific area which are vital for observing clusters. Results show that Nueva Ecija and Tarlac have SIR higher than 1 and are found in high-risk cluster areas. These are accredited to RF and POVINC, as the NB model has revealed that the following provinces have the highest expected DENC.

With that, it is essential to monitor these provinces as they can be possible sources of dengue spreading in 2018. Although the data is from 2018, the derived results can approximate future dengue trends. Health organizations can use these results to provide health programs and allocate more funds in areas with SIR higher than 1. Visayas and Mindanao provinces should also be tested and modeled to ensure the Filipinos' safety from dengue and include them in programs.

It is also recommended to create a better estimate of the dengue counts by adding more independent variables other than meteorological factors. Additionally, the utilization of heat maps for data visualization, which focuses on new fields like data science, can help determine factors contributing to the spread of dengue.

Considering the COVID-19 pandemic, the statistical procedures used can be executed in determining factors correlating to the increase in COVID-19 cases. Given the availability of data, researchers can secure copies for statistical

procedures; and adding variables such as population density, number of hospitals, and Intensive Care Units (ICUs) can be utilized to predict COVID-19 incidences and create a better-fitting model for predictions.

5. ACKNOWLEDGMENTS

6. REFERENCES

Natividad, J.M., Necesito, R.M., Ocampo, S., & Leong, R.N. (2019). Bayesian conditional autoregressive model for mapping human immunodeficiency virus incidence in the national capital region of the Philippines. 62nd ISI World Statistics Congress, pp. 291-299.

Sia Su, G. L. (2008). Correlation of climatic factors and dengue incidence in Metro Manila, Philippines. AMBIO: A Journal of the Human Environment, 37(4), 292–294. doi:10.1579/0044-7447(2008)37[292:cocfad]2.0.co;2

Thammapalo, S. , Chongsuwiwatwong, V., McNeil, D., & Geater, A. (2005). The climatic factors influencing the occurrence of dengue hemorrhagic fever in Thailand. Southeast Asian Journal of Tropical Medicine and Public Health; 36(1):191-6. PMID: 15906666.

World Health Organization. (2020a, March 2). Dengue and severe dengue. World Health Organization. https://www.who.int/en/news-room/fact-sheets/detail/dengue-and-severe-dengue

World Health Organization. (2020b, January 16). Update on the Dengue situation in the Western Pacific region. World Health Organization. https://www.who.int/docs/default-source/wpro---documents/emergency/surveillance/dengue/dengue-20200116.pdf?sfvrsn=fc80101d_28

The Integration and Appraisal of Electronic Medical Records (EMR) in Cotabato Regional and Medical Center

Jeffrey Harold C. Chan, Aerelle Myeica S. Manansala
and Redj Nicole L. Mojares
De La Salle University Integrated School, Manila

Abstract: This research investigates the adoption, implementation, and overall satisfaction of electronic medical records (EMR) in the Cotabato Regional and Medical Center (CRMC). A purposive sampling method was utilized in the recruitment of the participants after getting clearance from its ethical review board. This study engaged 16 participants from CRMC: administrators, health personnel, and non-health personnel. The participants responded in a google survey form with structured and unstructured items that centered on the what, when, how, and why of the adoption of the implementation of the EMR and their overall satisfaction. EMR adoption in CRMC is associated with the mandate from the Department of Health's initiative to modernize the health care system in the Philippines. The hospital's top administration initiated the adoption with consultations from the different stakeholders in the hospital. Several consultations were conducted, and training of both healthcare and non-healthcare personnel were conducted to prepare the hospital system. Despite these efforts, several issues confronted the efficient implementation of EMR in the recording, archiving, and retrieval of the medical records which include: internet connectivity, lack of skilled manpower to handle the EMR system, financing issues, and preference of other personnel to the "manual process" of doing things. Interestingly, the level of overall satisfaction on the implementation of EMR remains to be high. Improved infrastructure, more training, and recruitment of skilled staff are recommended to optimize the utilization of EMR.

Key Words: electronic medical records; ehealth; structure-process-output assessment, Cotabato Regional and Medical Center;, Philippine healthcare system

1. INTRODUCTION

1.1. Background of the Study

The medical and healthcare aspect in the Philippines continuously inclines itself to modernization and advancements. The adaptation of eHealth in the Philippines started in the year 1998 (DOH & DOST, 2014). The eHealth system in the Philippines aims to draw a long-term strategic plan for developing a lasting healthcare system, develop the infrastructure of ICTs for more equitable and affordable access, reach communities and vulnerable groups far from the urban life, and mobilize multi-sectoral collaboration with the different departments. This technology is designed for the collection, retrieval, and sharing of medical knowledge by health providers (Angst & Agarwal, 2009).

The Cotabato Regional and Medical Center (CRMC), located in Cotabato City, Bangsamoro is a tertiary government hospital under the Department of Health (CRMC, n.d.). The hospital is regulated by the Civil Service Commission, the Department of Budget and Management, and Commission of Audit. CRMC started with a 12-bed capacity in 1916. Due to demand and modernization, the hospital can now accommodate a 400-bed capacity. The group has decided to conduct a study in this particular area not only because it is accessible but rather it could also give a different perspective of the usage of EMR, especially in provincial areas. Before utilizing the electronic medical record, the institution has been using the manual process of pen and paper to record, retrieve, and archive data. It was only recently when CRMC made use of the system following the launch of the Integrated Hospital Operations Management Information System (IHOMIS) and The Integrated Hospital Operations and Management Program (IHOMP). The adoption of EMRs has been plagued with issues and pushback with its implementation as the enforcement of a new system would burden the hospitals with financial and educational incentives along with doubts if it would be a more efficient addition to the Philippine hospital system.

1.2. Statement of the Problem

This study investigates the effectiveness of the utilization of EMRs to provide quality health care services in Cotabato Regional and Medical Center (CRMC), a public hospital in Cotabato City, Maguindanao. The following specific questions are sought:

1. What are the preparations and other resources on the implementation of EMR in the provision of health services in CRMC?
2. What is the attitude of the medical staff on the integration of EMR in the provision of health services?
3. What are the perceived benefits of the medical staff on the integration of EMR in the provision of health services?
4. What are the issues and challenges that confronted the medical staff on the integration of EMR in the provision of health services?
5. How are the issues and challenges addressed by the medical staff on the integration of EMR in the provision of health services?
6. What lessons can be generated on the integration of EMR in the provision of quality of health care service in CRMC?

1.3. Conceptual Framework
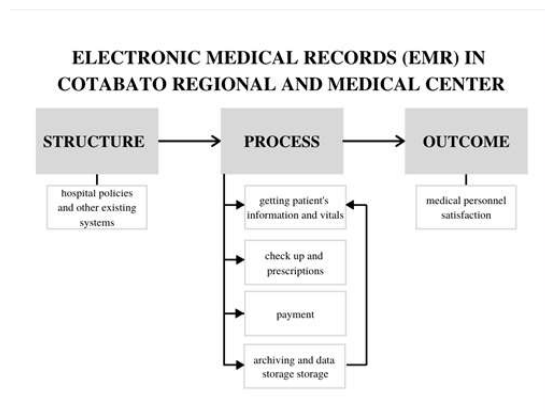
[Figure 1.1 Conceptual Framework of EMR implementation in Cotabato Regional and Medical Center, 2020 Source: Adopted from the Conceptual framework of Berhe et al. and modeled from the Deleon and Maclean Model (D&M)]

Micheale Berhe, et al.'s (2017) structure-process-outcome assessment model is adopted to investigate the efficiency of the implementation of EMR in CMRC. Structure refers to the observance of the eHealth Law, hospital policies, institutional training in EMR, and placement of infrastructure systems. Process refers to the systematic flow of the utilization of Electronic Medical Records in collecting, recording, archiving, and retrieval of patient's records and vital information, check-ups, prescriptions, and the payment and accounting system. Lastly, the Outcomes refer to the perceived satisfaction of the medical personnel towards the usage of Electronic Medical Records in CRMC.

1.4. Scope and Limitations

This study centers on the assessment of the efficiency in the implementation of EMR in CRMC in three major domains: structure, process & outcomes. Engaging the different levels of administration, and both health care and non-healthcare personnel is intended to collect their different perceptions, observance, utilization, and satisfaction. This is based on the understanding that each stakeholder has a different experience with EMR thus influencing their appraisal and satisfaction with the system. COVID 19 pandemic and strict implementation of community quarantine limit the opportunity for the researchers to conduct in-person interviews. Poor internet connection and the difficulty in the recruitment of participants had also prevented the researchers from adopting online interviews via Google Meet or Zoom.

1.5. Significance of the Study

With the existing technologies present in the Philippines, it is still evident that the implementation of Electronic Medical Records (EMR) in institutions needs improvements and refinements. Despite this, EMRs remain a crucial bridgeway to an advanced healthcare system in the entire country. It is generally recognized that the EMR has the ability to be the central electronic health-care information and communication device (Ball 2003; Haux 2006; Chang & Chang 2008). The Electronic Medical Record (EMR) is an innovative technology that enables doctors' practices to implement more effective performance assurance initiatives than paper-based documents can do, although achieving quality enhancement by the use of EMR is neither low-cost nor simple (Miller and Sim 2004). Increased use of electronic medical records (EMRs) is generally believed to improve the quality of health care and the reliability with which it is provided.

2. METHODOLOGY

2.1. Research Design

This study investigated the effectiveness of the utilization of EMRs to provide quality health care services in CRMC utilizing an institutional case study design. An institutional case study research design

was adopted due to its compatibility with the structure-process-output assessment model.

2.2. Sampling

Purposive sampling method was adopted in the recruitment of the participants of the study. The study recruited 16 medical and non-medical personnel: (3) administrator/s, (5) medical staff (doctors), (2) nurse/s, (2) midwives, ((1) radiologic technologist/x-ray technician, (1) medical technologist), support staff ((2) IT staff) who use EMR at work. The primary criterion in the recruitment include: (1) Individuals with medical or technical experience in Cotabato Regional and Medical Center, and (2) Personnel from Cotabato Regional and Medical Center (CRMC).

2.3. Instrumentation

A Google Form Survey was the primary instrument adopted in this study which was divided into four major sections: 1) whats, hows, and whys of the adoption of EMR, 2) the actual EMR engagement and experience of the participants, 3) the issues and challenges in the implementation, and 4) their overall satisfaction. Open-ended items were formulated for the first three sections and an overall satisfaction measure with five-point agreement Likert scale was formulated for the fourth section.

2.4. Data Gathering Procedure

The researchers secured the approval of the CRMC administration and the in-house ethical review committee before proceeding to the process of recruitment of the participants. The researcher initially listed 18 participants who met the recruitment criteria, however, only 16 respondents responded to the invitation. Informed consent was secured before providing the participants with the link to the Google Survey Form.

2.5. Data Analysis Strategy

Braun & Clark (2006) six-stage thematic analysis was adopted in the analysis of the responses in the open-ended questions: 1) familiarization, 2) coding,3) theme-development, 4) review, 5) defining of themes, and 5) report writing the researchers will analyze the data harvested. The measure of central tendency, mean, for each item in the overall satisfaction measure was prepared to present the level of satisfaction of the participants in the different processes where EMR is implemented.

3. RESULTS AND DISCUSSION

Adoption and Implementation of EMR

The implementation of EMR in Cotabato Regional and Medical Center was due to the compliance of the hospital administration with the directive from the DOH Central Office. The Department of Health launched the Integrated Hospital Operations Management Information System (IHOMIS) and The Integrated Hospital Operations and Management Program (IHOMP) which directed all hospitals in the country to comply with the directive. However, most participants noted that their hospital adoption of the EMR system was also in consideration of the Philhealth Incorporated requirements for hospital accreditation.

Several of the challenges faced by the institution regarding the implementation of the system include internet connectivity, financial, and manpower issues. These serve as the common barrier in the utilization of EMR in the recording of patients' information and vitals, check-up, prescriptions, and payment systems in the hospital. Despite this, over time with the continuous implementation of EMR in CRMC and the development and training of the institution the advantages of EMR may be fully utilized by the personnel with adequate time.

Issues and Challenges in the Utilization of EMR

The main challenge in the implementation of EMR is associated with very poor or intermittent internet connection. System lag and poor connection due to weak LAN are two of the main issues identified by the medical personnel. Lack of manpower and equipment also affects the overall process of recording, archiving, and retrieval of patient's records and vital information, medical check-ups, prescription, and payment. The whole process is observed to be time-consuming and requires double the work, as not everyone is technologically literate. As such, most of the staff prefer manual processes instead of utilizing EMR. Some participants also raised the issue of incorrect and double entry as to the reason for preferring the manual process instead of EMR. Internet connectivity, just like in other areas of EMR implementation, has been considered a major challenge in the integration of EMR in the accounting or payment system. Adding to this issue is the lack of skilled staff to attend to this process. Additional burdens include payment adjustments and the availability of the funds from PhilHealth to cover a patient's medical bill. The additional cost of the adoption of accounting software is also considered a major issue. The encoding of the records has also been delayed or is not always updated.

Overall Satisfaction on the Implementation of EMR

There is a high level of satisfaction among the participants on the implementation of EMR in CRMC in all areas where it is adopted (see Table 1). There is a high level of satisfaction on the utilization of EMR in the recording (m=4.07, sd=0.70), archiving (m=4.27, sd=0.70) and retrieving (m=4.53 sd=0.52) of patient's information and vital records. High levels of satisfaction was also found among the participants on the utilization of EMR in the recording (m=3.93, sd=0.79), archiving(m=4.13, sd=0.49), and retrieving (m=4.33 sd=0.78) of patient checkups. Additionally, there is a high level of satisfaction was found among the participants on the utilization of EMR in the recording (m=3.87, sd=1.21), archiving (m=3.60, sd=1.23) and retrieving (m=3.60, sd=1.23) of patient's prescriptions. Lastly, there is a high level of satisfaction on the utilization of EMR in the recording (m=4.27, sd=0.72), archiving (m=4.27, sd=0.72) and retrieving (m=4.20, sd=0.79) of patient's information and payments.

Table 1

Overall Satisfaction on the Implementation of EMR

Satisfaction	Mean	SD	Interpretation
Overall Vital			
Recording	4.07	0.70	High
Archiving	4.27	0.70	High
Retrieving	4.53	0.52	High
Overall Checkup			
Recording	3.93	0.79	High
Archiving	4.13	0.49	High
Retrieving	4.33	0.78	High
Overall Prescription			
Recording	3.87	1.21	High
Archiving	3.60	1.23	High
Retrieving	3.60	1.23	High
Overall Payment			
Recording	4.27	0.72	High
Archiving	4.27	0.72	High
Retrieving	4.20	0.79	High

4. CONCLUSIONS

EMR adoption in Cotabato Regional and Medical Center has been associated with the mandate from the Department of Health's initiative to modernize the health care system in the Philippines. The hospital's top administration initiated the adoption with consultations from the different stakeholders in the hospital. Several consultations were conducted and training of both healthcare and non-healthcare personnel was conducted to prepare the hospital system. Despite these efforts, several issues confronted the efficient implementation of EMR in the recording, archiving, and retrieval of the medical records which include internet connectivity, lack of skilled manpower to handle the EMR system, financing issues, and preference of other personnel to the "manual process" of doing things. Interestingly, the level of overall satisfaction on the implementation of EMR remains to be high. Improved infrastructure, more training, and recruitment of skilled staff are recommended to optimize the utilization of EMR.

5. ACKNOWLEDGMENTS

6. REFERENCES

Angst, & Agarwal. (2009). Adoption of Electronic Health Records in the Presence of Privacy Concerns: The Elaboration Likelihood Model and Individual Persuasion. *MIS Quarterly*, *33*(2), 339. https://www3.nd.edu/~cangst/CoreyAngst_Faculty Website_files/Angst2009MISQ.pdf

Berhe, M., Tadesse, K., Berhe, G., & Gebretsadik, T. (2017b). Evaluation of Electronic Medical Record Implementation from User's Perspectives in Ayder Referral Hospital Ethiopia. *Journal of Health & Medical Informatics*, *08*(01), 4. https://www.researchgate.net/profile/Gebremedhin-Berhe-Gebregergs/publication/315824479

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://www.researchgate.net/publication/23535639 3_Using_thematic_analysis_in_psychology

About Us - Cotabato Regional and Medical Center. (n.d.). Cotabato Regional and Medical Center. http://crmc.doh.gov.ph/transparency-seal/about-us

Department of Health. (2014). Chapter 1 : *Philippine eHealth strategic plan*. http://www.ehealth.doh.gov.ph/index.php?option=co m_content&view=category&layout=blog&id=73

Heale, R., & Twycross, A. (2017). What is a case study? *Evidence Based Nursing*, *21*(1), 7–8. https://ebn.bmj.com/content/21/1/7

A Systematic Review on the Efficacy of Common Antacid Components

Ma. Fatima Jesuniña M. Gornez,
Hailey Vanessa G. Mendoza, Timothy P. Rapacon and Errol Joriz N. Solano
De La Salle University Integrated School, Biñan City, Laguna

Abstract: Gastroesophageal Reflux Disease (GERD) is a common health issue worldwide that utilizes antacids to mitigate its symptoms such as chest pains and burning sensations. However, the most common component used in antacids, Aluminum Hydroxide, has a high toxicity level as it builds up in the body. Thus, this study aims to determine whether Alginate, an organic compound, and Calcium Carbonate, which is considered an age-friendly component, are suitable antacid component alternatives to Aluminum Hydroxide in terms of their corresponding Acid Neutralization Capacity (ANC) and adverse effects. The researchers utilized a systematic review approach, guided by the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P), to accomplish the study objectives. The study results suggest that Calcium Carbonate has the highest ANC while Alginate has the second-highest ANC and has fewer adverse effects than placebo. These results support the claim that Alginate and Calcium Carbonate are suitable alternatives to Aluminum Hydroxide.

Key Words: antacid; gastroesophageal reflux disease; calcium carbonate; alginate; systematic review

1. INTRODUCTION

Gastroesophageal Reflux Disease (GERD) occurs when there are backflows of stomach acid in the esophagus, irritating its walls (Yamamichi et al., 2012). People with GERD have been more prevalent in the Philippines over the years (Sollano et al., 2007). One problem with treating GERD is that the majority of medications contain Aluminum; allergic reactions, such as exposure to xenobiotics, may occur when it is ingested or vaccinated (Crisponi et al., 2013). Though branded safe for usage as Aluminum Hydroxide, Aluminum has a record of toxicity (Jensen-Jarolim, 2015).

Due to this, researchers sought out an organic compound called Alginate derived from algae and Calcium Carbonate, which are also used to formulate antacids (Szekalska et al., 2016). Alginate is in recent antacid formulations because it is organically derived. Additionally, it also develops rafts that help maintain stomach acidity (Hampson et al., 2010). Calcium Carbonate is widely used in antacid formulations because it is suitable for all ages (Li et al., 2018). In comparison to the level of toxicity obtained by consuming Calcium Carbonate, the toxicity of Aluminum Hydroxide is significantly higher (Salisbury & Terrell, 2020). Adverse side effects of Calcium Carbonate are dizziness, nausea, and constipation.

Antacids are formulated to mitigate GERD symptoms, but a problem with this is that one of the most common antacid components is Aluminum Hydroxide, which can be toxic to humans when it builds up in the body (Crisponi et al., 2013). Thus, this research aims to determine, via a systematic review, if Alginate and Calcium Carbonate are effective alternative antacid components to Aluminum Hydroxide so that this toxic component may eventually be removed in antacids for GERD patients.

The paper is a systematic literature review on the efficacy of common antacid components present in the formulation of over-the-counter medications. The identified components are Alginate and Calcium Carbonate. The collected journals only focused on the properties of these compounds. Different parameters, acid neutralization, and adverse effects were identified and used to evaluate the two chemical components' efficacy. Also, the findings were based on the gathered data; no theoretical computations and primary data were presented. This study will help fill the research gaps in the academic and medical community and will help to further improve antacid formulations.

2. METHODOLOGY

2.1. Study Design

The methodology is composed of three phases as seen in Figure 1. First is the selection process of literature according to predetermined eligibility criteria. Second is the data collection process and the risk of bias assessment of the eligible papers. Last is the generalization of the collected data to determine a suitable alternative to Aluminum Hydroxide based on

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Acid Neutralization Capacity or adverse effects. The study's methods were guided by the protocols for reporting systematic reviews adapted from the Preferred Reporting Items of Systematic Reviews and Meta-Analysis (PRISMA) website. Subsections: Eligibility Criteria, Information Sources, Search Strategy, Study Records, ROB assessment, and Data Synthesis, were kept and modified accordingly in this study (Shamseer et al., 2015).
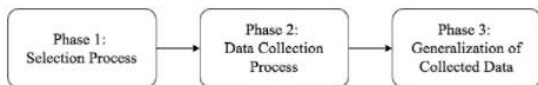

Figure 1. Flowchart of the Main Methodology

2.2. Eligibility Criteria

A literature search was performed where every title of a paper that the researchers read was considered a viewed paper and the papers that met the requirements of the eligibility criteria were considered accepted papers. The eligibility criteria include:

acceptability - if the paper was published by a reputable publisher and the paper's academic affiliations

study design - if the paper was quantitative study design

compound assessed - if the papers studied Alginate or Calcium Carbonate

parameter for evaluation - if the papers studied Acid Neutralization Capacity or adverse effects

2.3. Information Sources

The researchers prioritized sources such as Google Scholar, JSTOR, Science Direct, and ResearchGate. The researchers used these databases during the initial search period, including the use of the eligibility criteria. Afterward, the researchers branched out to different databases such as school repositories.

2.4. Search Strategy

In searching for literature through different recognized databases, a search strategy using specific keywords and search techniques was applied to set a guided framework for the researchers.

2.5. Study Record

To manage the literature and information, the researchers utilized the software Mendeley,

OneDrive Microsoft Excel, and Risk of Bias Visualizer (ROBVis). The selection process in Figure 2 involved the literature search protocol for systematic reviews, which began with utilizing the search strategy. The criteria for filtering the literature according to its relevance to the study involved reading: title, publisher, and abstract during the search. In the title, the researchers sought out Alginate and Calcium Carbonate, then accepted papers with recognized publishers before scanning the abstract for quantitative study designs mentioning Acid Neutralization Capacity and adverse effects. Journals that did not meet the criteria were not eligible for the study. The researchers viewed a total number of 750 journals.
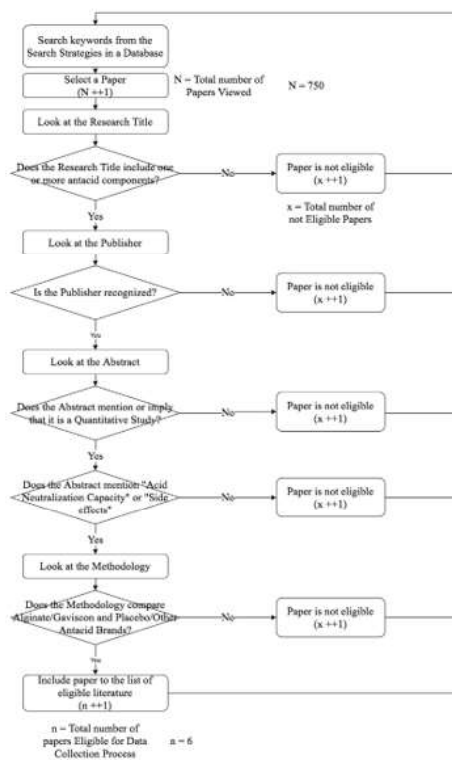

Figure 2. Flowchart of the Selection Process

2.6. Risk of Bias in Individual Studies

In the Cochrane Review Handbook, Higgins & Green (2011) defined bias as a systematic error that must be assessed by considering the Risk of Bias (ROB). This study's objectives require data collection from experimental trials that do not necessarily involve participants. Thus, the researchers modified the criteria from the Cochrane Handbook to suit the study's needs better.

After performing an individual ROB assessment, a general assessment was done by assigning number values for each risk (High = 2; Low = 1; None = 0) and computing for the average of each bias of the paper. The ROB Visualizer for systematic reviews was used to make a visual summary. The general assessment was utilized to justify the conclusions of the study.

Table 1. Risk of Bias Criteria

Bias	Risk	Criteria
Generated Source Type	Low	Primary source
	High	Secondary source Tertiary source
	Unclear	Not Enough Data (NED)
Randomized Testing of Market Antacids	Low	Random selection of market antacids
	High	Specific or non-random selection of market antacids
	Unclear	NED
Number of Trials	Low	5 or more trials
	High	4 or less trials
	Unclear	NED
Declaring the Control Variables	Low	All factors aside from the independent variable are controlled
	High	One or more factors aside from the independent variable are not controlled
	Unclear	NED
Generalizable Outcome Data	Low	Used statistics to determine the significance of results
	High	Did not use statistics to determine the significance of results
	Unclear	NED

Selective Reporting	Low	Specified expected outcomes, reported all of the results
	High	Specified outcomes, selective reporting of results
	Unclear	NED
Other Biases	Low	None
	High	1 or more
	Unclear	NED

2.7. Data Synthesis

The researchers collected information under Acid Neutralization Capacity (ANC) and adverse effects, then categorized the data in Microsoft Excel. Results that agreed with the same hypothesis and have similar implications on the efficacy of the compound were under the same category. The categorized data were used to make generalizations on the ANC and adverse effects of the compounds. These generalizations were the basis for determining whether Alginate and Calcium Carbonate are suitable alternatives to Aluminum Hydroxide for treating Gastroesophageal Reflux Disease (GERD).

3. RESULTS AND DISCUSSION

3.1 General Assessment of Risk of Bias

Figure 4 and Figure 5 present the summary of all risk of bias assessment in terms of the criteria. Generated source type, generalizable outcome data, selective reporting, and other biases had a low risk of bias in total, while the number of trials and declaring the controlled variables had a majority summation of low risk of bias. The overall summary of the risk of bias in the accepted papers is a low risk of bias.

Figure 4 is the traffic plot which is prescribed by Cochrane in presenting the ROB assessment. Green represents a low risk of bias, red for a high risk of bias, and yellow for an unclear risk of bias. The traffic plot's purpose is to illustrate which study and criterion of that study had a different risk of bias judgment from the majority. It was observed that the only high risk of bias came from the randomized testing of market antacids in Tytgat and his team's paper. This implies that in general, the accepted papers are considered to have a low risk of bias.
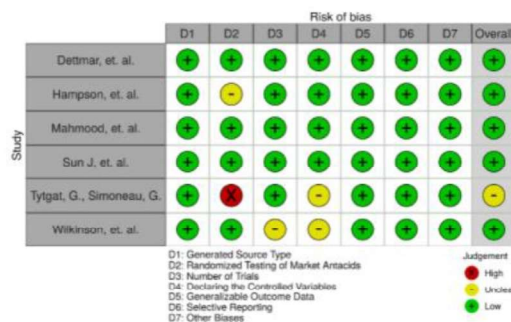

Figure 4. General ROBVis Assessment Traffic plot

Figure 5 presents the summary of all risk of bias assessment in terms of the criteria. Generated source type, generalizable outcome data, selective reporting, and other biases had low risk of bias in total, while the number of trials and declaring the controlled variables had a majority summation of low risk of bias. Randomized testing of market antacids, although it was observed to have a high risk of bias in one of the papers, resulted in a low risk of bias in the summary. The overall summary of the risk of bias in the accepted papers is a low risk of bias. Meaning, for all accepted papers, no other possible sources of bias were observed.
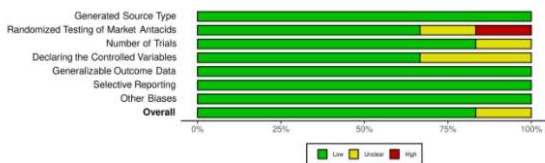
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Figure 5. General ROBVis Assessment Summary plot

3.2 Antacid Component with Highest Acid Neutralization Capacity

The Acid Neutralizing Capacity (ANC) was used to test the amount of acid neutralization and the duration of the antacid maintaining the pH level of above 3.5 (Dhawal & Barve, 2020). According to Ayensu et al. (2020), antacid efficacy can be determined according to neutralizing capacity. The information synthesized, as seen in Table 2, implies that Calcium Carbonate, present in the antacid brand Rennie Duo, is a suitable alternative to Aluminum Hydroxide in terms of ANC. This is because Calcium Carbonate shows the highest ANC among the comparators' components, excluding Aluminum Hydroxide. Calcium carbonate, an inorganic salt, neutralizes Hydrochloric acid in gastric secretions when it is dissolved in the stomach, which is why the preferred formulation of Calcium Carbonate is in a compressed powder tablet. Additionally, the collected data supports the claim that Alginate is another suitable alternative to Aluminum Hydroxide since it has the second-highest ANC, below Calcium Carbonate.

Table 2. Resulting Efficacy of Antacids and their components based on ANC

Study	Year Published	Parameters Identified (ANC, adverse effects)	Results (Highest to Lowest Parameter)	Components (of the corresponding antacids)
Hampson, F. C., et al.	2005	ANC	1. Gaviscon Extra Strength (liquid) 2. Mylanta Heartburn Relief (liquid) 3. Algicon (liquid) 4. Rennie Duo (liquid) 5. Gaviscon Regular Strength (liquid)	1. Aluminum Hydroxide 2. Calcium Carbonate 3. Magnesium Alginate 4. Calcium Carbonate 5. Magnesium Carbonate
			6. Gaviscon Original (liquid) 6. Peptac (liquid) 7. Gastrocote (liquid) 8. Gaviscon Advance (liquid)	6. Sodium Alginate 7. Sodium Alginate 8. Sodium Alginate
Tygant, G. & Simoneau, G.	2005	ANC	1. Rennie Duo (liquid) 2. Gaviscon Original (liquid) 3. Placebo (liquid)	1. Calcium Carbonate 2. Sodium Alginate 3. not mentioned
Dettmar, P. W., et al.	2017	ANC	1. Rennie Duo (liquid) 2. Gaviscon Double Action (liquid) 3. Gaviscon Original (liquid) 4. Peptac (liquid) 5. Mylan Liquid Suspension (liquid) 6. Maalox RefluRAPID (liquid)	1. Calcium Carbonate 2. Sodium Alginate 3. Sodium Alginate 4. Sodium Alginate 5. Sodium Alginate 6. Sodium Alginate 7. Alginic Acid
			7. Algicon (solid)	
Mahmood, D., et al.	2020	ANC	1. Moxal Plus (solid) 2. Rennie Duo (solid) 3. Gaviscon Original (solid) 4. Gaviscon Advance (liquid) 5. Moxal (solid) 6. Gaviscon Original (liquid) 7. Moxal Plus (liquid) 8. Epicogel (liquid) 9. Moxal (liquid) 10. Mucogel (liquid) 11. Fawar lemon (effervescent powder)	1. Aluminum Hydroxide 2. Calcium Carbonate 3. Sodium Alginate 4. Sodium Alginate 5. Aluminum Hydroxide 6. Sodium Alginate 7. Aluminum Hydroxide 8. Aluminum Hydroxide 9. Aluminum Hydroxide 10. Aluminum Hydroxide 11. Sodium Bicarbonate

3.3 Antacid Component with Less Adverse Effects

The information collected, tabulated in Table 3, implies that in addition to Alginate being a suitable alternative to Aluminum Hydroxide in terms of high Acid Neutralization Capacity (ANC), Alginate also causes fewer adverse effects when taken by patients. Meaning, Alginate is also a suitable alternative to Aluminum Hydroxide and Calcium Carbonate for patients who choose to intake a more organic antacid component. Alginate is considered organic because it has Alginic Acid that is derived from brown seaweeds. Organic compounds contain more carbon and oxygen than inorganic compounds, these elements are already present within the biochemical makeshift of a human. Sodium Alginate is a raft-forming agent that

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floats on top of the stomach which traps carbon dioxide. This raft stops incoming acidic gases that may worsen gastric pH. The raft gives gastric acid time to normalize before it eventually dissolves and gets digested.

Table 3. Resulting Efficacy of Antacids and their components based on Adverse Effects

Study	Year Published	Parameters Identified (ANC, adverse effects treatment)	Results (Highest Parameter to Lowest Parameter)	Components (of the corresponding antacids)
Sun, J., et al.	2015	Adverse effects	1. Gaviscon Double Action (solid) 2. Placebo (solid)	1. Sodium Alginate 2. not mentioned
Wilkinson, J., et al	2019	Adverse effects	1. Gaviscon Double Action (liquid) 2. Placebo (liquid)	1. Sodium Alginate 2. not mentioned

3.4 Alginate and Calcium Carbonate as an alternative to Aluminum Hydroxide

The researchers evaluated the most effective chemical component, excluding Aluminum Hydroxide, in treating Gastroesophageal Reflux Disease (GERD) based on the resulting Acid Neutralization Capacity (ANC) and Adverse Effects among the accepted papers. Finding an alternative to Aluminum Hydroxide is significant because Aluminum Hydroxide can become toxic if built up in the body when intaking antacids. According to Dettmar et al., Hampson et al., Mahmood et al., and Tytgat & Simoneau, the most effective chemical component in treating GERD based on ANC is Calcium Carbonate. It is then followed by Alginate, more specifically Sodium Alginate. According to the studies of Sun et al. and Wilkinson et al., the most effective antacid component in treating GERD based on Adverse effects is Alginate. Overall, both Calcium Carbonate and Alginate are suitable alternatives to Aluminum Hydroxide.

4. CONCLUSIONS

The research aims to find the best alternative antacid component to Aluminum Hydroxide through a systematic literature review. Results from the eligible papers indicate that Calcium Carbonate has the highest Acid Neutralization Capacity (ANC), while Alginate, specifically Sodium Alginate, has fewer adverse effects than placebos. These results support the claim that either Alginate or Calcium Carbonate are suitable alternative components to Aluminum Hydroxide in terms of ANC and adverse effects. The research findings suggest that Alginate and Calcium Carbonate can be an alternative to Aluminum Hydroxide. However, the potential of these components to completely replace Aluminum Hydroxide can be further looked into by future researchers. Also, it is recommended for future studies to explore other antacid components and different efficacy parameters to expand the scope of the study.

6. REFERENCES

Ayensu, I., Bekoe, S. O., Adu, J. K., Brobbey, A. A., & Appiah, E. (2020). Evaluation of acid neutralizing and buffering capacities of selected antacids in Ghana. Scientific African, 8, e00347. https://doi.org/10.1016/j.sciaf.2020.e00347

Crisponi, G., Fanni, D., Gerosa, C., Nemolato, S., Nurchi, V. M., Crespo-Alonso, M., Lachowicz, J. I., & Faa, G. (2013). The meaning of aluminium exposure on human health and aluminum-related diseases. Biomolecular Concepts, 4(1), 77-87. http://doi.org/10.1515/bmc-2012-0045

Dettmar, P. W., Gil Gonzalez, D., Fisher, J., Flint, L., Rainforth, D., Moreno-Herrera, A., & Potts, M. (2018). A comparative study on the raft chemical properties of various alginate antacid raft forming products. Drug Development and Industrial Pharmacy, 44(1), 30-39. https://doi.org/10.1080/03639045.2017.1371737

Hampson, F. C., Jolliffe, I. G., Bakhtyari, A., Taylor, G., Sykes, J., Johnstone, L. M., & Dettmar, P. W. (2010). Alginate–antacid combinations: raft formation and gastric retention studies. Drug development and industrial pharmacy, 36(5), 614-623. https://doi.org/10.3109/03639040903388290

Higgins, J. P. T. & Green, S. (2011). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.; The Cochrane Collaboration, 2011. Retrieved from https://training.cochrane.org/handbook/current

Jensen-Jarolim, E. (2015). Aluminium in Allergies and Allergen immunotherapy. World Allergy Organization Journal, 8, 7. https://dx.doi.org/10.1186/s40413-015-0060-5

Li, K., Wang, Z. F., Li, D. Y., Chen, Y. C., Zhao, L. J., Liu, X. G., Guo, Y. F., Shen, J., Lin, X., Deng, J., Zhou, R., & Deng, H. W. (2018). The good, the bad, and the ugly of calcium supplementation: a review of calcium intake on human health. Clinical Interventions in Aging, 13. 2443-2452. https://dx.doi.org/10.2147%2FCIA.S157523

Mahmood, D., Alnaseer, S., Muhammad, B. Y., Khalilullah, H., Abdulghani, M. A., Anwar, M. J. Alenezi, S. K., Haider, M., & Elleban, N. (2020). Acid-neutralising capacity and pharmacoeconomic studies of commercially available antacids in the Qassim Region of Saudi Arabia. Hamdan Medical Journal, 13(3), 150. https://doi.org/10.4103/HMJ.HMJ_10_20

Salisbury, B. H., & Terrell, J.M. (2020). Antacids; StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; January 2021. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK526049

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., and Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ, 349, 1-25. https://doi.org/10.1136/bmj.g7647

Sollano, J. D., Wong, S. N., Andal-Gamutan, T., Chan, M. M., Carpio, R. E., Tady, C. S., Ismael, A. E., Judan-Ruiz, E. A., Ang, V. N., Go, J. T., Lim, V. Y., Perez, J. Y., & Alvarez, S. Z. (2007). Erosive esophagitis in the Philippines: A comparison between two time periods. Journal of Gastroenterology and Hepatology, 22(10), 1650-1655. https://doi.org/10.1111/j.1440-1746.2006.04355.x

Sun, J., Yang, C., Zhao, H., Zheng, P., Wilkinson, J., Ng, B., & Yuan, Y. (2015). Retracted: Randomised clinical trial: the clinical efficacy and safety of an alginate-antacid (Gaviscon Double Action) versus placebo, for decreasing upper gastrointestinal symptoms in symptomatic gastroesophageal reflux disease (GERD) in China. Alimentary pharmacology & therapeutics, 42(7), 845-854. https://doi.org/10.1111/apt.13334

Szekalska, M., Puciłowska, A., Szymańska, E., Ciosek, P., & Winnicka, K. (2016). Alginate: current use and future perspectives in pharmaceutical and biomedical applications. International Journal of Polymer Science, 2016. http://doi.org/10.1155/2016/7697031

Tytgat, G. N., & Simoneau, G. (2005). Clinical and laboratory studies of the antacid and raft-forming properties of Rennie alginate suspension. Alimentary pharmacology & therapeutics, 23(6), 759-765. https://doi.org/10.1111/j.1365-2036.2006.02814.x

Wilkinson, J., Abd-Elaziz, K., den Daas, I., Wemer, J., van Haastert, M., Hodgkinson, V., Foster, M. & Coyle, C. (2019). Two placebo-controlled crossover studies in healthy subjects to evaluate gastric acid neutralization by an alginate–antacid formulation (Gaviscon Double Action). Drug development and industrial pharmacy, 45(3), 430-438. https://dx.doi.org/10.1080/03639045.2018.1546314

Yamamichi, N., Mochizuki, S., Asada-Hirayama, I., Mikami-Matsuda, R., Shimamoto, T., Konno-Shimizu, M., Takahashi, Y., Takeuchi, C., Niimi, K., Ono, S. & Kodashima, S. (2012). Lifestyle factors affecting gastroesophageal reflux disease symptoms: a cross-sectional study of healthy 19864 adults using FSSG scores. BMC medicine, 10(45). https://dx.doi.org/10.1186/1741-7015-10-45

A Systematic Review on the Effects of L-theanine and Caffeine Combination on Human Mood and Cognition

Kyra Dominique M. Andres, Angela Mae P. Corcuera,
Raissa Marie S. Macaraig and Marie Nicole Jade C. Mendoza
De La Salle University Integrated School, Manila

Abstract: Caffeine is one of the most widely ingested psychoactive drugs in the world. However, this central nervous system stimulant has raised concerns because of its inauspicious effects on health that come with its overconsumption. Recent scientific advancements have allowed for the theoretical regulation of these side effects through the combination of caffeine and L-theanine, an amino acid that promotes relaxation and improves mental function. This mini-review aims to extend current knowledge by synthesizing both beneficial and detrimental effects of the administration of the combination of caffeine and L-theanine to the human brain and cognition. Information was extensively reviewed, analyzed, and compiled from a sample of 50 works of literature published from 2014 to 2020 in the DLSU Library Databases, as well as referenced studies excluded from the given timeframe that contain highly relevant information that help structuralize the review. Dosage was found to be important in attaining benefits on mood and cognition such as suppressed anxiety and stress, positive mental state, neurochemically fostered changes in neurotransmitter systems, improved accuracy, improved semantic and recognition memory, and heightened mental alertness. On the other hand, L-theanine was found to reduce arousal more than it regulates elevated emotions caused by caffeine while some literature found that induced cognitive effects were only independent for each substance. In summary, existing studies support the hypothesis that the combination benefits human mood and cognition. As such, future research may gear towards a build-up on knowledge and innovations on the topic.

Key Words: L-theanine; caffeine; human cognition; mood

1. INTRODUCTION

1.1. Background of the Study

Caffeine is one of the most widely ingested psychoactive drugs worldwide. It is an alkaloid found in various plants synthetically manufactured for incorporation into beverages and supplements (Turnbull et al., 2017). The chemical structure of caffeine is very similar to that of adenosine, one of the breakdown products of the high-energy molecule adenosine triphosphate. The longer a person is awake, the higher the adenosine levels present in neurons which eventually attach to adenosine receptors causing sleepiness. Due to similarities, caffeine has the ability to block these receptors and counteract adenosine activities such as release of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA) which inhibits arousal and wakefulness, and reduction of dopamine activity, which accounts for the feeling of pleasure, motivation, and enthusiasm, norepinephrine, which is associated with treating mood disorders, and glutamate, which is responsible for learning and memory (Ribeiro & Sebastião, 2010).

On the other hand, too many caffeine molecules blocking adenosine receptors may cause excitotoxicity or neuronal death processes (Simone et al., 2014), one of caffeine's inauspicious effects on health that come with its overconsumption.

Beverages such as tea have been popularly associated with relaxation due to an amino acid called L-theanine. It has beneficial bioactivities including "anti-cerebral ischemia-reperfusion injury, stress-reducing, antitumor, anti-aging, and anti-anxiety activities" (Saeed et al., 2017, p. 1261). Williams et al. (2016) claimed that L-theanine has generally proven to provide advantageous effects to cognitive functions including improved sleep quality and increased alertness. The chemical structure of L-theanine is very similar to that of glutamate, an excitatory neurotransmitter which, in excess, can lead to neuronal damage. Therefore, L-theanine can bind to glutamate receptors to antagonize fast synaptic transmission and agonize synaptic plasticity for learning and memory mechanisms (Adhikary & Mandal, 2017; Yamada et al., 2005). L-theanine also has the ability to elevate inhibitory neurotransmitters like serotonin and GABA, which causes a calming

effect, and reduces levels of excitatory brain chemicals linked to stress and anxiety. Most importantly, L-theanine enhances alpha brain waves which promote wakeful relaxation or relaxation without sedation (Dramard et al., 2018).

The presence of L-theanine in tea was found to help regulate the stimulation caused by caffeine, creating a synergistic effect that promotes different health benefits and minimizes health risks from its caffeine constituent (Dodd et al., 2015). This mini-review discusses both supporting and opposing findings of existing studies exploring the effects and benefits of the combination of caffeine and L-theanine, with the goal of synthesizing recent advancements regarding the understanding of this topic. Ultimately, the review aims to extend current knowledge on the topic by highlighting both beneficial and detrimental effects of L-theanine and caffeine administration on the human brain and cognition.

1.2. Research Objectives

This review aims to investigate the effects of caffeine, L-theanine, and their combination on human cognition by summarizing and evaluating the literature on the aforementioned topics. Furthermore, it aims to show relationships between studies discussing unclear and conflicting ideas. With this, the specific objectives are:

1.2.1 To provide an overview of current knowledge regarding the combination of caffeine and L-theanine on human cognition

1.2.2 To compare and contrast the findings of recent studies about the relationship of caffeine, L-theanine, and human cognition

1.2.3 To address whether or not the combination of caffeine and L-theanine is beneficial to human mood and cognition

1.3. Scope and Limitations

This mini-review focused on synthesizing the different effects of the combination of caffeine and L-theanine on different biological mechanisms of the human brain and cognition. Separate findings exploring effects of the combination were originally integrated into a single study and used in supporting other data and interpretations in the sample. Additionally, referenced studies outside the given timeframe containing highly relevant findings necessary to the review were mentioned.

The conclusions derived from this review were solely based on primary interpretations made in the sample studies and no further interpretations unsupported by published findings were made. Overall, this review provides a comprehensive chemistry-based categorical synthesis emphasizing common findings and contradictions present among recent studies on the topic.

1.4. Significance of the Study

Understanding the chemical structure of caffeine in combination with L-theanine creates a more detailed view of their impact on the human brain and cognition. Since L-theanine regulates the jolting effect of caffeine, enhances concentration, and increases relaxation without drowsiness, there is a heightened potential of how these components may help better obtain desired effects with minimal to no risks. Thus, this review will help achieve a better perspective on the combination of caffeine and L-theanine in terms of its chemical attribution to human mood and cognition.

2. METHODOLOGY

This review was conducted using the DLSU Library Databases and other electronic databases including Google Scholar, PubMed, and ProQuest Online. The search focused on different types of literature (original research, peer-reviewed articles, systematic reviews, etc.) published from 2014 to 2020. The keywords used in the search include L-theanine, theanine, caffeine, combination of caffeine and L-theanine, human cognition, human brain, and chemistry. Literature found in the initial search were further assessed whereas studies emphasizing relevant disciplines were included in the final sample. These disciplines include chemistry as the major discipline and biology and psychology as minor disciplines. A total of 50 works of literature were included and reviewed in the final sample.

3. RESULTS AND DISCUSSION

By itself, caffeine is thought to act as a central nervous system stimulant and has positive effects on cognitive and psychomotor functioning such as enhanced alertness, vigilance, reaction time, and memory function in both young and older adults (Waer et al., 2020). Contrarily, L-theanine is found to have an impact on mood, cognition, and human brain functions (Mancini et al., 2017).

Their combination has mostly been linked to the improvement of human cognitive function and mental clarity (Einother et al., 2010; Kahathuduwa et al., 2016; Haskell et al., 2008). However, there are also findings claiming that while it benefits the consumer, the effects are merely additive in that the effects are the same when the components are administered separately in similar dosages (Kahathuduwa et al., 2016). Saeed et al. (2017) also suggests that L-theanine inhibits the activation impact of caffeine on the problems of sleep.

Overall, the combination has both positive and negative effects, as well as promotional avenues that have yet to be extensively explored.

3.1. Beneficial effects of L-theanine and caffeine combination on the human brain and cognition

3.1.1 Mood

According to a study by Giles et al. (2017), "under emotional arousal, caffeine and theanine exert opposite effects on certain attentional processes, but when consumed together, they counteract the effects of each other". Moreover, a study by Unno et al. (2017) found that the combination of the substances was effective for the specific suppression of anxiety which is linked to stress. Additionally, several articles and reviews further imply that the combination of these substances seem to enhance overall mood and have a positive effect on the subjects' mental state. Similarly, Zaragoza et al. (2017) suggests the combination of caffeine and L-theanine have neurochemically fostered changes in neurotransmitter systems which include dopamine and serotonin that are responsible for pleasure, as well as stabilization of mood and happiness respectively.

3.1.2 Cognition

Reaction time, memory-retaining capacity, mental alertness, and attention were among the measures used to gauge the effectiveness of caffeine and L-theanine combination in cognition. Several studies including those conducted by Dodd et al. (2015), Einother et al. (2010), Camfield et al. (2014), and Giles et al. (2016) stated the effects of the combination in comparison to the effects of placebo. In summary, the studies concluded that there were relatively more beneficial effects on cognitive performance when consuming the combination than placebo.

Most studies highlight the importance of dosage when administering the substances together when analyzing their effect on cognition. Existing studies show that the highest dosage administered was 250mg L-theanine and 150mg caffeine, resulting in increased speed in accomplishing tasks as well as improvements in semantic memory and heightened alertness (Haskell et al., 2008). Dodd et al. (2015) revealed a 100mg:50mg combination improved accuracy, memory, and increased speed in attention-focused tasks, while Giles et al. (2016) cited the effectiveness of a 90-100mg:35-50mg and 50-100mg:75-100mg ratio in improving mental alertness and recognition memory. A 2.5mg/kg:2.0 mg/kg ratio also improved sustained attention and overall cognition acutely.

3.2. Toxicological effects of L-theanine and caffeine combination on the human brain and cognition

3.2.1 Mood

A study by Giles et al. (2016) tested the induction of negative emotions (e.g. anger, tension, etc.) in a psychologically aroused state wherein data showed participants had higher anger, confusion, vigor, tension, depression, and total mood disturbance rates 60-120 minutes following the administration of caffeine and L-theanine together and separately. Caffeine drives these mood effects; and although L-theanine may regulate these elevated emotions, it controls behavior less, obtains less relevant responses, and only reduces arousal in a stressful situation. On the contrary, according to Dekker et al. (2017), the combination was stated to have no definite impact on mood.

3.2.2 Cognition

Various data from studies and experiments on the effects of caffeine and L-theanine combination and its impact on cognition have been accumulated over the last few decades. Despite most studies claiming positive results of substances counteracting the effects of the other, there are some research specifying how cognitive benefits of the substances are independent of each other. According to Kelly et al. (2008, as cited in Giles et al., 2016), caffeine is mainly responsible for any beneficial determinants regarding attention, while L-theanine alone did not have any notable effects. Caffeine may also enhance cognitive performance, though in the long run may have consequences like impaired cognition (Giles et al., 2016). L-theanine was also found to inhibit caffeine and its activation effect on sleep problems (Saeed et al., 2017). Future studies have yet to assess the aforementioned, for most current studies state more favorable and significant effects for the substances combined.

3.3. Promotional avenues and commercialization aspects of the administration of L-theanine and caffeine combination

3.3.1 Vehicle of Administration

Tea, the main natural source of caffeine and L-theanine, is by far the most mentioned beverage across the reviewed studies. Since these components are known to have separate positive effects on human cognition and brain function, a variety of effective vehicles for their combination have been examined. A study by D'Cunha et al. (2020) suggests the ideal medium wherein effects may be optimally achieved is in pure encapsulated form, which induces better effects compared integration into food matrices. Dekker et al. (2017) mention its commercial

availability as a dietary supplement which "supports weight management, improves resting energy and mood states such as alertness, fatigue, and focus". This study also acknowledges the current advertisement of these supplements as a "cognition and mood-enhancing substance". However, there is a lack of a standardized dosage specialized according to certain soft biometric traits like body weight which may maximize effects on human cognition (D'Cunha et al., 2020). When the caffeine dose is higher than 75 mg per serving, the ability of L-theanine to decrease blood pressure becomes harder to accomplish (Dekker, et al., 2017). In relation to this, Giles et al. (2016) found that a 35-50mg to 90-100mg ratio of caffeine and L-theanine in tea exert similar benefits as having opposite concentrations which proves promising as a standardized dosage.

Several studies consistently show sensitivity of the combination to flavorings and other additional components for nutritional value which is perceived to improve sales. For instance, bitter matcha powder requires additional flavoring when used in products, limiting its functionality due to interference (Dekker et al., 2017). In fact, Antonio, et al. (2019) found that its anhydrous form is more capable of delivering enhanced endurance as opposed to its combination with other ingredients.

Baking is also accountable for a 19% decrease in total catechin content including epigallocatechin-3-gallate or EGCG which is the most abundant in tea, and epigallocatechin or EGC, both of which suppress cognitive dysfunction and improve memory functions and adaptive behavior, increase brain waves, and reduce stress. In combination, caffeine and EGCG suppress anti-stress effects of L-theanine while EGC and arginine retain these effects (Nakagawa et al., 2009). Therefore, more catechins improves stress reduction since it retains this effect of L-theanine by antagonizing caffeine's.

Furushima et al. (2018) confirm that "differences in the quantities and ratios of green tea components affect the efficiency of its stress-reducing action" and suggest that more catechin improves stress reduction. It was also found that a caffeine and epigallocatechin gallate to theanine and arginine (CE/TA) molar ratio of two or less is crucial in overcoming the disadvantage of adding other ingredients and cooking (Furushima et al., 2019), therefore keeping the combination functional when used in food or beverages. Further research is needed to establish effects relative to the vehicle in which it is administered. Domain-specific concentration ratios of caffeine and L-theanine may also be established by adjusting within the standard range.

3.3.2 Domain-specific Uses

Three studies examined the potential of the combination in the clinical setting as a therapeutic agent for ADHD patients and an antidepressant. Blume, et al. (2019) report that the combination may serve as a pharmacological and dose-sparing agent or adjuvant to manage ADHD-associated cognitive deficits, complementing other current medications while Ayaz, et al. (2020) states its potential as a neuroprotective agent, playing a role in saving ischemic neurons in the brain from irreversible injury. A variant called Shaded White Tea Leaf (SWLT) was also found to have antidepressant effects due to its higher levels of caffeine and L-theanine (Furushima et al., 2020).

Zaragoza et al. (2019) focused on the commercialization of the combination in sports, suggesting that "supplementation with caffeine, theanine, and tyrosine could potentially hold ergogenic value for athletes in sports requiring rapid accurate movements," and elaborating that athletes desiring maximized cognitive performance without altered mental state during training and competition could benefit from lower doses of caffeine within the combination.

4. CONCLUSIONS

The majority of existing studies conclude that the combination of caffeine and L-theanine gives rise to a number of benefits such as improvements in memory, alertness, switch tasks, speed, accuracy, and attention. These findings imply that the pair create a synergistic effect, giving off more nutritional advantages than when administered alone.

While some disadvantageous outcomes were recorded for the individual intake of these substances, their combination has favorable effects on mood and cognition, with only limited sources claiming negative effects when administered together. Although no toxicological effects have been precisely detected, additional research is still essential to better understand both short and long-term effects of the combination.

Consequently, more evidence is still necessary before its widespread application to clinical practice. Studies elaborating on the chemistry behind various concentration ratios and corresponding effects are necessary to support its potential as a pharmacological agent and allow development for further domain-specific specializations. Ultimately, this review may allow for future research to gear towards a build-up on knowledge and innovations on the topic.

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6. REFERENCES

Adhikary, R., & Mandal, V. (2017). l-theanine: A potential multifaceted natural bioactive amide as health supplement. Asian Pacific Journal of Tropical Biomedicine, 7(9), 842–848. https://doi.org/10.1016/j.apjtb.2017.08.005

Anstice, N., D'Cunha, N. M., Everett, J. M., Georgousopoulou, E. N., Keegan, R. J., McKune, A. J., Mellor, D. D., Naumovski, N., Sergi, D., & Williams, J. L. (2019). The effects of green tea amino acid l-theanine consumption on the ability to manage stress and anxiety levels: a systematic review. Plant Foods for Human Nutrition, 75, 12–23. https://doi.org/10.1007/s11130-019-00771-5

Anstice, N., D'Cunha, N. M., McKune, A., Naumovski, N., & Williams, J. (2020). Effect of green tea amino acid l-theanine on physiological responses: a protocol for clinical trial. Exploratory Research and Hypothesis in Medicine. https://doi.org/10.14218/ERHM.2020.00048

Antonio J., & Ellerbroek A. C. (2019). Effects of pre-workout supplements on strength, endurance, and mood. Internet Journal of Allied Health Sciences and Practice, 17(1). https://nsuworks.nova.edu/ijahsp/vol17/iss1/7/

Ashfique, R., Artyom, Z., Özdem Ceyona, Sohel, R. M., & Al-Amin, M. (2017). The effect of black tea on human cognitive performance in a cognitive test battery. Clinical Phytoscience, 3(1). http://doi.org.dlsu.idm.oclc.org/10.1186/s40816-017-0049-4

Ayaz, H., Sargent, A., Suri, R., Topoglu, Y., Watsons, J., & Ye, H. (2020). Impact of tea and coffee consumption on cognitive performance: an fNIRS and EDA study. Applied Sciences, 10(7), 2390. https://doi.org/10.3390/app10072390

Barulli, M. R., Bonfiglio, C., Guerra, V., Logroscino G., Osalle, A., Panza F., Pilotto, A., Sabbà, C., Seripa, D., & Solfrizzi, V. (2014). Coffee, tea, and caffeine consumption and prevention of late-life cognitive decline and dementia: A systematic review. The Journal of Nutrition, Health & Aging, 19, 313–328. https://doi.org/10.1007/s12603-014-0563-8

Binks, M., Chin, S., Dassanayake, T. L., Davis, T., Dhanasekara, C. S., Kahathuduwa, C. N., & Weerasinghe, V.S. (2018). L-theanine and caffeine improve target-specific attention to visual stimuli by decreasing mind wandering: a human functional magnetic resonance imaging study. Nutrition Research, 49, 67-78. https://doi.org/10.1016/j.nutres.2017.11.002

Blume, J., Dassanayake, T. L., Kahathuduwa C. N., Mastergeorge, A., Wakefield, S., Weerasinghe, V. S., & West, B. D. (2020). Effects of l-theanine–caffeine combination on sustained attention and inhibitory control among children with ADHD: a proof-of-concept neuroimaging RCT. Scientific Reports, 10. https://doi.org/10.1038/s41598-020-70037-7

Blume, J., Kahathuduwa, C., Mastergeorge, A., Wakefield, S., & West, B. (2019). L-theanine and caffeine improve sustained attention, impulsivity and cognition in children with attention deficit hyperactivity disorders by decreasing mind wandering. Current Developments in Nutrition, 3(1). https://doi.org/10.1093/cdn/nzz031.OR29-04-19

Bobe, J., Golden, E., Johnson, M., Jones, M., Viglizzo, R., & Zimmerman, N. (2020). Measuring the effects of caffeine and l-theanine on cognitive performance: a protocol for self-directed, mobile N-of-1 studies. Frontiers in Computer Science, 2. https://doi.org/10.3389/fcomp.2020.00004

Boros, K., Csupor, D., & Jedlinszki, N. (2016). Theanine and caffeine content of infusions prepared from commercial tea samples. Pharmacognosy Magazine, 12(45), 75-79. https://doi.org/10.4103/0973-1296.176061

Bowerbank, S. L., Dodd, F. L., Forster, J. S., Haskell-Ramsay, C. F., Jackson, P. A.. & Kennedy, D. O. (2018). The acute effects of caffeinated black coffee on cognition and mood in healthy young and older adults. Nutrients, 10(10), 1386. https://doi.org/10.3390/nu10101386

Boyle, N.B., Dye, L., & Lawton, C. L. (2018). The effects of carbohydrates, in isolation and combined with caffeine, on cognitive performance and mood—current evidence and future directions. Nutrients, 10(2), 192. https://doi.org/10.3390/nu10020192

Camfield, D. A., Pase M., Pipingas, A., Scholey, A., Stough, C. (2015). Herbal extracts and nutraceuticals for cognitive performance. In Best, T., & Dye, L. (Eds.), Nutrition for Brain Health and Cognitive Performance (pp. 221-244). Taylor & Francis Group.

Camfield, D. A., Stough, C., Farrimond, J., & Scholey, A. B. (2014). Acute effects of tea constituents l-theanine, caffeine, and epigallocatechin gallate on cognitive function and mood: a systematic review and meta-analysis. Nutrition Reviews, 72(8), 507–522. https://doi.org/10.1111/nure.12120

Chang, C., Jan, M., Wang, S., & Wang, W. (2017). Effect of black tea consumption on radial blood pulse spectrum and cognitive health. Complementary Therapies in Medicine, 31. https://doi.org/10.1016/j.ctim.2017.01.001

Che Din, N., Haron, H., Rosli, H., & Shahar, S. (2014). Dietary polyphenols consumption and its relation with cognitive and mental health in aging: a review. Malaysian Journal of Health Sciences, 12(2). http://doi.org/10.17576/JSKM-2014-1202-01

D'Cunha, N. M., Georgousopoulou, E. N., Kellet, J., McKune A. J., Mellor, D., Naumovski, N., Sergi, D., & Williams, J. (2020). The effect of l-theanine incorporated in a functional food product (mango sorbet) on physiological responses in healthy males: a pilot randomised controlled trial. Foods, 9(3), 371. https://doi.org/10.3390/foods9030371

Dekker, M., & Dietz, C. (2017). Effect of green tea phytochemicals on mood and cognition. Curr Pharm Des, 23(19), 2876-2905. https://doi.org/10.2174/1381612823666170105151800

Dekker, M., Dietz, C., & Piqueras-Fiszman, B. (2017). An intervention study on the effect of matcha tea, in drink and snack bar formats, on mood and cognitive performance. Food Research International, 99(1), 72-83. https://doi.org/10.1016/j.foodres.2017.05.002

De Klerk, S., Gondalie, S., Noonan, C., Scholey, A. B., White, D. J., Woods, W. (2016). Anti-stress, behavioural and magnetoencephalography effects of an l-theanine-based nutrient drink: a randomised, double-blind, placebo-controlled, crossover trial. Nutrients, 8(1). https://doi.org/10.3390/nu8010053

Dodd, F. L., Kennedy, D. O., Riby, L. M., & Haskell-Ramsay, C. F. (2015). A double-blind, placebo-controlled study evaluating the effects of caffeine and l-theanine both alone and in combination on cerebral blood flow, cognition and mood. Psychopharmacology, 232(14), 2563–2576. https://doi.org/10.1007/s00213-015-3895-0

Dodd, F. L., Kennedy, D. O., Riby, L. M., Wilde, A., & Haskell, C. F. (2011). An evaluation of the cerebral blood flow, cognitive and mood effects of caffeine and l-theanine both alone and in combination. Appetite, 57(2), 557. https://doi.org/10.1016/j.appet.2011.05.068

Dramard, V., Kern, L., Hofmans, J., Rème, C. A., Nicolas, C. S., Chala, V., & Navarro, C. (2018, October 9). Effect of l-theanine tablets in reducing stress-related emotional signs in cats: an open-label field study. Irish veterinary journal. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6178259/.

Duong, J., Gibson, A. (2014). L-theanine and caffeine's effect on cognitive performance in terms of short term memory. Broncho Scholar. http://hdl.handle.net/10211.3/118441

Einöther, S. J. L., Martens, V. E. G., Rycroft, J. A., & De Bruin, E. A. (2010). L-theanine and caffeine improve task switching but not intersensory attention or subjective alertness. Appetite, 54(2), 406–409. https://doi.org/10.1016/j.appet.2010.01.003

Ezaki, Y., Fukushima, Y., Hisatsune, T., Inamura, N., Masuoka, N., Sakurai, K., & Shen, C. (2020). Effects of matcha green tea powder on cognitive functions of community-dwelling elderly individuals. Nutrients, 12(12), 3639. https://doi.org/10.3390/nu12123639

Forster, J., Haskell-Ramsay, C. F., Jackson, P. A., Kennedy, D. O., Khan, J., & Whitman, E. L. (2017). Cognitive and mood effects of a nutrient enriched breakfast bar in healthy adults: a randomised, double-blind, placebo-controlled, parallel groups study. Nutrients, 9(12). https://doi.org/10.3390/nu9121332

Foxe, J. J., Morie, K. P., Laud, P. J., Rowson, M. J., de Bruin, E. A., & Kelly, S. P. (2012). Assessing the effects of caffeine and theanine on the maintenance of vigilance during a sustained attention task. Neuropharmacology, 62(7), 2320–2327. doi:10.1016/j.neuropharm.2012.01.020

Fukura, K., Sakamoto, K., Suzuki, M., Takeda, A., Tamano, H., & Yokogoshi, H. (2014). Advantageous effect of theanine intake on cognition. Nutritional Neuroscience, 17(6), 279-283. https://doi.org/10.1179/1476830513Y.0000000094

Furushima, D., Hamamoto, S., Horoe, H., Iguchi, K., Morita, A., Nakamura, Y., Unno, K., & Yamada, H. (2018). Stress-reducing function of matcha green tea in animal experiments and clinical trials. Nutrients, 10(10), 1468. https://doi.org/10.3390/nu10101468

Furushima, D., Hamamoto, S., Horoe, H., Iguchi, K., Morita, A., Nakamura, Y., Unno, K., & Yamada, H. (2019). Stress-reducing effect of cookies containing matcha green tea: essential ratio among theanine, arginine, caffeine and epigallocatechin gallate. Heliyon, 5(5). https://doi.org/10.1016/j.heliyon.2019.e01653

Furushima, D., Iguchi, K., Nakamura, Y., Nomura, Y., Ozeki, M., Suzuki, T., Taguchi, K., Unno, K., & Yamada, H. (2020). Antidepressant Effect of Shaded White Leaf Tea Containing High Levels of Caffeine and Amino Acids. Molecules, 25(15), 3550. https://doi.org/10.3390/molecules25153550

Gilbert, N. (2019). Drink tea and be merry. Nature, 566(7742). http://doi.org.dlsu.idm.oclc.org/10.1038/d41586-019-00398-1

Giles, G. E., Mahoney, C. R., Brunyé, T. T., Taylor, H. A., & Kanarek, R. B. (2016). Caffeine and theanine exert opposite effects on attention under emotional arousal. Canadian Journal of Physiology and Pharmacology, 95(1), 93–100. https://doi.org/10.1139/cjpp-2016-0498

Haskell, C. F., Kennedy, D. O., Milne, A. L., Wesnes, K. A., & Scholey, A. B. (2008). The effects of l-theanine, caffeine and their combination on cognition and mood. Biological Psychology, 77(2), 113–122. https://doi.org/10.1016/j.biopsycho.2007.09.008

Health benefits and chemical composition of matcha green tea: A review. (2021). Molecules, 26(1), 85. http://doi.org.dlsu.idm.oclc.org/10.3390/molecules26010085

Hidese, Ogawa, Ota, Ishida, Yasukawa, Ozeki, & Kunugi. (2019). Effects of l-theanine administration on stress-related symptoms and cognitive functions in healthy adults: a randomized controlled trial. Nutrients, 11(10), 2362. https://doi.org/10.3390/nu11102362

Kahathuduwa, C.N., Dassanayake, T. L., Amarakoon, A. M. T., & Weerasinghe V. S. (2016). Acute effects of theanine, caffeine and theanine–caffeine combination on attention. Nutritional Neuroscience. 20(6), 369-377. https://doi.org/10.1080/1028415X.2016.1144845

Kahathuduwa, C. N., Wakefield, S., West, B. D., Blume, J., Dassanayake, T. L., Weerasinghe, V. S., & Mastergeorge, A. (2020). Effects of l-theanine–caffeine combination on sustained attention and inhibitory control among children with ADHD: a proof-of-concept neuroimaging RCT. Scientific Reports, 10(1). https://doi.org/10.1038/s41598-020-70037-7

Kellet, J., Mellor, D., McKune, A., Naumovski, N., Roach, P.D., Thomas, J., & Williams, J. (2016). L-theanine as a functional food additive: its role in disease prevention and health promotion. Beverages, 2(2), 13. https://doi.org/10.3390/nu10101468

Mancini, E., Beglinger, C., Drewe, J., Zanchi, D., Lang, U., Borgwardt, S. (2017). Green tea effects on cognition, mood and human brain function: A systematic review. Phytomedicine, 34, 26-37. https://doi.org/10.1016/j.phymed.2017.07.008

Masley, S. (2018). Lifestyle approaches to prevent and manage cognitive impairment. Primary Care Reports, 24(2) https://search-proquest-com.dlsu.idm.oclc.org/trade-journals/lifestyle-approaches-prevent-manage-cognitive/docview/1993919448/se-2?accountid=190474

Nakagawa, K., Nakayama, K., Nakamura, M., Sookwong, P., Tsuduki, T., Niino, H., … Miyazawa, T. (2009). Effects of Co-Administration of Tea Epigallocatechin-3-gallate (EGCG) and Caffeine on Absorption and Metabolism of EGCG in Humans. Bioscience, Biotechnology, and Biochemistry, 73(9), 2014–2017. https://doi.org/10.1271/bbb.90195

Rogers, P. J., Smith, J. E., Heatherley, S. V., & Pleydell-Pearce, C. W. (2007). Time for tea: mood, blood pressure and cognitive performance effects of caffeine and theanine administered alone and together. Psychopharmacology, 195(4), 569–577. https://doi.org/10.1007/s00213-007-0938-1

Ribeiro, J. A., & Sebastião, A. M. (2010). Caffeine and Adenosine. Journal of Alzheimer's Disease, 20(s1). https://doi.org/10.3233/jad-2010-1379

Saeed, M., Naveed, M., Arif, M., Kakar, M. U., Manzoor, R., Abd El-Hack, M. E., … Sun, C. (2017). Green tea (camellia sinensis) and l-theanine: medicinal values and beneficial applications in humans—a comprehensive review. Biomedicine & Pharmacotherapy, 95, 1260–1275. https://doi.org/10.1016/j.biopha.2017.09.024

Schuster, J., Mitchell, E. (2019). More than just caffeine: psychopharmacology of methylxanthine interactions with plant-derived phytochemicals. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 89, 263-274. https://doi.org/10.1016/j.pnpbp.2018.09.005

Sharma, E., Joshi, R., Gulati, A. (2018). L-theanine: an astounding sui generis integrant in tea. Food Chemistry, 242, 601-610. https://doi.org/10.1016/j.foodchem.2017.09.046

Shu-Qing, C., Ze-Shi Wang, Yi-Xiao, M., Zhang, W., Jian-Liang, L., Yue-Rong, L., & Xin-Qiang, Z. (2018). Neuroprotective effects and mechanisms of tea bioactive components in neurodegenerative diseases. Molecules, 23(3), 512. http://doi.org.dlsu.idm.oclc.org/10.3390/molecules23030512

Simone, C., Daria, P., Gabriele, S., & Mariarosaria, A. (2014, December 31). Caffeine: Cognitive and Physical Performance Enhancer or Psychoactive Drug? https://www.eurekaselect.com. https://dx.doi.org/10.2174%2F1570159X13666141210215655.

Turnbull, D., Rodricks, J. V., Mariano, G. F., & Chowdhury, F. (2017). Caffeine and cardiovascular health. Regulatory Toxicology and Pharmacology, 89, 165–185. https://doi.org/10.1016/j.yrtph.2017.07.025

Unno, K., Hara, A., Nakagawa, A., Iguchi, K., Ohshio, M., Morita, A., Nakamura, Y. (2016). Anti-stress effects of drinking green tea with lowered caffeine and enriched theanine, epigallocatechin and arginine on psychosocial stress induced adrenal hypertrophy in mice. Phytomedicine, 23(12), 1635-1374. https://doi.org/10.1016/j.phymed.2016.07.006

Unno, K. Yamada, H., Iguchi, K., Ishida, H., Iwao, Y., Morita, A., Nakamura, Y. (2017). Anti-stress effect of green tea with lowered caffeine on humans: a pilot study. Biological and Pharmaceutical Bulletin, 40(6), 902-909. https://doi.org/10.1248/bpb.b17-00141

Waer, F., Laatar, R., Jouira, G., Srihi, S. Rebai, H., Sahli, S. (2021). Functional and cognitive responses to caffeine intake in middle-aged women are dose depending. Behavioural Brain Research, 397. https://doi.org/10.1016/j.bbr.2020.112956

Williams, J., Kellett, J., Roach, P., McKune, A., Mellor, D., Thomas, J., & Naumovski, N. (2016). L-theanine as a functional food additive: its role in disease prevention and health promotion. Beverages, 2(2). https://doi.org/10.3390/beverages2020013

Yamada, T., Terashima, T., Okubo, T., Juneja, L. R., & Yokogoshi, H. (2005). Effects of theanine, r-glutamylethylamide, on neurotransmitter release and its relationship with glutamic acid neurotransmission. Nutritional Neuroscience, 8(4), 219–226. https://doi.org/10.1080/10284150500170799

Zaragoza, J., Tinsley, G., Urbina, S., Villa, K., Santos, E., Juaneza, A., Tinnin, M., Davidson, C., Mitmesser, S., Zhang, Z., & Taylor, L. (2019). Effects of acute caffeine, theanine and tyrosine supplementation on mental and physical performance in athletes. Journal of the International Society of Sports Nutrition, 16(1). https://doi.org/10.1186/s12970-019-0326-3

Wound Healing Activity of Herbal Ointment Containing the Ethanolic Leaf Extract of Gumamela (Hibiscus rosa-sinensis)

Marjorie Lama Gutierrez, Sharmine Mae Cabanggangan Algones,
Isabella May Viado Andres and Jason Romeral Tabun-tabon
Taytay Senior High School, Taytay, Rizal

Abstract: The wound healing process is a multi-step cellular and biochemical process. For wound healing, antibiotics; preservatives; desalination agents; chemicals; and others are used. Some of these synthetic drugs are limited due to side effects. For this reason, the use of medicinal plants for wound healing has increased in popularity over the years due to the reduction of side effects. In fact, previous studies proved that Hibiscus rosa-sinensis (gumamela) extract can be used to treat wounds. Thus, the purpose of this study intends to evaluate the wound healing potentials of the formulated herbal ointment containing the gumamela ethanolic leaf extracts. The gumamela leaf ethanolic extract was mixed into the ointment foundation. The herbal ointment was then formulated. For the wound healing study, untreated and gumamela ointment treated wounds of albino mouse were observed to have a comparison after the experimentation. The physicochemical parameters of gumamela ointment including color, odor, washability, solubility, consistency, and pH level were all evaluated, and the results were satisfactory. Throughout the experimental period, there was a larger wound closure percentage in the wound treated with gumamela ointment as compared to the untreated. Hence, this finding clearly indicates that the ointment containing the gumamela leaf extract can enhance the healing of a wound as indicated by improved rates of wound closure.

Key Words: hibiscus rosa-sinensis; gumamela ointment; wound healing activity; wound splint model; ethanolic leaf extract

1. INTRODUCTION

According to Farahpour et al. (2019), the wound healing process is known as a cellular and biochemical interdependent step aimed at wound healing. Many individual herbal & multi-herbal compositions have been reported to accelerate wound healing in wound models. In fact, it has been scientifically proven that gumamela is used for wound healing (Shen et al., 2017). It is an ornamental plant that grows in China as an evergreen herb. It's only form, consisting of five red petals, is an ornamental mallow shrub from East Asia (Kitayima et al., 2010).

1.1. Theoretical Framework

As contested by Boateng et al. (2008), for wound healing; antibiotics, preservatives, desalination agents, chemicals and others are used. Some of these synthetic drugs are limited due to side effects. For this reason, the use of medicinal plants for wound healing has increased in popularity over the years due to the reduction of side effects and wound care (Farahpour et al., 2019). According to the findings of Al-Snafi et al. (2018), gumamela extract may be used to treat wounds. Kumar et al. (2012) claimed that this plant has various pharmacological activities that

can be used in various medical applications. For this reason, this study intends to validate the potential of the newly developed wound healing ointment containing the gumamela leaf extract.

1.2. Research Questions

What are the physicochemical parameters necessary in the evaluation of gumamela herbal ointment?

Does the gumamela herbal ointment show potential in healing wounds?

1.3. Scope and Delimitation

This study will focus on evaluating the wound healing potential of the formulated herbal ointment containing gumamela ethanolic leaf extracts. The objective of this study is limited since the other possible medicinal properties including the antibacterial activity of the ointment will not be studied. This study is also limited due to the use of a small sample size (1 albino mouse). Moreover, there was no positive control used in the treated and controlled experiment.

2. METHODOLOGY

Experimental research design is motivated by hypotheses, and statistical analysis is used to confirm or disprove a theory (Nunmaker et al., 2001). It is the most precise type of experimental design and can be performed on at least two randomly assigned dependent subjects with or without a pretest. The researchers used posttest only control design. The posttest-only control design is a study in which at least two groups are used, one of which does not receive a treatment or intervention, and data on the outcome measure is obtained after the treatment or intervention. The researchers used 1 albino male mouse. The untreated and gumamela ointment treated wounds of the mouse were observed to have a comparison after the experimentation.

2.1. Sampling Procedure

The researchers obtained a 27g 1 male albino mouse (Mus musculus) from the pet shop located at Dolores, Taytay, Rizal. albino rats were used for this study because it represents a cost-effective animal model that is easy to genetically modify for mechanistic research.

2.2. Ethical Consideration

To ensure the safety of the subject (albino mouse) the researchers seek technical assistance from a professional veterinary doctor to do the excision wounds on albino mouse. The researchers also assure that in line with this activity, precautionary actions were considered such as taking care of the subject with the intention that no subject will be exterminated. Moreover, proper handling protocols were observed for the safety of the researchers from getting bitten by the subject.

2.3. Proposed Product

Figure 1
Formulated gumamela ointment

2.4. Procedures

2.4.1. Preparation of gumamela Leaf Ethanolic Extract

Gumamela leaves were collected and thoroughly washed with distilled water to clean the adhering dust particles. After collecting and washing, the leaves were dried under the shade until they dried. The dried leaves were ground into powder with the aid of an electric blender. Thereafter, the 100g powder was imbibed with 350ml of 90% ethanol for 3 hours and moved to an airtight container of 150ml 90% ethanol for 7 days of maceration with occasional stirring. Finally, the Ethanolic extract of gumamela leaves was collected and condensed to produce a blackish green residue, which was then filtered using the simple filtration process. The extract was kept in an airtight container in a cold, dark place.

2.4.2. The procedure for making herbal ointment is as follows:

A. To make the ointment base, weigh precisely grated hard paraffin wax (25g) and place it in an evaporating dish over a water bath. The other ingredients (50g of petroleum jelly and 20ml of coconut oil) was added after the hard paraffin had melted, and gently stirred to aid melting and homogeneous mixing until the ointment base had cooled.
B. To make gumamela ointment, weigh the gumamela ethanolic leaf extract (5ml) and blend it into the ointment base to make a smooth paste. Gradually add more base until the ointment is homogeneous.

2.4.3. The following physicochemical parameters were used for the evaluation of the ointment:

Color & odor
Visual inspection was used to check the color and odor of the prepared ointment.
pH
The pH of ointment was determined using pH paper.
Solubility
The ointment was observed if it is soluble in water and alcohol.
Washability
After applying the ointment formulation to the skin, the degree to which it could be washed away with water was determined.
Consistency
Smooth and no greediness were observed.

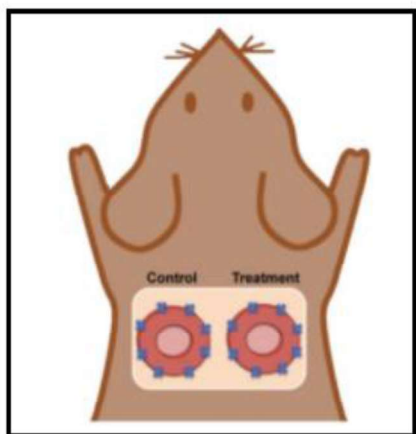#### 2.4.4. Excisional wound splinting procedure:

Wound healing activities were evaluated using the mouse excisional wound splinting model. The albino mouse was anesthetized prior to creation of the wounds. Subcutaneous injection of 50 mg/ml intravenous Tiletamine-Zolazepam was used. The dorsal fur of the animal was shaved using a razor

blade. Two excision wounds were made using a biopsy punch to cut away a 6mm diameter length full thickness of skin from the dorsal area. Two silicon discs were adhered to the skin around the wound and sutured in place, preventing local skin contraction. After suturing, the wounds were covered with bandages. The animal was placed in a clean plastic cage. The wounds of the mouse were treated topically and categorized as untreated wound and wound with gumamela ointment. The wound area was measured on the first, 6th, 8th, 10th, & 12th day post-surgery.

2.5. Experimental model

Figure 2
Excisional wound splinting model

The researchers used the excisional wound splinting wound healing model in albino mouse (Mus musculus). Two full-thickness wounds are produced on either side of the mouse's dorsal region in this model. Silicone splints are adhered and sutured to the wound's perimeter, creating a human-like model (Dunn et al., 2013). According to Wang et al., (2013), Mouse' wounds heal differently to humans, primarily due to the process of contraction. This is in part, due to an extensive subcutaneous striated muscle layer called the 'panniculus carnosus' that is largely absent in humans. In mice, this muscle layer allows the skin to move independently of the deeper muscles and is responsible for the rapid contraction of skin following wounding. To overcome this limitation, the researchers used the excisional wound splinting wound healing model in albino mouse. The use of silicone splints is to allow the re-epithelialization and new tissue formation, a key feature of this model, which is analogous to what happens in humans.

2.6. Data Analysis Procedure

For the wound healing study, the albino mouse was wounded as part of the experimentation. Two wounds were characterized as treated (wound with gumamela ointment) and negative controlled

(wound with no treatment). The untreated and treated wounds were observed to have a comparison after the experimentation.

2.7. Instruments

Between the first day and 12 post-surgery, the researchers used an observation sheet to record the untreated and treated wound areas of the albino mice. To determine the wound area: the diameter (mm) of each wound was measured and was then computed using the formula of πr^2. After that, the percentage of wound closure was computed as follows: (area of original wound – area of current wound) / area of original wound x $100\pi r^2 \pi r$

3. RESULTS AND DISCUSSION

3.3. What are the physicochemical parameters necessary in the evaluation of gumamela herbal ointment?

The following physicochemical parameters were used for the evaluations of the ointment:

Table 1
Physicochemical evaluation of the formulated gumamela ointment

Physicochemical parameters	Observations
1. color	Ocado green
2. odor	Characteristic
3. pH level	pH level of 5
4. consistency	Smooth
5. washability	Good
6. solubility	Soluble in water and alcohol

Physicochemical parameters including color, odor, washability, solubility, consistency, and pH level were all evaluated, and the results were satisfactory.
Color & odor
Visual inspection was used to check the color and odor of the prepared ointment.
pH level
The pH level of ointment was determined using pH paper. A little amount of ointment was wiped on the pH strip. The paper turned into a color yellow orange which indicates a pH level of 5.
Solubility
The ointment was observed if it is soluble in water and alcohol.
Washability
After applying the ointment formulation to the skin, the degree to which it could be washed away with water was determined.
Consistency
Smooth and no greediness were observed

3.2. Does the gumamela herbal ointment show potential in healing wounds?

In this finding, the researchers presented table and figures which show the observed albino mouse's wound area and wound closure percentage from day 0, day 6, day 8, day 10 and day 12. They are presented in order to have a comparison between the wound with gumamela ointment and the untreated.

Table 2
Wound area of the treated and untreated wound

	Wound Area (mm²)				
	DAY 0	DAY 6	DAY 8	DAY 10	DAY 12
Treated (gumamela Ointment)	28.27 mm²	23.76 mm²	12.57mm²	5.94mm²	0 mm²
Untreated	28.27 mm²	28.27 mm²	23.76 mm²	9.62mm²	4.91 mm²

Throughout the experimental period, there was a larger decrease in the area of the wound treated with gumamela ointment as compared to the untreated wound.

Figure 3
Representative percentage of wound closure graph
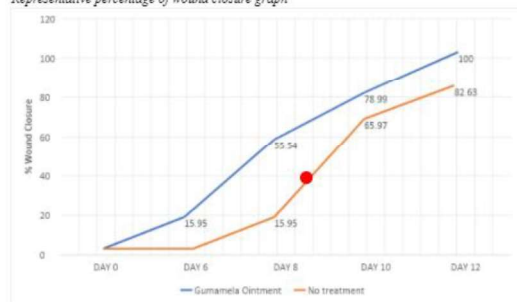
The researchers calculated (area of original wound – area of current wound) / area of original wound x 100 as the percentage of wound closure (Wang et al., 2013). There was a day-by-day increase in the wound closure percentage of the untreated and wound treated with gumamela ointment. However, the untreated wound closure percentage was less remarkable as compared to the wound closure percentage of gumamela ointment treated wound. The graph shows that by the 10th day of post-surgery, 78.99% of wound closure was observed on the wound with gumamela ointment while the untreated wound had only 65.97% of wound closure. Hence, the findings of this study clearly indicate that the ointment containing gumamela leaf extract can enhance the closure of a wound.

Figure 4
Wound healing activity on experimental mouse using wound splint model
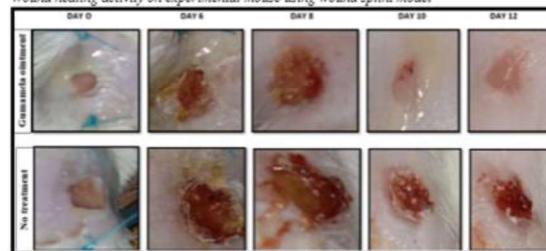
Throughout the experimental phase, the two wounds showed a day-by-day wound closure. However, the wounds treated with gumamela ointment were observed to show a more significant increase in wound healing activity as compared with untreated wounds. For the wound treated with gumamela ointment, a sharp decrease in the wound area was observed between the 6th & 12th after surgery, while a gradual reduction in the untreated wound area was recorded between days 6 & 12. The changes in the wound area as measured on days 0, 6, 8, 10, & 12 post surgery are shown in Table 2. Hence, this finding clearly indicates that the ointment containing the gumamela leaf extract can enhance the healing of a wound as indicated by improved rate wound closure.

Wound healing is a normal process in which dermal and epidermal tissues regenerate. When a wound occurs, a series of simultaneous events occur to repair the injury (Iba et al., 2004). There are three stages of these processes: inflammatory, proliferative, and remodeling (Stadelmann et al., 1998). In the inflammatory phase, bacteria and debris are phagocytosed and removed, while in the proliferative phase, cytokines and mediators are released, triggering cell migration and division. Angiogenesis, collagen deposition, granulation tissue development, epithelialization, and wound contraction are all part of the proliferative method (Midwood et al., 2004). During epithelialization, epithelial cells crawl across the wound bed to cover it (Garg, 2000).

4. CONCLUSIONS

The ethanolic leaf extract of gumamela was tested for wound healing operation. When the extract was mixed into the ointment foundation, the activity was preserved for topical use in the treatment of wounds. Its physicochemical parameters including color, odor, washability, solubility, consistency, and pH level were all evaluated, and the results were satisfactory.

Throughout the experimental period, there was a larger wound closure percentage in the wound treated with gumamela ointment as compared to the untreated one. Hence, this finding clearly indicates

that the ointment containing the gumamela leaf extract can enhance the healing of a wound as indicated by improved rates of wound closure.

4.1 Recommendations

The researchers would like to advise potential researchers who would use this study as a guide to use a larger sample size (more than two albino mice as an experimental model) because using a larger sample size in an experiment would make it less likely to draw an incorrect conclusion. They could also conduct a positive control on their experiment in order to obtain more reliable results.

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6. REFERENCES
Ali, M. & Ansari, S. H. (1997). Hair care and herbal drugs, Indian Journal of Natural products, Vol-13, 3-5.

Bahmani, M., Saki, K., Rafieian-Kopaei, M., Karamati, S. A., Eftekhari, Z., & Jelodari, M. (2014). The most common herbal medicines affecting Sarcomastigophora branches: a review study. Asian Pacific journal of tropical medicine, 7, S14-S21.

Bamidele, O., Kolawole, J. T., Ayoka, A. O., Babatunde, L. D., Onaseso, O. O., & Adedeji, G. T. (2017). Wound Healing Potentials of Aqueous Leaf Extract of Mangifera indica L. in Wistar Rats. Journal of Complementary and Alternative Medical Research, 1-11.

Chah, K. F., Eze, C. A., Emuelosi, C. E., & Esimone, C. O. (2006). Antibacterial and wound healing properties of methanolic extracts of some Nigerian medicinal plants. Journal of ethnopharmacology, 104(1-2), 164-167.

Chhetri, H. P., Yogol, N. S., Sherchan, J., Anupa, K. C., Mansoor, S., & Thapa, P. (2010). Formulation and evaluation of antimicrobial herbal ointment. Kathmandu University Journal of Science, Engineering and Technology, 6(1), 102-107.

Dunn, L., Prosser, H. C., Tan, J. T., Vanags, L. Z., Ng, M. K., & Bursill, C. A. (2013). Murine model of wound healing. JoVE (Journal of Visualized Experiments), (75), e50265.

Esimone, C. O., Nworu, C. S., & Jackson, C. L. (2008). Cutaneous wound healing activity of a herbal ointment containing the leaf extract of Jatropha curcas L.(Euphorbiaceae). Int J Appl Res Nat Prod, 1(4), 1-4.

Fayazzadeh, E., Rahimpour, S., Ahmadi, S. M., Farzampour, S., Anvari, M. S., Boroumand, M. A., & Ahmadi, S. H. (2014). Acceleration of skin wound healing with tragacanth (Astragalus) preparation: an experimental pilot study in rats. Acta Medica Iranica, 3-8.

Gangwar, M., Gautam, M. K., Ghildiyal, S., Nath, G., & Goel, R. K. (2015). Mallotus philippinensis Muell. Arg fruit glandular hairs extract promotes wound healing on different wound model in rats. BMC complementary and alternative medicine, 15(1), 1-9.

Kumar A, & Singh A. (2012). Review on Hibiscus rosa-sinensis. International Journal of Research in Pharmaceutical and Biomedical Sciences, 3(2): 534- 538.

Manzuoerh, R., Farahpour, M. R., Oryan, A., & Sonboli, A. (2019). Effectiveness of topical administration of Anethum graveolens essential oil on MRSA-infected wounds. Biomedicine & Pharmacotherapy, 109, 1650-1658.

Mudliar, V. S., Patil, P. A., Torgal, S. S., Malur, P. R., & Mittal, R. (2008). Influence of the fruit and leaf extract of Psidium guajava Linn. on wound healing in wistar rats. Journal of Cell and Tissue Research, 8(1), 1313.

Sawant, S. E., & Tajane, M. D. (2016). Formulation and evaluation of herbal ointment containing Neem and Turmeric extract. Journal of Scientific and Innovative Research, 5(4), 149-151.

Sekar, M., & Rashid, N. A. (2016). Formulation, evaluation and antibacterial properties of herbal ointment containing methanolic extract of Clinacanthus nutans leaves. International Journal of Pharmaceutical and Clinical Research, 8(8), 1170-1174.

Shivananda Nayak, B., Sivachandra Raju, S., Orette, F. A., & Chalapathi Rao, A. V. (2007). Effects of Hibiscus rosa sinensis L (Malvaceae) on wound healing activity: a preclinical study in a Sprague Dawley rat. The international journal of lower extremity wounds, 6(2), 76-81.

Verma, S., & Singh, S. P. (2008). Current and future status of herbal medicines. Veterinary world, 1(11), 347.

Wang, X., Ge, J., Tredget, E. E., & Wu, Y. (2013). The mouse excisional wound splinting model, including applications for stem cell transplantation. Nature protocols, 8(2), 302-309.

Eat, Train, Operate, Repeat: Ang Karanasan ng mga Orthopedic Ironman Triathletes sa kanilang Isport at Propesyon

Monica Isabel Jose and Martha Alyanna Lainey G. Tarrosa
Assumption College San Lorenzo, Makati City

Abstrak: Ang mga Orthopedic Ironman Triathlete ay bihira sa propesyon ng mga doktor. Kadalasan ay malay o mulat sila sa mga maaaring mangyari sa sandaling sumabak sila sa ganitong uri ng isports. Gayunpaman may iilang mga doktor ang naniniwalang may malaking pakinabang ito sa kanilang propesyon. Kaugnay nito nakatuon ang pag-aaral sa pagsusuri sa mga karanasan ng mga Orthopedic Ironman triathlete. Gumamit ang mga mananaliksik ng 15 gabay na tanong na ginamit upang makapanayam ang 13 orthopedic triathletes mula sa iba't ibang ospital sa Pilipinas tungkol sa kanilang mga motibasyon, hamon, at estratehiya. Batay sa isinagawang pagsusuri, natuklasan na ang mga motibasyon nila ay pagbuo ng relasyon sa ibang tao, pagkakaroon ng kredibilidad bilang orthopedic doktor, pagkakaroon ng positibong mental at pisikal na estado/kalusugan, kilalanin ang kakayahan ng sarili, at ang kanilang debosyon sa isport. Habang ang mga hamon na kanilang kinaharap ay ang work-life balance, mental na abala, pisikal na kadahilanan/salik, available resources, panlabas na kadahilanan/sanhi, responsibilidad bilang doktor, at pisikal na abilidad ng katawan pagdating sa pagganap sa isport. Panghuli, ang mga estratehiya na kanilang isinasagawa upang mabalanse ang pagiging doktor at isports ay ang distribusyon ng oras; pisikal, medikal, at kalusugang pangangailangan; pag-unawa at paggamit ng kaalamang pangmedikal at isport; paniniwala, at self-care. Batay sa mga lumabas na pagsusuri, natuklasan na ang mga Orthopedic Triathlete Doctor ay nakaranas ng mga hamon na may kaagapay na benepisyo sa kanilang propesyonal na buhay at kalusugan, bagama't mahirap itong pagsabayin nalagpasan nila ito dahil sa mga estratehiyang kanilang isinagawa.

Susing Salita: doctor-athlete; orthopedic; triathlete; triathlon

1. INTRODUKSIYON

Mahalagang magkaroon ng mabuting kalusugan ang mga doktor upang magampanan nang maayos ang kanilang mga responsibilidad sa kanilang propesyon. Isa sa mga dahilan kung bakit kailangan nila ng mabuting kalusugan ay upang maging handa sa kahit anumang gawain at responsibilidad sa trabaho maging araw man o gabi (Collier, 2012). Ayon sa "Characteristics of highly successful orthopedic surgeons: a survey of orthopedic chairs and editors", upang masabi na ang isang doktor ay matagumpay sa kanilang propesyon, kailangan nilang bigyang atensyon ang kanilang pisikal na kalusugan (Klein, Hussain, Sprague, Mehlman, Dogbey, & Bhandari, 2012). Ang mga doktor na kumakain ng maayos, inaalagaan ang kanilang kalusugan, nag-eehersisyo, at hindi gumagamit ng sigarilyo ay masasabing matagumpay sa kanilang propesyon. Ang pagsali rin sa iba't ibang isports sa libreng oras ng mga doktor ay isang paraan upang makatulong sa kanilang pisikal at mental na estado (Khan & Khan, 2016), at para sa ibang doktor ang kanilang sinasalihan na isport ay ang triathlon. Bagama't napag-uusapan ang tungkol sa mga orthopedic triathlete, wala masyadong mga

pag-aaral na tumutukoy sa hamon at estratehiya na kanilang nararanasan. Kung kaya't mahalaga ang pag-aaral na ito dahil ito ay magiging daan para sa mga orthopedic triathlete na maibahagi ang kanilang karanasan sa isport at propesyon. Matutuklasan din sa pag-aaral na ito ang iba't ibang estratehiya na ginagawa ng mga orthopedic triathlete upang harapin ang mga hamong dulot ng kanilang isport at propesyon.

Mga Layunin ng Pag-aaral

Nakatuon ang pananaliksik na ito sa pagsusuri sa karanasan ng mga Pilipinong Orthopedic Triathlete hinggil sa kanilang isport at propesyon.

Nais ng mga mananaliksik na masagot ang mga sumusunod na katanungan:

1. Ano ang motibasyon ng mga orthopedic triathletes sa kanilang isport at propesyon?
2. Ano ang mga hamon na kinakaharap ng mga orthopedic triathletes sa kanilang isport at propesyon?
3. Ano ang mga estratehiya na ginagawa ng mga orthopedic triathletes upang makaya

ang mga hamon ng kanilang isport at propesyon?

Saklaw at Limitasyon

Sakop ng pananaliksik na ito ang pag-aaral sa karanasan ng mga orthopedic triathlete sa Pilipinas. Nakatuon ang pananaliksik na ito sa karanasan ng mga orthopedic triathletes upang matuklasan ang motibasyon, hamon at estratehiya sa kanilang isport at propesyon. Nilimitahan ng mga mananaliksik ang pag-aaral na ito sa mga doktor-triathlete na nakatira sa Pilipinas at lumalahok sa triathlon.

2. METODOLOHIYA

Disenyo ng Pananaliksik

Ang pananaliksik na ito ay gumamit ng penomenolohikal na disenyo ng pag-aaral, sapagkat nakatuon ang papel na ito sa karanasan ng mga orthopedic triathletes. Tinangka nitong ilarawan ang perspektibo ng mga orthopedic triathletes hinggil sa mga hamon, motibasyon at estratehiya na kanilang nararanasan sa isport at propesyon.

Mga Kalahok at Sampling Teknik

Ang mga kalahok ay binubuo ng 13 na pinili mula sa mga orthopedic Ironman triathletes na nagmula sa mga piling ospital sa Pilipinas. Pinili ang mga kalahok gamit ang snowball/referral sampling teknik. Sa pagpili ng mga kalahok sila dapat ay mga orthopedic doktor na may tatlong taon o higit pa na karanasan sa trabaho. Pangalawa, bilang isang triathlete sila dapat ay nakatapos na ng isang Ironman Triathlon. Ito ay upang masukat ang kanilang karanasan sa isport.

Instrumento ng Pag-aaral

Ang instrumento ng pananaliksik na ginamit sa pangangalap ng mga datos ay ang Patnubay na Talatanungan. Naglalaman ito ng mga tanong na nagsilbing gabay sa isinagawang interbyu.

Paraan ng Pagkakalap ng mga Datos

Nagsimula sa pagbuo ng patnubay na talatanungan ang mga mananaliksik. Matapos itong maaprobahan at maipa-validate ay humanap ng 13 na mga potensyal na kalahok na siyang kinapanayam.

Pagsusuri ng mga Datos

Mula sa isinagawang pakikipanayam, sinuri ng mga mananaliksik ang mga sagot ng mga respondenteng Orthopedic Ironman Triathlete sa mga tanong tungkol sa mga hamon at motibasyon na kanilang hinaharap at ang mga estratehiya na ginagawa sa kanilang isport at propesyon batay sa mga nangingibabaw na tema.

3. RESULTA AT DISKUSYON

Batay sa unang tiyak na layunin ang motibasyon ng mga respondente sa kanilang isport at propesyon ay ang pagbuo ng relasyon sa ibang tao. Sila ay nagkakaroon ng mga kaibigan sa labas ng mundo bilang isang doktor dahil sa pagiging triathlete. Isa sa mga halimbawa ng verbatim nito ay "I just know some several friends and several colleagues who were into triathlon so that's the reason I wanted to do the triathlon."

Ang sumunod na motibasyon ay ang pagkakaroon ng dagdag na kredibilidad bilang orthopedic doktor. Ito ay sapagkat ang pagiging triathlete ay nagbibigay sa kanila ng pagkakataon upang magkaroon nang mas malalalim na koneksyon sa kanilang mga pasyente. Isa sa mga halimbawa ng verbatim nito ay "It's important for myself as an orthopedic sports medicine specialist to at least appear or be able to perform athletic endeavors so that I have more credibility with my patients who come to me as injured athletes."

Ang pagkakaroon naman ng positibong mental at pisikal na estado/kalusugan ay isa rin sa mga motibasyon ng mga kalahok. Bukod pa rito, ang higit na makilala ang kakayahan ng sarili ay isa rin sa kanilang motibasyon. Nagagawa nila ang mga bagay na tulad ng pagsali sa triathlon na akala nila ay hindi nila kayang gawin. Ang panghuli naman ay ang debosyon sa isport sapagkat ang ilan sa mga respondente ay mga atleta mula noong sila ay bata pa. Isa sa mga halimbawa ng verbatim nito ay "We have immediate connection, we can relate immediately, we can talk easily and can voice out their concerns. I would understand cause somehow along the way I probably have experience that type of pain for that kind of problem so we give tips to each other and somehow its very helpful for the patient."

Ang mga hamon naman na kinahaharap ng mga kalahok ay ang pagkakaroon ng work-life balance. Ang pagiging doktor at triathlete ay parehas na nangangailangan ng maraming oras upang makapag-ensayo at magawa ang responsibilidad sa trabaho. Isa sa mga halimbawa ng verbatim nito ay "Training as a whole takes a lot of time and and medical practice as well"

Dagdag pa rito, ang mga mental na abala (mental distractions) ay isa rin sa hamon na kanilang kinahaharap. Ito ay resulta ng mga mental na salik, kawalan ng motibasyon, at burnout na dulot ng kanilang isport at propesyon. Isa sa mga halimbawang verbatim nito ay "Challenges are: to wake up early the next day after surgery during the wee hours, to smell like chlorine during clinic hours, to sacrifice clinic days for the scheduled triathlon events."

Ang mga pisikal na kadahilanan/salik naman ay isa ring hamon na kinahaharap ng responente sapagkat ang kanilang mga pisikal na limitasyon, pisikal na katangian, at pisikal na pinsala ay nakaaapekto sa kanilang pagganap bilang orthopedic triathlete. Isa sa mga halimbawa ng verbatim nito ay "Ahh relatively I have pains, because of the previous operation and I'm muscular, big, I'm heavy so it adds up impact to my knees as I approach about the 15th or 16th kilometer in doing 70.3."

Nakikita rin ng mga kalahok bilang hamon ang kakulangan sa kagamitan at pera na nakaaapekto sa kanilang pag-eensayo at pagganap sa triathlon. Malaki rin ang salik ng available resources pagdating sa pagpapatuloy ng isport, sapagkat ang kanilang pagganap bilang isang triathlete ay nakadepende rito. Isa sa mga halimbawang verbatim nito ay "The only reason that kept me away from joining triathlon events is money- too expensive."

Nahaharap din sila sa panlabas na kadahilanan tulad ng edad kung saan nalilimitahan ang pagganap ng isang tao, at ang pagiging delikado ng pag-eensayo at pagsali sa triathlon. Isa sa mga halimbawang verbatim nito ay "triathlon is relatively dangerous sport right. There aren't where a lot of people die during the race right"

Isa rin sa hamon na kanilang kinahaharap ay ang pagtulong sa pasyente dahil hindi nila maaaring kalimutan ang kanilang mga responsibilidad bilang doktor. Isa sa mga halimbawang verbatim nito ay "personal experience, would be stopping for example during a race because you witnessed someone crash on his bike. Any orthopedic surgeon will be compelled to stop and help the triathlete out."

Panghuli, ang pisikal na abilidad ng katawan pagdating sa pagganap sa isport ay isa ring hamon sapagkat kulang sila sa karanasan sa isang isport na kasama sa triathlon, o sa antas ng kahirapan ng isport. Isa sa mga halimbawang verbatim nito ay "the race it's typically middle-aged men noh of which I'm part of that ahh that age group, that population is at risk right".

Para naman sa mga estratehiyang isinasagawa ng mga orthopedic triathlete upang malampasan ang mga hamon na kanilang kinahaharap ay ang pagkakaroon ng maayos na distribusyon ng oras para sa isport at propesyon. Isa sa mga halimbawang verbatim nito ay "Don't race against anyone, but rather find your own pace and reach your own goals, and remember to balance triathlon, work, and family."

Isa rin sa estratehiya na mayroon ang mga respondente ay ang pag-unawa at paggamit ng kaalamang pangmedikal at isport para sa mas mahusay na pagganap sa isport at propesyon. Isa sa mga halimbawang verbatim nito ay "Train smart by listening and adhering to my body and I make sure I do my annual cardiac check-ups."

Ang susunod na estratehiya naman ay ang pagkakaroon ng paniniwala sa Diyos at sa sarili. Ito ay nakatutulong upang magawa nila ang mga bagay na higit pa sa akala nilang kaya nilang gawin. Isa sa mga halimbawang verbatim nito ay "Triathletes can avoid injuries thru proper training/gears, diet, hydration, and 8 hours of sleep, listen to your body, and PRAY, always Pray to God".

Ang panghuling estratehiya naman ay ang pangangalaga sa sarili sa pamamagitan ng pagbibigay ng premyo sa kanilang mga sarili. Isa sa mga halimbawang verbatim nito ay "one simple mechanism that I apply to myself would be the reward system."

Diskusyon

Batay sa inilahad na resulta, isa sa motibasyon ng mga orthopedic triathlete ay ang pagbuo ng relasyon. Sumang-ayon dito ang pag-aaral nina Soklaridis et al. (2016), kung saan inilahad na importante na magkaroon ng relasyon/koneksyon ang mga doktor sa kanilang pasyente sapagkat batay sa relationship-centered care (RCC) framework may relasyon ang koneksyon ng mga pasyente at doktor sa kinalalabasan ng paggamot sa kanila. Samantala, ang tema naman na pagkakaroon ng kredibilidad bilang orthopedic doktor ay isang motibasyon din ng mga orthopedic triathlete. Sumang-ayon naman dito sina Gopichandran at Chetlapalli (2015), ayon sa kanilang pag-aaral, mas malaki ang pagkakataon na pagkatiwalaan ng mga pasyente ang kanilang doktor kapag nakikita nila na alam nila ang kanilang ginagawa. Isa ring tema na lumabas ay ang positibong mental at pisikal na estado/kalusugan. Marami sa mga doktor ay nakararanas ng burnout at stress na dulot ng kanilang propesyon (Feeney et al., 2016). Samantala ang pagsali sa mga isport na tulad ng triathlon ay isang epektibong coping mechanism upang makalimutan ang mga problemang kinahaharap sa trabaho. Sinang-ayunan ito ng pag-aaral nina Khan at Khan (2016) kung saan inilahad na isang halimbawa ng positibong coping mechanism ng mga doktor ay ang pagiging pisikal na aktibo. Ang tema rin na pagkakataon upang higit na kilalanin ang kakayahan ng sarili ay lumabas sapagkat ayon sa mga respondente hindi nila inaakala na magagawa nila ang pagsali sa mga paligsahang pan-triathlon. Ito ay sinang-ayunan ng isang doktor-triathlete na si Dr. Gossage na nagsabi na ang triathlon ay naging isang paraan upang mas makilala niya ang kaniyang sarili (O' Dowd, 2020). Ang panghuling tema naman ay ang debosyon sa isport. Masasabi na ito ay katulad ng karanasan ng isang doktor triathlete, na nagsabi na siya ay isang batang atleta, at ito ang nakaenganyo sa kaniya na maging triathlete noong siya ay tumanda na at naging doktor (Carter, 2016).

Ipinakita naman sa resulta na isa sa mga hamon na kinaharap ng mga orthopedic triathlete na kalahok ay ang kawalan ng work-life balance at hindi maganda ang nagiging epekto nito sa propesyonal na pagganap ng mga doktor. Apektado rito ang mga kababaihan, dahil ang mga babae ay likas na maaruga at ito ay isa sa pinakaimportanteng ugali ng isang doktor, ngunit dahil sa pagkawala ng work-life balance ito ay maaaring mawala sa kanila (Rich et al., 2016). Nagiging hamon din ang pisikal na kadahilanan kung saan ang kanilang pisikal na katangian at mga pinsala ay nakaaapekto sa kanilang pagganap sa ekstensibong pagsasanay at mga triathlon na kanilang sinasalihan. Kung ang isang atleta ay nagkaroon ng pinsala sa nakaraan at hindi malakas ang pangangatawan, posible silang makaranas ng mas malala na pinsala at sakit (Vleck et al., 2014). Ayon naman sa pag-aaral nina Prinz et al., (2013) ang triathlon ay naging isang mamahaling isport dahil sa lumalaking bilang ng mga taong sumasali rito. Sinasang-ayunan nito ang lumabas na tema hinggil dito. Ang iba't ibang panganib naman na maaaring maganap sa panahon ng triathlon at pag-eensayo ay kadalasang walang malinaw na ebidensya at hindi nasusukat sa antas ng karanasan (Ashkar & Romani, 2014) at ito rin ay isa sa mga nagiging hamon sa kanila. Nakikita rin bilang isang hamon ang hindi maaaring kalimutan ang responsibilidad bilang doktor. Ang mga doktor ay may responsibilidad na gampanan ang iba't ibang pangangailangan ng kanyang pasyente at ang paglabag sa alinman sa mga tungkulin na ito ay kapabayaan sa bahagi ng doktor (Pandit & Pandit, 2009). Ang huling tema na lumabas ay ang pisikal na abilidad ng katawan pagdating sa pagganap sa isport. Ayon sa ilang kalahok nahihirapan sila sa ibang mga isport na kasama sa triathlon at dahil rito hindi nila naibibigay ang kanilang buong kakayahan. Ayon sa pag-aaral na ginawa nina Stevenson, Song, at Cooper (2013) ang pagbaba ng antas ng pagganap ng isang triathlete ay maiuugnay sa kanilang edad sapagkat ang edad 30-35 ay kung kailangan na naaabot ng atleta ang tugatog ng kaniyang pagganap.

Ayon sa pag-aaral nina Macquet at Skalej (2015), ang mga atleta ay gumagamit ng iba't ibang klase ng estratehiya tulad ng time management. Ito ay sumang-ayon sa lumabas na tema sa estratehiya ng distribusyon sa oras. Ang pisikal, medikal at kalusugang pangangailangan ay isa rin sa mga estratehiya na ginagawa ng mga respondente kung saan kanilang pinakikinggan o pinakikiramdaman ang pangangailangan ng katawan (Etxebarria et al., 2019). Nakikita rin ng mga respondente bilang isang estratehiya ang pagkakaroon ng paniniwala sa sariling kakayahan at pagtitiwala sa Diyos. Sumasang-ayon ang mga resulta sa ilang pag-aaral, kung saan ang mga tao na may inspirasyon ay kadalasang may malakas na pananampalataya sa Diyos dahil ito ay nagbibigay ng isang koneksyon na higit pa sa kanilang sarili (Critcher & Lee, 2018). Panghuli, ayon sa isang pag-aaral nina Harwood et al., (2014), ang intrinsic motivation ay ang paggawa ng isang bagay sapagkat ito ay nakagaganyak sa sarili, isa ito sa motivational influences na estratehiya na ginagawa ng mga tagapagsanay at mga atleta na nagpapabuti sa kanilang mga gawain.

4. KONKLUSYON

Sa kabuoan ang karanasan ng mga Orthopedic Triathlete sa pagiging doktor at atleta ay hindi palaging maganda dahil sa iba't ibang hamon na kanilang nararanasan. Ngunit, mas nangingibabaw pa rin ang naging benepisyo nito para sa kanilang propesyonal na buhay at kalusugan sa tulong na rin ng mga estratehiyang kanilang isinagawa. Samakatuwid, nakatutulong ang kanilang propesyon bilang doktor sa kanilang pagiging triathlete at gayundin naman ang triathlon sa kanilang pagiging isang epektibong Orthopedic doktor.

5. PASASALAMAT

Taus-pusong pasasalamat ang aming ipinaabot sa mga sumusunod na indibidwal at tanggapan dahil sa mahahalagang tulong, kontribusyon at/o suporta tungo sa matagumpay na reyalisasyon ng pananaliksik na papel na ito:

Sa mga Orthopedic Triathletes na nakilahok sa pakikipanayam na naglaan ng panahon at sumagot nang matapat sa aming inihandang talatanungan.
Kay Dra. Jose na nagsilbing inspirasyon at tulay upang makahanap ng mga respondente, at sa paggabay sa mga mananaliksik sa pag-intindi sa mga termino ng medisina,
Sa mga awtor, editor at mga mananaliksik ng mga akdang pinaghanguan namin ng mahahalagang impormasyong aming ginagamit sa pagsulat ng una at ika-apat na kabanata ng pananaliksik na papel,
Kina Bb. Anna Patricia V. Gerong at Bb. Abbygale C. Pinca, mga masisigasig naming dalubguro na gumabay sa amin sa tamang hakbangin sa pagsulat at paggawa ng isang pananaliksik na papel,
Sa aming mga magulang at pamilya, sa pag-unawa, paghintulot at pagsuporta sa buong proseso ng paggawa ng mga mananalisik sa pananaliksik na papel,
Sa 11-S2, sa pagbibigay saya, sigla, at pag-asa tuwing nahihirapan na kami sa pagsulat ng aming papel, at sa pagbibigay aruga kapag kami ay umiiyak na, at higit sa lahat,
Sa Poong Maykapal, sa pagdinig sa aming mga dalangin lalung-lalo na sa sandaling kami ay pinanghihinaan na ng pag-asang matapos naming ito nang maayos sa itinakdang-panahon.

Muli ay maraming Salamat po! Mga Mananaliksik

6. MGA SANGGUNIAN

Andersen, C., Clarsen, B., Engebretsen, L. & Johansen, T. (2013). High prevalence of overuse injury among iron-distance triathletes. Br J Sports Med 2013, 47(13), p. 857–861. doi:10.1136/bjsports-2013-092397

Braun, S. (2015). Determinants of stress and effects on performance in internal medicine residents (Master's Thesis). Mula sa http://scholarscompass.vcu.edu/etd/3799

Carter, S. (2016). The sporty doctor. Mula sa https://www.bmj.com/content/354/sbmj.i1715.full

Charlton, R. (w.p.). Top tips: difficult decisions – doctors as patients. Mula sa https://journals.sagepub.com/pb-assets/cmscontent/INO/Charlton%20-%20Doctors%20as%20patients%20FINAL-1502289426580.pdf

Critcher, C., & Lee, C. (2018). Feeling Is Believing: Inspiration Encourages Belief in God. Psychological Science, 29(5), p. 723–737. doi:10.1177/0956797617743017

Collier, R. (2012). Healthier doctors, healthier patients. 184(17), p. E895-E896. doi:10.1503/cmaj.109-4327

Eime, R.,Young, J., Harvey, J., Charity, M., & Payne, W. (2013). A systematic review of the psychological and social benefits of participation in sport for adults: informing development of a conceptual model of health through sport. International Journal of Behavioral Nutrition and Physical Activity, 10, p. 1-14. doi: 10.1186/1479-5868-10-135

Etxebarria, N., Mujika, I., & Pyne, D. (2019). Training and competition readiness in triathlon. Sports, 7(5), p. 1-15. https://doi.org/10.3390/sports7050101

Feeney, S., et. al. (2016). Practise what you preach: health behaviours and stress among non-consultant hospital doctors. Clinical Medicine Journal, 16(1), p. 12-18. doi: 10.7861/clinmedicine.16-1-12

Feil, M. (2013). Distractions and their impact on patient safety. Pennsylvania Patient Safety Authority, 10(1), p. 1-12. Mula sa https://www.researchgate.net/publication/237154749_Distractions_and_Their_Impact_on_Patient_Safety

Field, A., Kocher, M., Tepolt, F., Yang, D., & Mininder, K. (2014). Injury risk associated with sports specialization and activity volume in youth. The Orthopaedic Journal of Sports Medicine, p. 1-6. doi: 10.1177/2325967119870124

Gopichandran, V., & Chetlapalli, S. (2015). Trust in the physician–patient relationship in developing healthcare settings: a quantitative exploration. Indian Journal of Medical Ethics, 12(3), p. 141-148. doi: 10.20529/IJME.2015.043

Harwood, C., Lavallee, D., Keegan, R., & Spray, C. (2014). A qualitative investigation of the motivational climate in elite sport. Psychology of Sport and Exercise, 15(1), p. 97–107. doi:10.1016/j.psychsport.2013.10.006

Khan, S. & Khan, A. (2016). Effectiveness of recreational activities among the doctors community of district dera. Noble International Journal of Social Sciences Research, 1(1), p. 16-20. Mula sa https://napublisher.org/pdf-files/NIJSSR-206-16-20.pdf

Klein, G., Hussain, N., Sprague, S., Mehlman, C., Dogbey, G., & Bhandari, M. (2012). Characteristics of highly successful orthopedic surgeons: a survey of orthopedic chairs and editors. Canadian Journal of Surgery, 56(3), p. 192-198. doi: 10.1503/cjs.017511

Kruger, M., Myburgh, E., & Saayman M. (2014). A motivation-based typology of triathletes. South African Journal for Research in Sport, Physical Education and Recreation, 36(3), p. 117-134. Mula sa https://www.ingentaconnect.com/content/sabinet/sport/2014/00000036/00000003/art00010

Lepers, R., Knechtle, B., & Stapley, P. (2013). Trends in triathlon performance: effects of sex and age. Sports Medicine, 43(9), p. 851–863. doi:10.1007/s40279-013-0067-4

Lundman, B., Aléx, L., Jonsén, E., Norberg, A., Nygren, B., Fischer, R., & Strandberg, G. (2009). Inner strength—a theoretical analysis of salutogenic concepts. International Journal of Nursing Studies, 47(2), p. 251–260. doi:10.1016/j.ijnurstu.2009.05.020

Macquet, A. C. & Skalej, V. (2015). Time management in elite sports: How do elite athletes manage time under fatigue and stress conditions?. Journal of Occupational and Organizational Psychology, 88(2), p. 341-363. doi: 88. 10.1111/joop.12105.

Medical College of Wisconsin. (2018). On the other side of the stethoscope: when doctors become patients. Mula sa https://www.mcw.edu/mcwknowledge/mcw-stories/on-the-other-side-of-the-stethoscope-when-doctors-become-patients

Ocampo, J. (2010). Personal motivation of physicians: A study focused on motivations by job enrichment and job satisfaction of public sector physicians in Ecuador (Doctoral Dissertation). Mula sa ProQuest Dissertations Publishing (3423955)
O' Dowd, A.(2020). Why I . . . do triathlons. doi: 10.1136/bmj.l6891

Pandit, M. S., & Pandit, S. (2009). Medical negligence: Coverage of the profession, duties, ethics, case law, and enlightened defense - A legal perspective. Indian journal of urology : IJU :Journal of the Urological Society of India, 25(3), p. 372–378. doi: 10.4103/0970-1591.56206

Parry, D., Chinnasamy, C., Papadopoulou, E., Noakes, T., & Micklewright, D. (2010). Cognition and performance: anxiety, mood and perceived exertion among Ironman triathletes. British Journal of Sports Medicine, 45(14), p. 1088–1094. doi:10.1136/bjsm.2010.072637

Prinz, J., Wicker, P., & Weimar, D. (2013). Big spenders in a booming sport: Consumption capital as a key driver of triathletes' sport-related expenditure. Managing Leisure, 18(4), p. 286-299. doi: 18. 10.1080/13606719.2013.809190.

Rich, A., Viney, R., Needleman, S., Griffin, A., & Woolf, K. (2016). 'You can't be a person and a doctor': the work–life balance of doctors in training—a qualitative study. BMJ Open, 6, p. 1-9. doi:10.1136/bmjopen-2016- 013897

Robert Wood Johnson Foundation. (2015). Sports and health in America. Mula sa https://media.npr.org/documents/2015/june/sportsandhealthpoll.pdf

Romani, M., & Ashkar, K. (2014). Burnout among physicians. Libyan Journal of Medicine, 9(1), p. 23556. doi:10.3402/ljm.v9.23556

Schorn, D., et. al. (2018). Risk factors for acute injuries and overuse syndromes of the shoulder in amateur triathletes - a retrospective analysis. PLOS one, 13(6), p. 1-9. doi: 10.1371/journal.pone.0198168

Soklaridis, S., Ravitz, P., Nevo, G., & Lieff, S. (2016). Relationship-centred care in health: A 20-year scoping review. Patient Experience Journal, 3(1), p. 130-145. doi: 10.35680/2372-0247.1111

Stanciu, C., Gnanasegaram, S., Brooks, N., Ahmed, S., Kohrman, S., & Teja, N. (2018). Physician wellness and substance use-a brief review. Journal of Alcoholism & Drug Dependence, 6(3), p. 1-3. doi:10.4172/2329-6488.1000e142

Stevenson, J., Song, H., & Cooper, J. (2013). Age and sex differences pertaining to modes of locomotion in triathlon. Medicine & Science in Sports & Exercise, 45(5), p. 976–984. doi:10.1249/mss.0b013e31827d17eb

Stults-Kolehmainen, M., & Sinha, R. (2013). The effects of stress on physical activity and exercise. Sports Medicine, 44, p. 81-121. doi: 10.1007/s40279-013-0090-5

Steifel, M., Rust, C., Rosemann, T., Knechtle, B. (2013). A comparison of participation and performance in age-group finishers competing in and qualifying for Ironman Hawaii. Int J Gen Med, 6, p. 67-77. doi: 10.2147/IJGM.S40202

van den Hombergh, P., Ku̇nzi, B., Elwyn, G., van Doremalen, J., Akkermans, R., Grol, R., & Wensing, M. (2009). High workload and job stress are associated with lower practice performance in general practice: an observational study in 239 general practices in the Netherlands. BMC Health Services Research, 9(118), p. 1-8. doi:10.1186/1472-6963-9-118

van der Burgt, S., Kusurkar, R., Croiset, G., Peerdeman, S. (2018). Exploring the situational motivation of medical specialists: a qualitative study. 9, p. 57-63. doi: 10.5116/ijme.5a83.6025

Vleck, V., Millet, G. & Alves, F. (2014). The impact of triathlon training and racing on athletes' general health. Sports medicine, 44, p. 1659-1692. doi: 10.1007/s40279-014-0244-0

Ang mga Coping Mechanisms at Motibasyon ng mga Medikal na Frontliners hinggil sa Stress at Burnout sa Panahon ng Pandemya 2021

Anne Mairead P. Castaneda, and Mary Kamillah R. Reyes
Assumption College, San Lorenzo, Makati

Abstract: Taong 2020 nang simulang mapabalita ang nakahahawang sakit na Covid-19, nang dahil dito maraming ospital ang unti-unting napuno ng mga pasyente at isa sa mga matatapang at magigiting na frontliners na humaharap at patuloy na lumalaban dito ay ang mga doktor. Kaugnay nito nakatuon ang pag-aaral na ito sa mga karanasan ng mga medikal frontliners partikular na ang mga doktor sa kanilang coping mechanisms at motibasyon sa pagharap sa stress at burnout. Gumamit ang mga mananaliksik ng 13 Patnubay na talatanungan na ginamit sa 15 kalahok na pinili gamit ang purposive sampling teknik. Batay sa isinagawang pagsusuri natuklasan ng mga mananaliksik na ang mga dahilan ng kanilang stress at burnout ay ang mabibigat na kondisyon sa trabaho, exposure sa Covid-19, seguridad ng trabaho, at problema sa kalusugang mental. Samantala ang kanilang mga coping mechanisms ay pagkain, komunikasyon sa pamilya at kaibigan, self-care, emotional release, entertainment, at ispiritwal. Panghuli ang pangako sa tungkulin, pamilya, at pasyente ang nagsisilbing motibasyon nila. Sa kabuoan hindi naging madali ang pagiging medikal frontliner lalo na sa panahon ng pandemya. Bagama't ganito ang sitwasyon hindi pa rin tumitigil ang mga doktor dahil pinanghahawakan nila ang kanilang sinumpaang tungkulin.

Key Words: stress; burnout; motibasyon; coping; mechanisms

1. INTRODUKSYON

Noong Marso 15, 2020, ipinatupad ng gobyerno ng Metro Manila at ng iba pang apektadong rehiyon ang ilang mga gabay para sa *community quarantine* sa pag-asang masugpo ang paglaganap ng COVID-19 (Talabong, 2020). Ngunit sa kabila nito, marami pa rin ang nahahawa at nagkakasakit. Ayon sa *Department of Health*, ang bansa ay muling nakapagtala noong Enero 11, 2021 ng higit sa dalawang libong panibagong kaso (Magsambol, 2021). Nangangahulugan na patuloy pa rin ang trabaho at sakripisyo ng sektor para sa *healthcare*. Bagama't lubhang napakahalaga ang gawain ng mga medikal na *frontliners* sa pag-aalaga ng mga nahawa at sa pagpapapatigil sa mga epekto ng COVID-19, makikita na hindi kasiya-siya ang sitwasyon nila. Nariyan ang kakulangan sa mga ospital at pasilidad, ang kakulangan sa mga kagamitan para sa kanilang proteksyon, ang halos walang patid na pagtatrabaho dahil na rin sa kakulangan ng mga medikal na tauhan at empleyado, ang patuloy na pagsuway ng mga tao sa mga itinakdang mga protokol, at ang patuloy na pagdagsa ng mga pasyente. Dahil dito, maraming mga medikal na *frontliners* ang nakararanas ng *stress* at *burnout*. Ayon kay Zhang at iba pa (2020), sa Hong Kong, 92.3% sa mga nars na sumagot sa sarbey nito ay nakaranas ng *burnout* dahil sa kanilang trabaho dahil hindi nila makapiling ang kanilang mga

pamilya sa matagal na panahon. Ang mga respondenteng may mas matagal na oras ng pagtatrabaho at ang mga mas batang respondente ay nagpapakita ng mas matinding sintomas ng *stress* at *burnout.* Batay naman sa isang pag-aaral na nanggaling sa Portugal, ang pagdaragdag ng trabaho ng mga *frontliner* sa mga ospital, gayundin ang patuloy na pagkakalantad nila sa nakababahalang mga sitwasyon, ay mayroong kaugnayan sa kanilang mga karanasan tungo sa *stress* at *burnout* (Duarte atbp., 2020). Bilang mga medikal na *frontliners*, ang pisikal na kalusugan ay kinakailangan para sa episyenteng pangangalaga sa mga pasyente. Ipinakikita sa isang pag-aaral na maliban sa sikolohikal na epekto, mayroon ding masamang naidudulot ito sa pisikal na kalusugan ng mga tao.

Mula sa mga dahilang nabanggit, layunin ng pag-aaral na ito na malaman at masuri ang mga karanasan ng mga medikal na *frontliners* sa panahon ng pandemya. Sa mas espesipikong pagtingin, bibigyang pansin ang mga dahilan na nagdudulot ng *stress* at *burnout*, ang *coping mechanisms* nila sa pagharap sa mga ito at ang kanilang motibasyon sa kabila ng mga hamong kanilang nararanasan. Ang kapakinabangan ng mga resulta sa isasagawang pag-aaral na ito ay ang maaaring tulong na maidudulot nito sa mga taong nalalagay sa parehong sitwasyon

kung saan madaling makaranas ng *stress* at *burnout* ngayong panahon ng pandemya.

1.2 Mga Layunin ng Pag-aaral

Nakatuon ang pag-aaral na ito na malaman at masuri ang iba't ibang karanasan ng mga medikal na *frontliners* sa panahon ng pandemya.

Nais ng mga mananaliksik na masagot ang mga sumusunod na katanungan:

1. Anu-ano ang mga **dahilan** ng *stress* at *burnout* sa trabaho ng mga medikal na *frontliners?*
2. Anu-ano ang **coping mechanisms** na ginagawa ng mga medikal na *frontliner*s sa pagharap sa *stress* at *burnout?*
3. Anu-ano ang mga **motibasyon** ng mga medikal na *frontliners* sa kabila ng mga hamong nararanasan nila ngayong panahon ng pandemya?

1.3 Saklaw at Limitasyon

Sakop ng pananaliksik na ito ang pagsusuri sa karanasan ng mga medikal na *frontliners* na nagtrabaho sa Metro Manila sa taong 2021 hinggil sa kanilang *coping mechanisms* at motibasyon sa stress at burnout. Ang pag-aaral na ito rin ay limitado sa mga nars at mga doktor na nagtatrabaho bilang medikal na *frontliners* sa kasalukuyang panahon ng pandemya sa mga ospital (pribado o pampubliko) sa Metro Manila.

Sa pag-aaral na ito, hindi kabilang ang mga doktor at nars na hindi nagtatrabaho sa mga ospital, ospital sa rural, mga medikal na *frontliners* na nagtatrabaho sa ibang rehiyon, ang mga OFW (Overseas Filipino Workers) na medikal na *frontliner*, at ang mga doktor na hindi pa nakapagtapos ng kanilang *residency*.

2. METODOLOHIYA

2.1 Disenyo ng Pananaliksik

Ang pag-aaral na ito ay tungkol sa mga karanasan ng mga medikal na *frontliners* sa Metro Manila. Binigyang pansin ang kanilang *coping mechanisms* hinggil sa *stress at burnout,* at ang kanilang mga motibasyon upang ipagpatuloy ang kanilang mga tungkulin. Ito ay isinagawa gamit ang penomenolohikal na disenyo. Tinangka nitong suriin sa konteksto ang saloobin ng mga medikal na frontliners.

2.2 Mga Kalahok at Sampling Teknik

Ang mga kalahok ay binubuo ng 13 medikal na frontliners mula sa iba't ibang ospital o klinik sa Metro Manila. Pinili ang mga kalahok gamit ang teknik na *SnowBall Sampling* kung saan ilang *point persons* ang nagsilbing tagapag-ugnay sa mga napiling tutugon sa pananaliksik. Ang isa pang sampling teknik na ginamit ay *Purposive Sampling*, dahil may batayan na dapat hanapin sa bawat kalahok. Katulad na lamang ng pagiging doktor at pagseserbisyo sa panahon ng pandemya.

2.3 Instrumento ng Pag-aaral

Ang instrumento ng pananaliksik na ginamit sa pangangalap ng mga datos ay ang Patnubay na Talatanungan. Naglalaman ito ng 13 mga tanong na nagsilbing gabay sa isinagawang interbyu.

2.4 Paraan ng Pagkakalap ng mga Datos

Nagsimula sa pagbuo ng patnubay na talatanungan ang mga mananaliksik. Matapos itong maaprobahan at maipa-validate ay humanap ng mga potensyal na kalahok na siyang kinapanayam.

2.5 Pagsusuri ng mga Datos

Mula sa isinagawang pakikipanayam, sinuri ng mananaliksik ang mga sagot ng mga kalahok na medikal na *frontliners* sa Metro Manila batay sa mga nangingibabaw na tema. Sinuri din ang mga dahilan sa mga karanasan hinggil sa *stress at burnout, coping mechanims* at motibasyon ng mga medikal na *frontliners*.

3. RESULTA AT DISKUSYON

Batay sa isinagawang pagsusuri makikita na isa sa mga dahilan ng *stress* at *burnout* sa mga kalahok ay ang mahirap o mabigat na kondisyon sa trabaho. Isa na rito ay ang paggamit ng PPE sa trabaho sapagkat mainit at hindi komportable ang pagsuot nito. Dahil mahaba ang kanilang araw bilang medikal na *frontliner*, nakakapagod ito. Narito ang isa sa mga halimbawang verbatim *"Especially the respirator, when you have been wearing it for quite some time. It's draining already. And it's also hot. Aside from that it is quite tedious not to see things clearly because you have to wear goggles.."*

Bukod pa rito, dahil sa pandemya, ang bilang ng mga pasyente sa E.R. at sa buong ospital ay biglang dumami. Dagdag pa sa kahirapan ng mga kondisyon sa ospital dahil may kakulangan ang bilang ng mga *frontliners* at ang mga PPE na kailangan nilang gamitin. Ayon kay Hanna at Mona (2014) tulad

sa nabanggit sa Fried at Fisher (2016), sa iba't ibang institusyon, katulad ng ospital, ang stress at burnout ay maaaring magmula sa mga mahirap na kondisyon at sitwasyon hinggil sa trabaho, ang mga problema sa pamilya o ang mga katrabaho, at ang kondisyon ng paligid nila, katulad ng kakulangan ng suporta at sobrang *pressure* galing sa mga kailangan nilang makamit. Isa pang dahilan ng *stress at burnout* ay ang malaking posibilidad ng *exposure* sa COVID-19, lalo na bilang medikal na *frontliner* na laging kailangang nakaharap sa mga pasyente sa mga ospital at klinika. Sinag-ayunan ito ng isang pag-aaral nina Mahmood at iba pa (2020), na ang malaking posibilidad na mahawa ang mga medikal na frontliners at ang kanilang pamilya, ay nagreresulta sa high anxiety sa trabaho. Narito ang isa sa mga halimbawang verbatim *"Everytime you hear the anxiety it's because you have to trace everyone whom you contacted with. If ever I got infected, I have to contact whom I infected with. That is the most stressful part of me as a doctor."*

Isa pang dahilan ng *stress* at *burnout* ay ang mga problema ng mga pasyente. Batay sa mga sagot ng mga respondente, ang mga problema ng mga pasyente ay nagpapaalala sa kanilang kondisyon dahil sa emosyonal na epekto ng pandemya at ang *stigma* patungo sa mga pasyente na nagreresultang positibo para sa COVID-19. Kaugnay dito, minsan mayroong mga pagkakataon na namamatay ang mga pasyente. Samakatuwid, ang mga problema ng mga pasyente ay maaaring maging problema ng mga doktor at nars sapagkat ang mga pasyente nila ay ang kanilang responsibilidad. Karagdagan dito, ang pag-aalala sa seguridad ng kanilang trabaho ay isa sa mga dahilan ng *stress* at *burnout* ng mga medikal na *frontliners*. Mga bagong protokol ng COVID, at pagpapatupad ng quarantine sa simula ng pandemya, marami sa mga *frontliners* ang hindi nakakapasok sa kanilang mga trabaho sa ospital o klinika. Dahil dito, nagkaroon ang ilang mga *frontliners* ng takot sapagkat hindi sigurado ang pagtanggap ng kanilang sweldo para sa pang araw-araw na gastusin. Ang huling dahilan ng *stress* at *burnout* ay ang mga negatibong epekto ng pandemya sa mental na kalusugan ng mga tao. Ito ang nagiging dahilan ng *anxiety* at kalungkutan. Ang mga kondisyon at pang araw-araw na ganitong karanasan ang nagbibigay daan sa *stress* o *burnout* sa mga medikal na frontliners. Narito ang isa sa mga halimbawang verbatim *"Now na may work na kami, malaki ang… nawala sa income, kasi sa income ko, personally, I lost more than half of my income because I don't do surgeries nowadays kasi nga I'm-I'm wary of the…"*

Batay naman sa naging resulta hinggil sa coping mechanisms sa *stress at burnout* ng mga kalahok, isa sa mga isinasagawa nila ay ang pagkain. Ginagawang *stress relief* ito ng mga kalahok matapos ang mahirap at nakakapagod na araw sa trabaho. Narito ang isa sa mga naging verbatim *"Yes, non-negotiable talaga yun. Naku fatty foods hehe, carbs. At coffee, puro coffee. But I really make sure that I hydrate talaga, non-negotiable din yan. Coffee, hydrate, maraming kinakain na Carbs and sweets."*

Isa ring *coping mechanism* na ginagawa ng mga respondente ay ang pakikipag-usap sa mga katrabaho, pamilya o sa mga taong malapit sa kanilang buhay. Sapagkat napapagaan nito ang kanilang loob at ito ay isang pagkakataon para ipahayag ang kanilang nararamdaman sa ibang tao. Bukod pa rito ayon kay Kaiser (2018), ang komunikasyon ay nakatutulong din sa pagbaba ng antas ng *stress*, lalo na sa kapaligiran ng trabaho. Isa pang *coping mechanism* na ginagawa nila sa sitwasyon ng *stress at burnout* ay ang paglabas ng mga emosyon nila sa pamamagitan ng pag-iyak at *journaling*. Ang pag-iyak ay isang paraan para makakuha ng kalakasan para sa sarili at para sa mga hamon na kailangan nilang harapin. Karagdagan dito, ang *journaling* din ay isang paraan para ilabas ang mga bagay na kinatatakutan nila. Ang pag-iyak ayon kay Gracanin, at iba pa (2014), ay isang paraan para alisin ang tensyon sa katawan, kaya ito ay ginagawa ng mga tao kapag sila ay nagiging emosyonal . Ang journaling naman, ayon kay Johnson (2019), ay isang paraan para ilabas ang mga matinding emosyon pagkatapos ng isang *stressful* na karanasan.

Isa pang *coping mechanism* na ginagawa nila ay sa pamamagitan ng ehersisyo, meditasyon at kalinisan o *hygiene*. Ang mga gawain na ito ay nakatutulong sa paglabas ng mga negatibong pag-iisip at enerhiya. Bukod pa rito, ayon kay Mellis (2018), ang *self-care* ay mahalaga dahil ito ay nagbibigay ng positibong emosyon habang nagtatrabaho ang isang tao, ito rin ay nakakabawas ng antas ng *stress* sa kapaligiran ng trabaho. Ang mga gawaing masaya katulad ng panonood ng mga Koreanong teleserye o K-drama, Netflix at paglalaro ng *computer/mobile games* ay isa pang *coping mechanism*. Ito ang nagiging isang paraan para makaisip sila ng iba pang bagay maliban sa trabaho lamang. Ito rin ay isang paraan upang mapasaya ang sarili kahit sobrang matindi ang mga ginagawa nila sa trabaho. Sa huli, isa pang *coping mechanism* na ginagawa ng mga medikal na *frontliners* ay ang pagdarasal dahil ito ay isang paraan upang makondisyon ang sarili para sa mga hamon na kailangan nilang harapin sa trabaho, kahit ito ay mahirap at nakakapagod. Narito ang isa sa mga halimbawang verbatim *"I feel like praying really helped me. The fact that I can't mentally even just for myself kind of unburden or talk to somebody without judgement."*

Samantala ang mga naging motibasyon naman ng mga medikal na *frontliners* ay ang mga pangako at tungkulin sa kanilang trabaho, ang kanilang mga pamilya at mahal sa buhay, at ang kanilang mga pasyente. Ang unang motibasyon ng mga kalahok ay ang pangako at tungkulin nila bilang mga medikal na *frontliner*. Ito ay binubuo ng kanilang pagmamahal para sa kanilang trabaho, ang mga responsibilidad sa trabaho nila, at ang pagnanais na makatulong sa ibang tao katulad ng mga pasyente nila. Narito ang isa sa mga halimbawang verbatim *"We have that hippocratic oath that do no harm, do good and try to help everybody. So I guess that's it... So even if there's no pay...."*

Kaugnay nito, nagiging motibasyon din ang mga responsibilidad nila sa kanilang mga pasyente sa paggawa ng kanilang tungkulin. Batay sa mga datos, maraming mga kalahok ang nagsisilbing guro at tagagabay para sa mga nagnanais na maging medikal na *frontliner* sa kabila ng pandemya. Ang responsibilidad sa mga estudyante ay naging isang motibasyon para sa mga naging kalahok. Ang isa pang motibasyon ng mga medikal na *frontliners* ay ang kanilang tungkulin para sa kanilang pamilya at mahal sa buhay. Ayon sa mga datos, isa sa mga responsibilidad ng mga medikal na *frontliners* sa kanilang mga pamilya ay ang pagsisigurado na ang kanilang mga pamilya ay hindi mahihirapan sa panahon ng pandemya. Sinusuportahan ito ng isang pag-aaral nina Ratanawongsa at iba pa (2006), na ang dahilan kung bakit tumutuloy ang mga doktor sa kanilang trabaho, ay dahil sa pagnanais na tumulong sa ibang tao, pamilya, at ang kanilang komunidad. Ang huling motibasyon ng mga medikal na *frontliners* ay ang kanilang mga pasyente. Sapagkat ang mga pasyente na muling bumabalik sa mga klinika o ospital ay isang bagay na nag-uudyok sa mga medikal na *frontliners* na tumuloy magtrabaho kahit may posibilidad ng *exposure* sa COVID-19. Bukod pa rito, ang mga pasyente na gumaling mula sa kanilang mga sakit ay nagsisilbing inspirasyon at motibasyon sa mga medikal na *frontliners*, lalo na sa mga mahihirap na sitwasyon. Ang paggaling ng mga pasyente ay nagbibigay ng pag-asa sa kanila sa kabila ng *stress* at *burnout* na nararanasan nila sa kanilang mga trabaho ngayong panahon ng pandemya. Sinag-ayunan ito ng isang pag-aaral nina Deng, at iba pa (2018), na ang magandang relasyon ng isang doktor sa pasyente, ay nagiging dahilan kung bakit tumataas ang *work satisfaction* nila, at nagiging dahilan din kung bakit tumutuloy sila sa kanilang trabaho. Narito ang isa sa mga halimbawang verbatim *"A lot of people usually say the money... but at the end of the day with things that you do, it is really being able to do what you do and knowing that you actually helped somebody."*

Kongklusyon

Sa kabuoan hindi madali ang maging isang medikal frontliner lalo na sa panahon ng pandemya. Maraming mga bagay na dapat isaalang-alang katulad na lamang ng mga bagong protokol at ang takot na mahawa sa sakit. Gayunpaman sa kabila ng mga stress at burnout na nararanasan ng mga medikal na frontliners nanatili pa rin sila sa kanilang sinumpaang tungkulin at patuloy nilang nalalagpasan ang mga hamon nang dahil sa kanilang motibasyon at coping mechanisms.

Rekomendasyon

Batay sa isinagawang pag-aaral inirerekomenda ang mga sumusunod:
1. Magkaroon ng komparatibong pag-aaral hinggil sa naging pagtugon ng mga doktor sa pandemya sa Pilipinas.
2. Alamin at suriin din ang mga karanasan ng mga Frontliners na hindi doktor o nars, upang malaman din ang kanilang mga naging karanasan.

4. PASASALAMAT

proseso ng paggawa ng mga mananalisik sa pananaliksik na papel,

7. Sa **Poong Maykapal**, sa pagdinig sa aming mga dalangin lalung-lalo na sa sandaling kami ay pinanghihinaan na ng pag-asang matapos naming ito nang maayos sa itinakdang-panahon.

Muli ay maraming Salamat po!

5. SANGGUNIAN

Deng, S., Yang, N., Li, S., Wang, W., Yan, H., & Li, H. (2018). Doctors' job satisfaction and its relationships with doctor-patient relationship and work-family conflict in China: a structural equation modeling. INQUIRY: The Journal of Health Care Organization, Provision, and Financing, 55, 0046958018790831.

Duarte, I., Teixeira, A., Castro, L. et al. (2020). Burnout among Portuguese healthcare workers during the COVID-19 pandemic. BMC Public Health, 20, pp. 1-10. https://doi.org/10.1186/s12889-020-09980-z

Fried, A. L., & Fisher, C. B. (2016). Moral stress and job burnout among frontline staff conducting clinical research on affective and anxiety disorders. Professional Psychology: Research and Practice, 47(3), 171. https://doi.org/10.1037/pro0000060

Gračanin, A., Bylsma, L. M., & Vingerhoets, A. J. (2014). Is crying a self-soothing behavior?. Frontiers in Psychology, 5, 502. 10.3389/fpsyg.2021.604692

Johnson, S. B., & Butcher, F. (2021). Doctors during the COVID-19 pandemic: what are their duties and what is owed to them?. Journal of Medical Ethics, 47(1), 12-15. 10.1136/medethics-2020-106266

Mills, J., Wand, T., & Fraser, J. A. (2018). Exploring the meaning and practice of self-care among palliative care nurses and doctors: a qualitative study. BMC Palliative Care, 17(1), 1-12. https://doi.org/10.1186/s12904-018-0318-0

Lambert, V. A., & Lambert, C. E. (2008). Nurses' workplace stressors and coping strategies. Indian Journal of Palliative Care, 14(1), 38. https://doi.org/10.4103/0973-1075.41934

Mahmood, Q. K., Jafree, S. R., Jalil, A., Nadir, S. M. H., & Fischer, F. (2021). Anxiety amongst physicians during COVID-19: cross-sectional study in Pakistan. BMC public health, 21(1), 1-10. https://doi.org/10.1186/s12889-020-10134-4

Magsambol, B. (2021, Enero 11). PH logs over 2,000 COVID-19 cases for first time since holidays. Rappler. https://www.rappler.com/nation/coronavirus-cases-philippines-january-11-2021

Ratanawongsa, N., Howell, E. E., & Wright, S. M. (2006). What motivates physicians throughout their careers in medicine?. Comprehensive therapy, 32(4), 210-217. https://doi.org/10.1007/BF02698065

Salvagioni, D. A. J., Melanda, F. N., Mesas, A. E., González, A. D., Gabani, F. L., & Andrade, S. M. (2017). Physical, psychological and occupational consequences of job burnout: A systematic review of prospective studies. PLOS ONE, 12(10), pp. 1–29. https://doi.org/10.1371/journal.pone.0185781

Sarada, P.A. & Ramkumar, B. (2015). Positive stress and its impact on performance. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 6(2), pp. 1519-1522. https://www.researchgate.net/publication/282700608_Positive_stress_and_its_impact_on_performance

Talabong, R. (2020, Marso 14). Metro Manila lockdown begins. Rappler. https://www.rappler.com/nation/coronavirus-metro-manila-lockdown-begins

Yaribeygi, H., Panahi, Y., Sahraei, H., Johnston, T. P., & Sahebkar, A. (2017). The impact of stress on body function: A review. EXCLI journal, 16, pp. 1057–1072. https://doi.org/10.17179/excli2017-480

Zhang, Y., Wang, C., Pan, W., Zheng, J., G, J., Huang, X., Cai, S., Zhai, Y., Latour, J. M., & Zhu, C. (2020). Stress, Burnout, and Coping Strategies of Frontline Nurses During the COVID-19 Epidemic in Wuhan and Shanghai, China. Frontiers in psychiatry, 11, pp. 1-9. https://doi.org/10.3389/fpsyt.2020.565520 https://www.cdc.gov/coronavirus/2019-ncov/testing/serology-overview.html

Mango (*Mangifera indica*) Bark Aqueous Extract as Antimicrobial Spray

Kenneth A. Morales, Jomari B. Carandang, Marben J. Javier,
and Rein Lester L. Tatco
Taytay Senior High School, Taytay, Rizal

Abstract: Emerging microbial agents have been increasing in number. Microbial agents are necessary in combating microbes such as bacteria that cause viruses and diseases. Hence, some bacteria are being resistant to antioxidant and antibacterial drugs that is why it resulted to find antimicrobial agents coming from organic molecules. This reason resulted in the researchers finding an organic antimicrobial agent using Mango Bark Aqueous Extract (MBAE). In the previous studies, it was proven that Mangifera indica (Mango) has phytochemicals that help inhibit the growth of bacteria. Thus, the researchers screened the antimicrobial activity of MBAE by applying the MBAE with a concentration of 50 mg/ml to the cultured microbes. The researchers selected chicken meat samples within the vicinity of Taytay, Rizal marketplace in March 2021. The sample was used to culture the microbes to be treated. The microbes were cultured on Nutrient agar over 24 hours under room temperature then the MBAE was applied by dropping an adequate amount of the extract on the plate and spreading it until the surface is fully covered. After twenty-four hours, the extract almost inhibited the growth of microbes on the plate. This justifies the claims regarding the potential usage of the Mango Bark Aqueous Extract as an antimicrobial agent.

Key Words: mango aqueous extract; antimicrobial screening; microbial agents; microbes; bark.

1. INTRODUCTION

The mango belongs to genus *Mangifera*, which consists of numerous species of tropical fruits in the family of *Anacardiaceae*. *Mangifera indica* L. is native to India and Southeast Asia where it has been cultivated for over 4000 years for the good qualities of the fruits. Currently, mango is also grown in Central America, Africa, Australia, and for a few years in Europe (Lauricella et al., 2017).

According to the study of Scartezzini et al. (2000, as cited by Ghuniyal, 2015), aqueous extract is traditionally used for the treatment of, syphilis, anemia, scabies, cutaneous infections, menorrhagia, and diarrhea. In line with it, as the aqueous extract shows that it combats different bacteria onto these diseases, the bark infusion has been used to treat mouth sores. In the study of Sanusi et al. (2011), the antimicrobial activity of the aqueous and methanolic extract of *Mangifera indica* stem bark both inhibits the growth of *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli* at a concentration of 50 mg/ml of the reconstituted extract. Similarly, Abubakar (2009), as cited by Osei-Djarbeng et al. (2020), has studied and found that the bark extract of the plant has exhibited antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa, Klebsiella pneumoniae and Streptococcus pneumoniae*. Moreover, in the study Prado et al. (2015), they stated that some studies have been performed in Cuba from one standardized aqueous stem bark of mango extract they isolated and purified mangiferin. Mango bark contains mangiferin (Nwoke et al., 2016; Govindan, 2019; Sani et al., 2015) and other phytochemical constituents. According to Stoilova et al. (2005) as cited by Tyagi et al. (2019), in an in vitro agar diffusion technique, mangiferin showed activity against 7 bacterial species, *Bacillus pumilus, B. cereus, Staphylococcus aureus, S. citreus, Escherichia coli, Salmonella agona, Klebsiella pneumoniae*, 1 yeast (*Saccharomyces cerevisiae*) and 4 fungi (*Thermoascus aurantiacus, Trichoderma reesei, Aspergillus flavus and A. fumigatus*).

Given this data, the researchers are encouraged to conduct experiments in testing the antimicrobial efficacy of the MBAE. The researchers will synthesize Mango (*Mangifera indica*) bark as antimicrobial spray for possible product development. This study aims to justify the potential of the MBAE as an organic antimicrobial agent.

1.1 Theoretical Framework

Resistance to antimicrobial drugs has become an increasingly important and pressing global

problem (Savant et al., 2017). Resistance of microorganisms to antibiotics and orthodox drugs has resulted in finding antibacterial agents that came from organic molecules from plants that have antibacterial properties (Sanusi et al., 2011). According to the study of Savant et al. (2017), there has been a ruthless increase in antimicrobial resistance in most of the pathogenic microorganisms all over the world due to irrational use of antimicrobial agents. Therefore, the use of antibacterial properties of Mango (*Mangifera indica*) bark extract is significant to the foregoing research.

Nworie et al. (2016), stated that the chance to find antibacterial property on both leaves and bark extract of the Mango were apparent, therefore, they suggested that the plant could be a new source of antibiotics. Accordingly, the study of Mazlan et al. (2019), mangiferin and its derivative compounds is a safe natural product, which can potentiate antibacterial effects of some antibiotics suggesting good potential for combination therapy against S. aureus. Likewise, the study of Savant et al. (2017), also showed the extract's potential antibacterial activity against different Gram positive and Gram-negative bacteria by performing MIC and zone of inhibition. Interestingly, these results encourage the researchers to carry out further study for its clinical use.

1.2 Research Question
Does the MBAE inhibits microbes?

1.3 Scope and Delimitation
This study focused mainly on the effect of antimicrobial properties of Mango on microbes collected on chicken meat samples.

This study is limited since the microbes collected on the chicken meat sample were not identified and verified. In addition, the researchers did not use positive and negative control in the experiment.

2. METHODOLOGY

2.1 Research Design
The researchers used Pretest and Posttest Control Group Design. They selected the test organisms on raw chicken samples at Taytay, Rizal public market in March 2021. The test organism was pre-tested, without the application of the MBAE, observed and post-tested after 24 hours of the application of the MBAE. After 24 hours of observation the treated plate was analyzed and drawn to a conclusion.
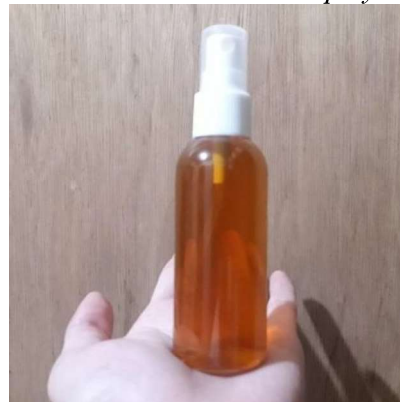
2.2 Selections and Trials
All the conclusions were drawn only after the testing of organisms on collected chicken sample. The purpose of taking samples was to randomly select test organisms on the raw chicken sample to get the data and information, which conclusions are drawn.

2.3 Proposed Product

Figure 1
MBAE as antimicrobial spray

2.4 Procedures

2.4.1 Collection of Plant Materials
Samples of Mango (*Mangifera indica*) tree bark were obtained from Taytay Rizal.

2.4.2 Preparation of Plant Materials
Freshly collected stem barks of *M. indica* were thoroughly cleaned and washed with water and were dried under sunlight with a span of three days. After drying the stem bark, it was pounded with mortar and pestle to obtain smaller pieces and then powdered using an electric blender. 150 grams of the powdered stem bark of the *M. indica* was stored in a container until required.

2.4.3 Preparation of Aqueous Extract
The researchers used five grams of the dried powdered sample soaked in 100 ml of distilled water contained in a container. The container was covered and then stored for 24 hours. After 24 hours, the suspension was shaken vigorously and filtered using filter paper. The extract was stored 24 hours under room temperature. After 24 hours, the 50 mg/ml extract was used in the antimicrobial screening.

2.4.4 Preparation of Microbial Media
As suggested by the manufacturer's specification, 8.4g of Nutrient agar was dissolved in 300ml of distilled water. After the agar was dissolved the solution was then autoclaved. After autoclaving,

the nutrient agar was poured on petri dishes and allowed to harden under room temperature. The plates were then inoculated with the test organisms and then treated by 50 mg/ml concentration of MBAE.

2.4.5 Collection of Test Organisms

Test organisms were obtained upon culturing microbes from the raw chicken food sample. The test organisms were cultured on Nutrient Agar. The researchers swabbed the surface of the food sample using sterile swabs and transferred it into the nutrient agar plate in a side-by-side motion. The plates were incubated at a room temperature for 24 hours.

3. RESULTS AND DISCUSSION

1. Does the MBAE inhibits microbes?

This study's finding intends to show antimicrobial activity of the MBAE on the test organism within the time interval; 5:50 PM, 6:00 PM, 9:00 PM, 10:00 PM, 7:00 AM, 12:00 PM, 3:00 PM, 5:50 PM.

Figure 2
The antimicrobial activity of the MBAE on the test organism within 24 hours.

Figure 3
Effect of the MBAE to the test organism after incubation for 24 hours.
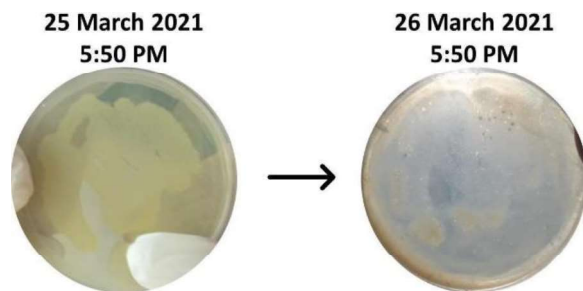
Through 24 hours of observation, the results were gathered and analyzed. The results showed that at the concentration of 50 mg/ml, the growth of microbes has been inhibited. As shown on Figure 2 the first ten minutes of the application of the extract the results were visible that MBAE acted fast. Continuously, the 24 hours of observation showed that

every time interval after the application of the MBAE it showed significant effect that it inhibits the growth of microbes.

As the study of Sanusi et al. (2011), stated that in their phytochemical screening, aqueous extract of Mango bark has the presence of tannins, saponins, sterols, cardiac glycosides, flavonoids, and alkaloids. Mango bark also contains mangiferin (Nwoke et al., 2016; Govindan, 2019; Sani et al., 2015), which is, according to Stoilova et al. (2005, as cited by Tyagi et al., 2019), showed activity against 7 bacterial species, *Bacillus pumilus*, *B. cereus*, *Staphylococcus aureus*, *S. citreus*, *Escherichia coli*, *Salmonella agona*, *Klebsiella pneumoniae*, 1 yeast (*Saccharomyces cerevisiae*) and 4 fungi (*Thermoascus aurantiacus*, *Trichoderma reesei*, *Aspergillus flavus* and *A. fumigatus*).

4. RECOMMENDATION

This study only focused on the 50 mg/ml concentration of the extract. There are still concentrations suggested by Sanusi et al. (2011), to be explored. The concentration showed inhibition to the growth of microbes in the sample. To further know the efficacy of the extract on foodborne bacteria, it is suggested to find different food samples like meat, vegetable, and fruit regarding also from where these food samples come from. It is also suggested to use identified and verified test organisms, use verified methods in finding the inhibitory effect, and conduct a positive and negative control to the experiment.

5. ACKNOWLEDGEMENTS

6. REFERENCES

Bykowski, T., & Stevenson, B. (2008). Aseptic technique. Current protocols in microbiology, 11(1), A-4D.

Ghuniyal, J. (2015). Ethanomedical, chemical, pharmacological, toxicological properties of mangifera indica: a review. International Journal of Pharma Research & Review, 4(10), 51-64.

Kemegne, G. A., Nyegue, M. A., Kamdem, S. L. S., Etoa, F. X., & Menut, C. (2018). Mangifera indica Bark Essential Oil: Chemical Composition and Biological Activities in Comparison with Aqueous and Ethanol Extracts. Natural Product Communications, 13(7), 1934578X1801300730.

Mazlan, N. A., Azman, S., Ghazali, N. F., Yusri, P. Z. S., Idi, H. M., Ismail, M., & Sekar, M. (2019). Synergistic antibacterial activity of mangiferin with antibiotics against Staphylococcus aureus. Drug Invention Today, 12, 14-17.

Noghogne, L. R., Gatsing, D., Kodjio, N., Sokoudjou, J. B., & Kuiate, J. R. (2015). In vitro antisalmonellal and antioxidant properties of Mangifera indica L. stem bark crude extracts and fractions. British Journal of Pharmaceutical Research, 5(1), 29.

Nworie, O., Orji, J. O., Ekuma, U. O., Agah, M. V., Okoli, C. S., & Nweke, M. C. (2016). Antibacterial activity of the leaf and stem bark of Irvingia gabonensis (Bush Mango) against Escherichia coli and Staphylococcus aureus. Global Journal of Pharmacology, 10(1), 13-18.

Osei-Djarbeng, S. N., Kwarteng, R. O., Osei-Asante, S., & Owusu-Dapaah, G. (2020). Comparative antimicrobial activities of ethanolic extracts of leaves, seed and stem bark of Mangifera indica (Mango). Journal of Pharmacognosy and Phytochemistry, 9(1), 1240-1243.

Phytochemical screening and antimicrobial efficacy of aqueous and methanolic extract of Mangifera indica (mango stem bark).

Sanusi, B. M., GARBA, A., MUHAMMAD, A., MOHAMMED, A., & David, O. (2011).

Savant, C. B., Kulkarni, A. R., Abdel-Wahab, B. A., Al-Qahtani, A. M., Mannasaheb, B. A., & Shaikh, I. A. (2017). Phytochemical characterization and Antibacterial potentials of Mangifera indica L. bark oil. Journal of Applied Pharmaceutical Science, 7(04), 138-141.

Singh, R., Singh, S. K., Maharia, R. S., & Garg, A. N. (2015). Identification of new phytoconstituents and antimicrobial activity in stem bark of Mangifera indica (L.). Journal of pharmaceutical and biomedical analysis, 105, 150-155.

Tyagi, U., Dwivedi, S. P., & Bagchi, S. (2019). Evaluation of antimicrobial and antioxidant properties of Mangifera indica bark extracts to prolong the shelf life of fruits and food products. Journal of Biopesticides, 12(2).

VAGANINA Caillouette, J. C., Sharp Jr, C. F., Zimmerman, G. J., & Roy, S. (1997). Vaginal pH as a marker for bacterial pathogens and menopausal status. American journal of obstetrics and gynecology, 176(6), 1270-1277.

A Review on the Antioxidant Activity of Select Philippine Fruitsand Wines

Kyle Nicole P. Babista, Rowell Andrew A. Kalalang, Frances Ivy C. Mesina
and Lara Nicole B. Pegalan
De La Salle University Integrated School, Manila

Dr. Joseph R. Ortenero
De La Salle University, Manila

Abstract: Antioxidants are an abundant type of substance that is found in various fruits and wines. The literature on antioxidants has been growing consistently due to various reports on their health benefits. Hence, this study is a literature review of the antioxidant activity of local fruit and wines in the Philippines using various spectrophotometric techniques. Specifically, the researchers assessed the state of research on the antioxidant properties of local fruits and the effect of temperature and aging on the antioxidant activity of local wines. In gathering the related studies, the following keywords/phrases were used: "antioxidant activity of Philippine wines"," spectrophotometry", "Philippine fruit", and "temperature and age of Philippine wines." These were assessed using the Quality of Reporting of Meta-analyses (QUORUM) standard to measure its reliability. The results showed that there was a correlation between the temperature of both local fruits and wines towards the antioxidant ($x2c$ = 1.53, α = 2.71; $x2c$ = 5.00, α = 6.25, respectively). However, the age of the wine did not display any relationship with its antioxidant ($x2c$ = 11.56, α = 6.25). As for the heterogeneity of the studies, there was a considerable heterogeneity for the temperature of the fruits and wines towards the antioxidant ($I2$ = 34.64%; $I2$ = 40.00%). But the data for the age and wine were varied significantly since it accounted for a high heterogeneity ($I2$ = 82.69%). In conclusion, there was a mildly significant correlation between the temperature of both fruit and wines towards the antioxidant activity. However, the wine age did not affect its antioxidant activity.

Key Words: Philippine fruits; antioxidant activity; Philippine wines; spectrophotometry; heterogeneity

1. INTRODUCTION

As of modern-day, the Philippines is not known for its wine production. However, its climate and culture contribute to its significant consumption and production of wine. The Philippine winery produces various types of wine which are commonly associated with the plants that grow locally. As a result, most of the wines that are being produced in the country are mostly local fruits such as strawberries, mangoes, pineapple, mangosteen, calamansi, and bignay (Morelock, 2018).

The antioxidants, which are sometimes called free-radical scavengers are considered to be a type of substance that has the ability to prevent or slow down the damage to the cells that are caused by free radicals (Morelock, 2018). Wines and fruits alike are found to have a significant amount of antioxidants which are commonly in the form of polyphenols, flavonoids, etc. (Barcelo, 2015). These compounds offer a lot to the human body because they aid in a lot of biological processes like anti-cancer or anti-inflammatory activities (Han et al., 2017).

The objective of this literature review is to provide sufficient information about the antioxidant activity of local fruit and wines that utilize various spectrophotometric techniques. The obtained literature will then be compared with each other in terms of the concluded results and the parameters observed in the experimentation process. For the fruit samples, the parameter that is considered is the temperature to which the sample was subjected during the experiment. Meanwhile, for the local wines, the parameters that are analyzed are the temperature during the experiments and the age of the local wines from the day of packaging. The review journal articles that were studied all took place in the Philippines and must use spectrophotometric techniques in acquiring data.

2. METHODOLOGY

The study is an intensive review of the Philippines' local papers about fruit and wines and their antioxidant levels. The researchers used various academic search engines in order to scour different articles. Among a few of the research engines used are Google Scholar, ScienceDirect, ResearchGate, Academia, and Philippine E-journal. To search for the relevant articles, the researchers used search strings such as "Antioxidant activity of Philippine wines", "spectrophotometry", "Philippine fruit", and "temperature and age of Philippine wines." The journal articles were assessed using the Quality of Reporting of Meta-analyses (QUORUM) standard. The researchers carefully filtered the articles utilizing a checklist to ensure the validity of the study's publications. The relevant data were presented in tabular form by indicating its age, temperature, and antioxidant activity. But for the fruits, only the temperature and antioxidant activity were indicated. Additionally, the chi-square test and Higgins' I2 heterogeneity statistic were used to assess the relationship of age and temperature on the antioxidant activity. This will be computed through a Microsoft Excel add-in called PHStat.

3. RESULTS AND DISCUSSION

Among the studies that have been searched, the researchers picked 31 pieces of literature based on the title and abstract of the paper. It consisted of both foreign and local literature therefore all the literature were consequently deducted by checking the criterion (see Table 1). Therefore, only 6 studies met the criterion which also needed to have a reliable result.

Table 1. The criteria used in the selection of studies

Parameter	Criteria
Date and Year	2005-2021
Author	Any author would suffice
Language	English
Research Status	Scholarly (Peer-reviewed)
General Setting	The antioxidant activity of Philippine fruit/wines using spectrophotometric techniques
Methodology	Meta-analysis of journal articles using key terms to search the journal article repositories (ScienceDirect, Philippine E-journal, Google Scholar, and ResearchGate)
Publication	Any database that offers scholarly articles

Spectrophotometric techniques are methods that are reliant on the reaction of a radical, radical cation, or a complex antioxidant molecule that can donate a hydrogen ion. The 2,2-diphenyl-1-picrylhydrazyl DPPH method consists of a stable free radical which is caused by the delocalization of the spare electron within the totality of a molecule. The 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) method is a cation that is formed due to the loss of electrons from the nitrogen atom of ABTS which is a type of acid. The Ferric Reducing Antioxidant Potential (FRAP) method relies on the reduction of certain species through an antioxidant of the ferric ion. The Oxygen Radical Absorbance Capacity (ORAC) method measures the scavenging activities of the antioxidant against a peroxyl radical.

Table 2. Summary of the different spectrophotometric methods

Antioxidant capacity assay	Principle of the method	End-product determination
DPPH	Antioxidant reaction with an organic radical	Colorimetry
ABTS	Antioxidant reaction with an organic cation radical	Colorimetry
FRAP	Antioxidant reaction with a Fe(III) complex	Colorimetry
PFRAP	Potassium ferricyanide reduction by antioxidants and subsequent reaction of potassium ferrocyanide with Fe3+	Colorimetry
CUPRAC	Cu (II) reduction to Cu (I) by antioxidants	Colorimetry
ORAC	Antioxidant reaction with peroxyl radicals, induced by AAPH (2,2'-azobis-2-amidino-propane)	Loss of fluorescence of fluorescein
HORAC	Antioxidant capacity to quench OH radicals generated by a Co(II) based Fenton-like system	Loss of fluorescence of fluorescein
TRAP	Antioxidant capacity to scavenge luminol-derived radicals, generated from AAPH decomposition	Chemiluminescence quenching
Fluorimetry	Emission of light by a substance that has absorbed light or other electromagnetic radiation of a different wavelength	Recording of fluorescence excitation/ emission spectra

Note. Table 2 shows the process and result of the spectrophotometric methods (Pisoschi & Negulescu, 2012).

The Hydroxyl Radical Averting Capacity (HORAC) method relies on measuring the metal-chelating activities of antioxidants under Fenton-like conditions (ferric reactions). The Total peroxyl Radical-trapping Antioxidant Parameter (TRAP) method involves luminol enhanced chemiluminescence (CL) being exploited to measure the peroxyl radicals. The lipid peroxidation inhibition assay is a type of inhibition that uses a Fenton-like method to induce a lipid substance. The Potassium Ferricyanide Reducing Power (PFRAP) method involves the reducing capabilities of an antioxidant to reduce a ferric into a ferrous substance. The Cupric Reducing Antioxidant Power (CUPRAC) assay is a method wherein antioxidants are mixed with copper to be reduced. Lastly, Fluorimetry is utilized by exposing the antioxidant for it to emit a light that will emit energy (Pisoschi & Negulescu, 2003).

Garcia et al. (2005) acquired the bignay and durian from IFST and Davao City, respectively. The samples were kept and incubated at 37oC in a hot water bath. The experiment utilized the Lipid-peroxidation assay (Linoleic-acid) and resulted in an

84.44% antioxidant activity for the bignay and 90.76% for the durian. The study from Santiago et al. (2007) also used the Lipid-peroxidation assay to effectively identify the antioxidant of the local duhat and kalumpit. An 80.38% activity is found in duhat while kalumpit garnered 66.15% in their antioxidants. Additionally, Barcelo et al. (2015) employed the use of DPPH assay in their experiment involving pineapple, guyabano, strawberry, mangosteen, and ayosep fruit. All of these were kept under room temperature and yielded an antioxidant activity of 62.39%, 86.41%, 92.35%, 89.08%, and 80.02%, respectively. Lastly, a study by Lizardo et al. (2015) also aimed to study the antioxidant activity of bignay under 4oC. The DPPH assay was used and the result came out as the fruit having 87.10%.
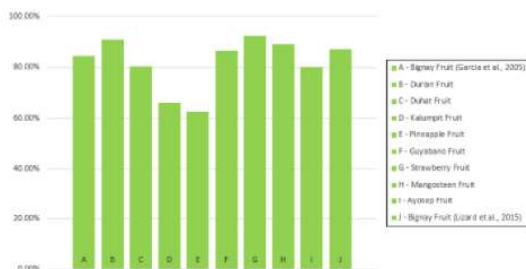
Figure 1. Comparison of the antioxidant activity of select Philippine fruits

Kalumpit Fruit	Lipid-peroxidation assay	40°C	66.15%	Santiago et al. (2007)
Pineapple Fruit	DPPH radical scavenging assay	25°C	62.39%	Barcelo et al. (2015)
Guyabano Fruit	DPPH radical scavenging assay	25°C	86.41%	Barcelo et al. (2015)
Strawberry Fruit	DPPH radical scavenging assay	25°C	92.35%	Barcelo et al. (2015)
Mangosteen Fruit	DPPH radical scavenging assay	25°C	89.08%	Barcelo et al. (2015)
Ayosep Fruit	DPPH radical scavenging assay	25°C	80.02%	Barcelo et al. (2015)
Bignay Fruit	DPPH radical scavenging assay	4°C	87.10%	Lizardo et al. (2015)

The study by Hipol & Alma-in (2018) focused on tapuy, a rice wine that originated from the Cordillera regions, and assessed different variants of tapuy, each variant coming from different municipalities of Benguet. The researchers found out through the use of DPPH assay with ascorbic acid as the standard curve that the tapuy from Sablan had the most antioxidant activity to which was quantitated at 88.5%. Next, the tapuy from Trinidad ranked the lowest in antioxidant activity at 50.00%. Tapuy from the municipalities of Atok, Kapangan, Bokod, Tublay, and Tuba were calculated at 65.1%,

71.3%, 68.6%, 63.6%, and 76.6% respectively. 50 µL of each of the tapuy variants were analyzed at 37°C and were between 15-21 days old.

Dela Rosa & Medina (2021) is another research study that experimented on different types of rice wine with each wine differing in their originating rice varieties. The DPPH radical scavenging assay was used against the standard curve of gallic acid in order to determine the different wine samples' antioxidant activity. According to the researchers, the rice wine that was made from black rice (Ballatinao) had the highest antioxidant activity at 70.63% while the rice wine made from white rice (Bongkitan) had the lowest antioxidant activity at 45.44%. For the remaining rice wine varieties; red rice (Kintoman) and brown rice (Tinawon) had antioxidant activities of 57.66% and 57.20% respectively.

On the other hand, Barcelo et al. (2015) utilized the standard curve of gallic acid that was prepared in 80% methanol to quantify the results of the samples. The 6-month-old sample wines were left in a dark room at room temperature after being shaken thoroughly. The guyabano wine had the most % DPPH radical scavenging activity at 90.38% (±2.51), mangosteen wine had second-most at 89.55% (±0.76), then ayosep wine at 74.4% (±2.99), followed by strawberry wine at 69.95% (±12.8), and pineapple wine at 62.39% (±12.3).

Zubia & Dizon (2018) formulated their own fruit wines by blending three types of wines together with different proportions to compare the samples' antioxidant activity. The standard used was gallic acid to estimate the total phenolic contents of the different wine blends with the Folin-Ciocalteu method. 1000 µL of the sample wines were analyzed at room temperature after aging them for 3 months. The authors stated that the MPAPF blend's antioxidant activity is at 44.47%, then the 2M blend's is at 45.26%, the 2PA's blend at 42.67%, and lastly, the 2PF's blend is at 41.27%.

Table 4. Antioxidant activity of local wines evaluated using spectrophotometric techniques.

Type of Wine	Analytical Technique	Quantity of Wine Analysed	Temperature	Age	Antioxidant Activity	Author and Year
Tapuy wine (Sablan, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	88.5%	Hipol & Alma-in (2018)
Tapuy wine (Trinidad, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	50.0%	Hipol & Alma-in (2018)
Tapuy wine (Atok, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	65.1%	Hipol & Alma-in (2018)
Tapuy wine (Kapangan, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	71.3%	Hipol & Alma-in (2018)
Tapuy wine (Bokod, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	68.6%	Hipol & Alma-in (2018)
Tapuy wine (Tublay, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	63.6%	Hipol & Alma-in (2018)
Tapuy wine (Tuba, Benguet)	DPPH radical scavenging assay	50 µL	37°C	15-21 days	76.6%	Hipol & Alma-in (2018)
Tapuy wine (Bongkitan)	DPPH radical scavenging assay	100 µL	25°C	7 days	45.44%	Dela Rosa & Medina (2021)
Tapuy wine (Tinawon)	DPPH radical scavenging assay	100 µL	25°C	7 days	57.20%	Dela Rosa & Medina (2021)

continuation . . .

Type of Wine	Analytical Technique	Quantity of Wine Analysed	Temperature	Age	Antioxidant Activity	Author and Year
Tapuy wine (Kintoman)	DPPH radical scavenging assay	100 µL	25°C	7 days	57.66%	Dela Rosa & Medina (2021)
Tapuy wine (Ballatinao)	DPPH radical scavenging assay	100 µL	25°C	7 days	70.63%	Dela Rosa & Medina (2021)
Guyabano wine	DPPH radical scavenging assay	75 µl	25°C	6 months	90.38% (±2.51)	Barcelo et al. (2015)
Strawberry wine	DPPH radical scavenging assay	75 µl	25°C	6 months	69.95% (±12.8)	Barcelo et al. (2015)
Mangosteen wine	DPPH radical scavenging assay	75 µl	25°C	6 months	89.55% (±0.76)	Barcelo et al. (2015)
Ayosep wine	DPPH radical scavenging assay	75 µl	25°C	6 months	74.4% (±2.99)	Barcelo et al. (2015)
MPAPF*	DPPH radical scavenging assay	1000 µL	25°C	3 months	44.47%	Zubia & Dizon (2018)
2M**	DPPH radical scavenging assay	1000 µL	25°C	3 months	45.26%	Zubia & Dizon (2018)
2PA***	DPPH radical scavenging assay	1000 µL	25°C	3 months	42.67%	Zubia & Dizon (2018)
2PF ****	DPPH radical scavenging assay	1000 µL	25°C	3 months	41.27%	Zubia & Dizon (2018)

Note:
*MPAPF 33.33% mango wine + 33.33% pineapple wine + 33.33% passion fruit wine;
**2M - 50.00% mango wine + 25.00% pineapple wine + 25.00% passion fruit wine;
***2PA - 25.00% mango wine + 50.00% pineapple wine + 25.00% passion fruit wine;
***2PF - 25.00% mango wine + 25.00% pineapple wine + 50.00% passion fruit wine
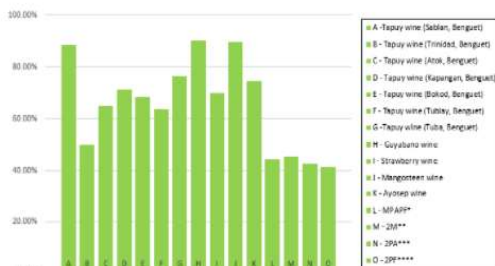
Figure 2. Comparison of antioxidant activity of various locally-available wines.

Statistical treatment was carried out in order to know the effects of temperature and age on the local wines and the effect of temperature on the fruits. The chi-square test was used to relate the age and temperature towards the antioxidant activity. As a result, the wine temperature and the antioxidant activity were found out to have a moderate correlation with each other ($x2c = 1.53$, $\alpha = 2.71$). Additionally, its age was found to have no significant correlation to the antioxidant activity of the wines ($x2c = 11.56$, $\alpha = 6.25$). But, the fruit temperature and its antioxidant activity were also found to have a significant correlation much like the wines ($x2c = 5.00$, $\alpha = 6.25$). Besides the relationship of the variables, Higgins' I2 heterogeneity statistics was utilized to find the variety of results in the given studies. The relationship between the wine temperature and antioxidant activity showed moderate heterogeneity ($I2 = 34.64\%$). Additionally, the age had a significant heterogeneity with the antioxidant ($I2 = 82.69\%$) while the fruit temperature was mildly homogenous with the antioxidant activity ($I2 = 40.00\%$).

4. CONCLUSIONS

With the results that the researchers have gathered, the fruit with the highest antioxidant activity was the strawberry fruit (Barcelo et al., 2015) and as for the wines, the wine with the highest

antioxidant activity was the guyabano wine from the same study. Based on the available data, the researchers concluded that the antioxidant activity of both wines and fruits are affected by the temperature that they were subjected to while the age of wines do not. Additionally, the heterogeneity was also considerable in the data involving the antioxidant activity in relation to both temperatures in fruit and wine ($I2 = 34.64\%$; $I2 = 40.00\%$). But the heterogeneity of the antioxidant in regards to age is significantly high ($I2 = 82.69\%$) which concludes that the data are not that associated with each other. In conclusion, the temperature of the wine and fruit has a direct correlation to the antioxidant activity while the wine age does not have an important role.

Recommendations

Given the limited amount of data available about the antioxidant activity of Philippine fruits and wines, the researchers suggest that future studies should have more data to further confirm the findings in this paper. Specifically, a longer range of temperature from 0°C to 100°C and a longer age frame of wines from 7 days to 10 years would be more beneficial to better understand the relationship between the parameters of local fruits and wines.

5. ACKNOWLEDGMENTS

6. REFERENCES

Barcelo, R.C. (2015). Phytochemical Screening and Antioxidant Activity of Edible Wild Fruits in Benguet, Cordillera Administrative Region, Philippines. Electronic Journal of Biology, 11.

Barcelo, R., Basilio, A., Calsiyao, I., Mabesa, C., Palconete, R., & Tobias, J. (2015). Antioxidant Property and Total Polyphenol and Flavonoid Content of Selected Fruits and Fruit Wines. Philippine E-Journal for Applied Research and Development, 5(2015), 57-64. Retrieved from http://pejard.slu.edu.ph/vol.5/2015.12.17.pdf.

Garcia, V. V., Magpantay, T. O., & Escobin, L. D. (2005). Antioxidant Potential of Selected

Philippine Vegetables and Fruits, 88(1), 78–83. https://www.researchgate.net/publication/281550680_Garcia_VV_Magpantay_T_o_and_Escobin_L_D2005_Antioxidant_potential_of_selected_vegetables_and_fruits_Phil_Agricultural_Scientist_88178-83.

Han, F., Ju, Y., Ruan, X., Zhao, X., Yue, X., Zhuang, X., f… Fang, Y. (2017). Color, anthocyanin, and antioxidant characteristics of young wines produced from spine grapes (Vitis davidii Foex) in China. Food & Nutrition Research, 61(1), 1339552. doi:10.1080/16546628.2017.1339552

Hipol, R. B., & Alma-in, A. B. (2018). Antioxidant potentials of indigenously produced Benguet tapuy (rice wine). International Food Research Journal, 25(5), 1968-1976. Retrieved from http://www.ifrj.upm.edu.my/25%20(05)%202018/(29).pdf

Lizardo, R. C., Mabesa, L. B., Dizon, E. I., & Aquino, N. A. (2015). Functional and antimicrobial properties of bignay [Antidesma bunius (L.) Spreng.] extract and its potential as natural preservative in a baked product. International Food Research Journal, 22(1), 88-95. Retrieved from http://www.ifrj.upm.edu.my/22%20(01)%202015/(14).pdf

Morelock, J. (2018, March 21). Wineries in the Philippines. https://traveltips.usatoday.com/wineries-philippines-100846.html

Pisoschi, A. M., & Negulescu, G. P. (2012). Methods for Total Antioxidant Activity

Determination: A Review. Biochemistry & Analytical Biochemistry, 01(01). doi:10.4172/2161-1009.1000106

Santiago, D. O., Garcia, V. V., Dizon, E. I., & Merca, F. E. (2007). Antioxidant

Activities, Flavonol and Flavanol Content of Selected Southeast Asian Indigenous

Fruits. Philippine Agricultural Scientist, 90(2), 123-130. Retrieved from https://www.researchgate.net/publication/281550813_SANTIAGO_D_M_O_V_V_GARCIA_E_I_DIZON_and_F_E_MERCA_2007_Antioxidant_Activities_Flavonol_and_Flavanol_Content_of_Selected_Southeast_Asian_Indigenous_Fruits_Phil_Agricultural_Scientist_90_2123-130

Zubia, C. S., & Dizon, E. I. (2019). Physico-chemical, antioxidant and sensory properties of artificially-carbonated fruit wine blends. International Food Research Journal, 26(1), 217-224. http://www.ifrj.upm.edu.my/26%20(01)%202019/(24).pdf

Effects of Different Drying Methods on Extractable Phenolic Compounds from Turkey Berry (Solanum torvum) Leaves

Mikaela Vivienne M. Bautista, Jennifer Love D. Calajate,
Zandrew Peter C. Garais and Jela May B. Yap
De La Salle University Integrated School, Manila

Abstract: In the Philippines, there is an abundance of plants rich in phenolic compounds such as *Solanum torvum* (turkey berry), a plant with antifungal, antibacterial, anticancer, antimicrobial, and antiviral properties; however, there is not much information on the extraction of its phenolics, especially on the best drying method that will give the highest yield. Drying reduces water which allows better extraction of the said phenolics, but different drying methods expose the phenolics to possible degradation. In this study, the effect of different drying methods, namely sun-drying, freeze-drying, and microwave-drying on the extraction of total phenolics from *S. torvum* leaves was investigated. The dried leaves were macerated to determine the best drying method that would give the highest content of phenolic compounds from *S. torvum* leaves. Sun-drying, the most energy-efficient method, resulted in the highest extraction yield of 2.14 ± 0.01 mg GAE/g d.w., which was significantly different from the yields of microwave-drying and freeze-drying. Freeze-drying resulted in the lowest yield of 1.02 ± 0.01 mg GAE/g d.w., while microwave-drying yielded 1.58 ± 0.03 mg GAE/g d.w. Due to the photosensitivity of the freeze-dried samples and the high temperature of microwave-drying, phenolic compounds have degraded resulting in lesser yields. Although microwave-drying yielded less than sun-drying, it is the most efficient drying method out of the three as it is more energy-efficient than freeze-drying and less time-consuming than the others.

Key Words: solanum torvum; phenolic compounds; drying methods; maceration; total phenolic content (tpc)

1. INTRODUCTION

1.1. Background of the Study

Solanum torvum (turkey berry), shown in Figure 1, is widely distributed in the Philippines (Centre for Agriculture and Bioscience International, 2014). It contains phenolic compounds (see Appendix A), some of which possess anticancer, anticonvulsant, anti-inflammatory, and anti-diabetic properties (Kaunda & Zhang, 2019). Extraction of these compounds would maximize the use of this plant in different fields, especially medicine.

Figure 1
Solanum torvum Plant

Note. Photo by J. Viñegas (2020)

All extraction methods of bioactive compounds from plants utilize drying. Drying reduces moisture while minimizing transportation and preservation costs and lengthening the sample's shelf life since bacteria and enzymes cannot proliferate under dry conditions (Pham et al., 2015; Ahmed et al., 2013). The reduction of water also increases the yield of phenolic compounds since enzymes in water degrade phenolic compounds (Ghomari et al., 2019). Extraction yield may vary depending on the drying method and temperature used since these factors can diminish bioactive compounds (Mbondo et al., 2018).

In this study, sun-drying, freeze-drying, and microwave-drying were utilized. Sun-drying exposes samples under direct sunlight. It was selected as a natural drying method for this experiment as it is widely used in similar studies (Roshanak et al., 2015). In freeze-drying, samples are frozen to let the water evaporate by sublimation, preserving the quality of bioactive compounds as there is no heat present (Thamkaew et al., 2020). Microwave-drying uses microwave electromagnetic radiation that reduces drying time, resulting in higher nutrient yield (Babu et al., 2018). Microwave-drying dries leaves within a short duration, while freeze-drying produces the

highest phenolic compounds and antioxidant quality, making them viable for investigation (Babu et al., 2018). With the advantages and disadvantages of these methods, this study aims to utilize different drying methods in extracting the highest yield of total phenolic content (TPC) present in *Solanum torvum* leaf.

1.2. Statement of the Problem

Plants with medicinal potential are endemic in the Philippines. However, more research should be done on these endemic plants with phenolic compounds such as *Solanum torvum* for the utilization of their beneficial compounds. Moreover, research on the drying methods and extraction techniques on these plants is not widely emphasized. Drying methods maximize the extraction of phenolic compounds for the utilization of their medicinal properties. However, certain parameters may degrade phenolic compounds. Thus, the researchers propose to investigate the effects of different drying methods on the phenolic content of *Solanum torvum* leaves.

1.3. Research Objectives

The general objective of this study is to determine the drying method that will yield the highest amount of phenolic compounds from *Solanum torvum* leaf via maceration. In order to accomplish the main objective, these specific objectives were followed:

1. To investigate the effect of the drying method on the amount of phenolic compounds extracted.
2. To identify the best drying method for *Solanum torvum* based on the yield of phenolic compounds, drying time, and energy consumption.

1.4. Scope and Limitations

This study focuses on the extraction of bioactive compounds in *Solanum torvum*, specifically phenolics. However, this study does not aim to identify the specific compounds nor demonstrate their effectiveness. It only investigated the effect of sun-drying, freeze-drying, and microwave-drying on the yield of phenolic compounds from *S. torvum* leaves. Only the drying method was tested. The dried samples were all macerated at room temperature. Data analysis was performed to compare the TPC obtained through phytochemical analysis and determine which among the three (3) drying methods produced the highest yield.

1.5. Significance of the Study

The leaves of *Solanum torvum* hold great potential in medical remedies with their abundance in medicinal properties and microbial activities. The medicinal constituents of the plant material can be obtained through extraction techniques such as maceration. However, the drying methods used may affect the extraction yield. Hence, results in investigating different drying methods that would give the highest TPC from this plant can maximize resources for developing natural remedies and medicine in the Philippines. Furthermore, this study may provide further knowledge on harvesting phenolic compounds from the plant for treating diseases and infections through the recommendation of the ideal drying method for maceration on *S. torvum*. Similar future studies may be provided with an initial standard of optimizing maceration of bioactive compounds from *S. torvum* from which they can improve with a broader scope.

2. METHODOLOGY

Sun-drying, freeze-drying, and microwave-drying were employed as independent variables to investigate the effect of each method on the phenolic extraction yield of *S. torvum* leaves. The dried samples were macerated for extraction. Using the Folin-Ciocalteu (F-C) method, the TPC of the extracts was quantified. The yields were then compared through statistical means to determine whether there is a significant difference between the drying methods. Figure 2 summarizes the methodology.

Figure 2
Flowchart of the Study
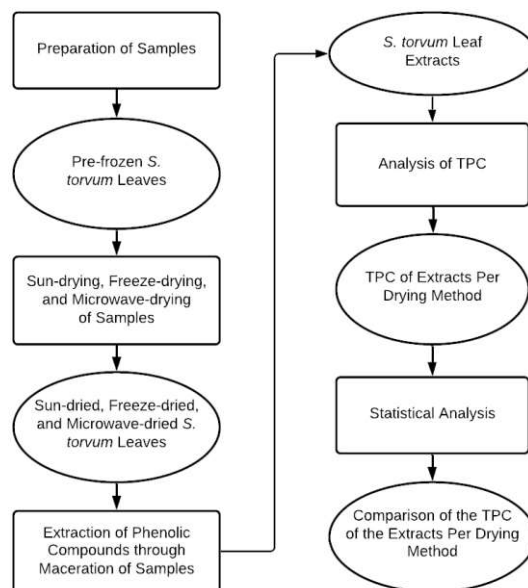
2.1. Materials

2.1.1. Solanum torvum Leaf Samples

Samples of Solanum torvum leaves were acquired from a local farm in Dasmariñas, Cavite.

2.1.2. Reagents

The extraction process utilized 80% aqueous ethanol. Its polarity encouraged researchers to recognize ethanol as a good solvent for retrieving polyphenols from plant extracts (Do et al., 2014).

The Folin-Ciocalteu reagent (FCR) was used to determine TPC of the extracts in terms of gallic acid concentration. It is highly reactive to bioactive compounds such as phenols (Everette et al., 2010). Gallic acid was also utilized as the analytical reference curve for obtaining the values of the TPC. Lastly, sodium carbonate enabled the reaction of the FCR and phenols as it increases the pH level of the solution.

2.1.3. Microwave

An American Home AMW-25 mechanical microwave oven was used for microwave-drying. It has an input power of 1200 W and a power output of 700 W. It has six power levels: low, defrost, medium-low, medium, medium-high, and high.

2.1.4. Freeze-Dryer

A SCIENTZ-18N Lyophilizer Manufacturers Vacuum Function Freeze-dryer with a base temperature of less than -56°C was utilized for freeze-drying. It has an input power of 1300 W.

2.2. Experimental Procedure

2.2.1. Preparation of Samples

After collection, the fresh Solanum torvum leaves were transferred to an airtight container and stored in a freezer with a temperature of -20°C to preserve the samples until they were needed.

2.2.2. Design of Experiment

The experiment was done under a full-factorial design (2^k levels where k is the number of factors) with the drying method as the only varying parameter. Duplicate runs of drying were done. The results of each run were macerated for 12 hours. Phytochemical analysis of its constituents was performed through the Folin-Ciocalteu method.

2.2.3. Drying of Samples

The samples were subjected to sun-drying, microwave-drying, and freeze-drying. The weight of the leaves before and after drying were recorded to determine the moisture content using Equation 1,

$$\% \; moisture \; content = \frac{M_0 - M}{M_0} \times 100 \qquad (1)$$

where M_0 is the mass of the sample before drying and M is the mass of the sample after drying.

2.2.3.1. Sun-Drying

The samples were dried in direct sunlight for four (4) hours and stored in a Ziplock plastic bag with desiccant. They were refrigerated until the next day to repeat the drying process until a constant weight was achieved. The sun-drying process took four days.

2.2.3.2. Microwave-Drying

Two containers of S. torvum leaves were microwaved for 18 minutes per trial at a medium power level of 462 W, equating to a temperature of around 148.9°C to 190.6°C (Superb1.ca, 2016).

2.2.3.3. Freeze-Drying

Pre-frozen samples were lyophilized in a freeze-dryer for eight (8) hours at a temperature below 0°C and a pressure of 20 millibars (mbar).

2.2.4. Extraction of Phenolic Compounds

Phenolic compounds in S. torvum leaves were extracted from the powdered samples in 80% aqueous ethanol through maceration. In a loosely sealed glass vessel, 10 grams (g) of the sample was soaked in 100 milliliters (mL) of the solvent for 12 hours at room temperature. The solids were then separated from the extract using a filter paper. The liquid was refrigerated until it was needed for analysis.

2.2.5. Analysis of Total Phenolic Content

The Folin-Ciocalteu method by Abdulkadir et al. (2016) on the extraction of total phenolic compounds from Solanum torvum was followed with some modifications. This method is anchored to the reaction of the oxidant reagent and tyrosine, which exhibits the protein concentration of the extract (Sánchez-Rangel et al., 2013). First, 250 microliters of the sample extract was diluted in a test tube with ethanol. Then, 1.25 mL of FCR was diluted in distilled water with a volume-to-volume ratio of 1:9. The solution was then incubated at room temperature. After 10 minutes, 1 mL of 8% sodium carbonate solution was added. The solution was incubated again for 30 minutes. Using a spectrophotometer, the sample's absorbance was determined at 650 nanometers. Gallic acid was used as the standard. The

TPC was expressed as gallic acid equivalent (mg GAE/g).

2.2.6. Statistical Analysis

One-way ANOVA (analysis of variance) using Analysis ToolPak was performed at 95% confidence level (p-value=0.05) to compare the phenolic content of the *S. torvum* leaf extracts per drying method.

3. RESULTS AND DISCUSSION

3.1. Moisture Content of the Solanum torvum Leaves

Sun-drying, freeze-drying, and microwave-drying were used to investigate the moisture content of the *S. torvum* leaves. The moisture content was computed using Equation 1, ranging from 72.19% to 77.41% as seen in Table 1.

Table 1

Moisture Content of the Solanum torvum Leaves

Drying Method	Trial	Initial Mass (g)	Final Mass (g)	Moisture Content (%)
Sun-Drying	1	119.8	33.32	72.19
	2	107.4	26.83	75.02
Freeze-Drying	1	110.3	27.2	75.34
	2	111.1	26.7	75.97
Microwave-Drying	1	120.01	27.11	77.41
	2	120.1	27.73	76.91

3.2. Total Phenolics Extracted from Dried Solanum torvum Leaves

A calibration curve (see Appendix C) with an R^2 of 0.9958 was constructed by measuring the absorbance of a standard solution at different concentrations. The equation from the calibration curve for extrapolating the concentration of phenolic compounds in terms of mg gallic acid equivalent/mL is shown in Equation 2,

$$GAE_{volume} = \frac{(abs) - (-0.02356)}{3.7376} \qquad (2)$$

where GAE_{volume} is the gallic acid equivalent (GAE) of phenolics per milliliter and *abs* is the absorbance of the extract solution reacted with the FCR.

The extraction yield in terms of mg GAE/g was calculated using Equation 3,

$$GAE_{mass} = \frac{GAE_{volume} \times V_{extract}}{m_{sample}} \qquad (3)$$

where GAE_{mass} is the GAE of phenolics per gram of powdered sample, GAE_{volume} is the GAE of phenolics per milliliter, $V_{extract}$ is the volume of extract collected from maceration, and m_{sample} is the mass of powdered sample in grams.

The values calculated using Equations 2 and 3 are shown in Table 2.

Table 2

Absorbance, Phenolic Content, and Extraction Yield of the S. torvum Samples

Trial	Drying Method	Absorbance	Phenolic Content (mg GAE/mL extract)	Extraction Yield (mg GAE/g d.w.)
1	Sun-Drying	1.710	0.464	2.129
	Microwave-Drying	0.994	0.272	1.607
	Freeze-Drying	1.320	0.359	1.024
2	Sun-Drying	1.658	0.450	2.155
	Microwave-Drying	1.049	0.287	1.547
	Freeze-Drying	1.389	0.378	1.009

3.3. Effect of Parameters on Phenolics Yield

The TPC of each drying method derived from spectrophotometric analysis was compared by their extraction yield per trial. Sun-drying resulted in higher extraction yields from the maceration of dried *S. torvum* leaves. An average of 2.14±0.01 mg GAE/g d.w. was extracted from samples sun-dried for 16 hours, reaching maximum temperatures of 31°C to 33°C. Meanwhile, the drying of *S. torvum* leaves using a medium-powered microwave with a temperature of around 148.9°C to 190.6°C for 18 minutes returned an average of 1.58±0.03 mg GAE/g d.w. Samples freeze-dried at a temperature below 0°C for eight hours gave the lowest extraction yield of only 1.02±0.01 mg GAE/g d.w.

Table 3

Parameters and Extraction Yield of Each Drying Method

Drying Method	Energy Consumption (W)	Drying Time (hours or minutes)	Extraction Yield (mg GAE/g d.w.)
Sun-Drying	0	16 hours	2.142
Microwave-Drying	462	18 minutes	1.577
Freeze-Drying	1300	8 hours[a]	1.017

[a]The samples were left inside the freeze-dryer for around 30 hours.

As shown in Table 3, sun-drying took the longest time to dry the samples but yielded the most phenolic compounds without energy consumption. Microwave-drying took a significantly shorter drying period than the former but yielded lesser phenolics with greater energy consumption. Freeze-drying required the most energy and a longer drying period than microwave-drying yet derived the least phenolic compounds. Sun-drying is the most energy-efficient drying method out of the three, however, it is weather-dependent and uncontrollable. Meanwhile, microwave-drying is the most time-efficient as it yields a significant amount of phenolics while consuming less time. However, further study is needed to optimize microwave-drying and freeze-drying to extract more bioactive compounds in *S. torvum*.

3rd

Table 4

One-way ANOVA of Extraction Yield from S. torvum Leaves Dried Using Different Methods

Source of Variation	Sum of Squares	df	Mean Square	F	P-value	F crit
Between Groups	1.26606704	2	0.633034	844.7076	7.46E-05	9.552094
Within Groups	0.002248234	3	0.000749			
Total	1.268315274	5				

The statistical analysis through one-way ANOVA is shown in Table 4. A p-value of less than 0.05 was obtained, showing that there is a significant difference between the extraction yields of *S. torvum* leaves dried using different methods.

Figure 3
Average Extraction Yield of Phenolic Compounds from S. torvum Leaves
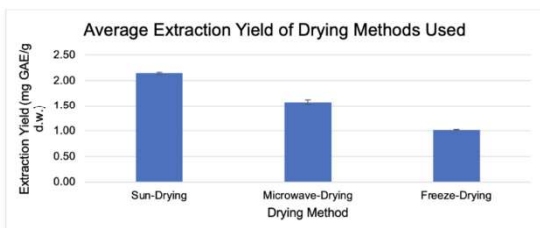
As shown in Figure 3, sun-dried samples had the highest yield, while the microwave-dried leaves had lower yields than the former, possibly due to high temperatures. Orphanides et al. (2013) elaborated that the degradation and instability of heat-sensitive phenolics in their samples might have caused their microwave- and oven-dried samples to yield the least phenolic contents. Meanwhile, freeze-dried samples yielded the lowest TPC among the three. Freeze-dried leaves are usually susceptible to atmospheric moisture and oxygen, resulting in destabilization and loss of bioactive compounds (Labconco, 2010). Overall, microwave-drying is the most efficient method for the extraction of *Solanum torvum* leaves as it has the shortest drying period, increasing its potential to produce larger volumes of extracts for medicinal use.

4. CONCLUSIONS

This study investigated the effect of three different drying methods on the TPC of *Solanum torvum* leaf extracts. Among them, sun-drying yielded the highest amount of TPC while consuming the least energy. Freeze-drying yielded the least amount of phenolic compounds while consuming the most energy, making it the least favorable drying method for *Solanum torvum* leaves.

Microwave-drying is the best drying method for *Solanum torvum* leaves in terms of drying time. Its extracts yielded a greater amount of TPC than the freeze-dried extracts despite having the shortest drying time among the three and consuming less power than freeze-drying.

5. ACKNOWLEDGMENTS

6. REFERENCES

Abdulkadir, A., Mat, N., Hasan, M., & Jahan, M. (2016). In vitro antioxidant activity of the ethanolic extract from fruit, stem, and leaf of Solanum torvum. ScienceAsia, 42(3), 184. https://doi.org/10.2306/scienceasia1513-1874.2016.42.184

Ahmed, N., Singh, J., Chauhan, H., Anisa Anum, P. G. A., & Kour, H. (2013). Different Drying Methods: Their Applications and Recent Advances. International Journal of Food Nutrition and Safety, 4(1), 34–42. https://www.researchgate.net/publication/275650176_Different_Drying_Methods_Their_Applications_and_Recent_Advances

Babu, A. K., Kumaresan, G., Raj, V. A. A., & Velraj, R. (2018). Review of leaf drying: Mechanism and influencing parameters, drying methods, nutrient preservation, and mathematical models. Renewable and Sustainable Energy Reviews, 90, 536–556. https://doi.org/10.1016/j.rser.2018.04.002

Centre for Agriculture and Bioscience International (2014, February 28). Solanum torvum (turkey berry). https://www.cabi.org/isc/datasheet/50559

Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismadji, S., & Ju, Y.-H. (2014). Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. Journal of Food and Drug Analysis, 22(3), 296–302. https://doi.org/10.1016/j.jfda.2013.11.001

Everette, J. D., Bryant, Q. M., Green, A. M., Abbey, Y. A., Wangila, G. W., & Walker, R. B. (2010). Thorough Study of Reactivity of Various Compound Classes toward the Folin-Ciocalteu Reagent. Journal of Agricultural and Food Chemistry, 58(14), 8139–8144. https://doi.org/10.1021/jf1005935

Ghomari, O., Sounni, F., Massaoudi, Y., Ghanam, J., Drissi Kaitouni, L. B., Merzouki, M., & Benlemlih, M. (2019). Phenolic profile (HPLC-UV) of olive leaves according to extraction procedure and assessment of antibacterial activity. Biotechnology Reports, 23, e00347. https://doi.org/10.1016/j.btre.2019.e00347

Kaunda, J. S., & Zhang, Y. J. (2019). The Genus Solanum: An Ethnopharmacological, Phytochemical and Biological Properties Review. Natural Products and Bioprospecting, 9, 77–137. https://doi.org/10.1007/s13659-019-0201-6

Labconco. (2010). A Guide To Freeze Drying for the Laboratory [Pamphlet]. https://condor.depaul.edu/jmaresh/instruments/Instruments/Freeze%20Dry/guide_fd.pdf

Mbondo, N. N., Owino, W. O., Ambuko, J., & Sila, D. N. (2018). Effect of drying methods on the retention of bioactive compounds in African eggplant. Food Science & Nutrition, 6(4), 814–823. https://doi.org/10.1002/fsn3.623

National Center for Biotechnology Information (2021, May 8). PubChem Compound Summary for CID 3314, Eugenol. https://pubchem.ncbi.nlm.nih.gov/compound/Eugenol

National Center for Biotechnology Information (2021, May 8). PubChem Compound Summary for CID 338, Salicylic acid. https://pubchem.ncbi.nlm.nih.gov/compound/Salicylic-acid

National Center for Biotechnology Information (2021, May 8). PubChem Compound Summary for CID 689075, Methyl caffeate. https://pubchem.ncbi.nlm.nih.gov/compound/Methyl-caffeate

National Center for Biotechnology Information (2021, May 8). PubChem Compound Summary for CID 88563, 2,4,6-Trimethoxyphenol. https://pubchem.ncbi.nlm.nih.gov/compound/ 2_4_6-Trimethoxyphenol

Orphanides, A., Goulas, V., & Gekas, V. (2013). Effect of drying method on the phenolic content and antioxidant capacity of spearmint. Czech Journal of Food Sciences, 31(5), 509–513. https://doi.org/10.17221/526/2012-cjfs

Pham, H., Nguyen, V., Vuong, Q., Bowyer, M., & Scarlett, C. (2015). Effect of Extraction Solvents and Drying Methods on the Physicochemical and Antioxidant Properties of Helicteres hirsuta Lour. Leaves. Technologies, 3(4), 285–301. https://doi.org/10.3390/technologies3040285

Roshanak, S., Rahimmalek, M., & Goli, S. A. H. (2015). Evaluation of seven different drying treatments in respect to total flavonoid, phenolic, vitamin C content, chlorophyll, antioxidant activity and color of green tea (Camellia sinensis or C. assamica) leaves. Journal of Food Science and Technology, 53(1), 721–729. https://doi.org/10.1007/s13197-015-2030-x

Sánchez-Rangel, J. C., Benavides, J., Heredia, J. B., Cisneros-Zevallos, L., & Jacobo-Velázquez, D. A. (2013). The Folin-Ciocalteu assay revisited: improvement of its specificity for total phenolic content determination. Analytical Methods, 5(21), 5990. https://doi.org/10.1039/c3ay41125g

Schauer, J. J., Kleeman, M. J., Cass, G. R., & Simoneit, B. R. T. (2001). Measurement of Emissions from Air Pollution Sources. 3. C1−C29 Organic Compounds from Fireplace Combustion of Wood. Environmental Science & Technology, 35(9), 1716–1728. https://doi.org/10.1021/es001331e

Simaratanamongkol, A., Umehara, K., Niki, H., Noguchi, H., & Panichayupakaranant, P. (2014). Angiotensin-converting enzyme (ACE) inhibitory activity of Solanum torvum and isolation of a novel methyl salicylate glycoside. Journal of Functional Foods, 11, 557-562. https://doi.org/10.1016/j.jff.2014.08.014

Superb1.ca. (2016, February 10). Basic Microwave Tips. http://www.superb1.ca/ Microwave%20Tips/BASIC%20MICROWAVE%20TIPS.pdf

Thamkaew, G., Sjöholm, I., & Galindo, F. G. (2020). A review of drying methods for improving the quality of dried herbs. Critical Reviews in Food Science and Nutrition, 1–24. https://doi.org/10.1080/10408398.2020.1765309

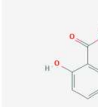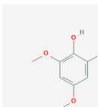Viñegas, J. (2020). [Photograph of Solanum torvum plant].

7. APPENDICES
Appendix A
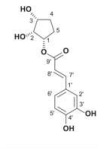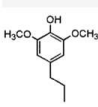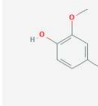
Table A1
Phenolic Compounds of Solanum torvum

Compounds	Part	Properties
Methyl caffeate	Fruit	Antibacterial, antidiabetic
(E)-2,3-dihydroxycyclopentyl-3-(3',4'-dihydroxyphenyl)acrylate	Fruit	Antihypertensive
Salicylic acid	Aerial	
2,4,6-Trimethoxyphenol	Stem	
Propionylsyringol	Stem	
Eugenol	Stem	

Note. Adapted from "The Genus Solanum: An Ethnopharmacological, Phytochemical and Biological Properties Review" by J.S. Kaunda & Y.J. Zhang, 2019, *Natural Products and Bioprospecting*, *9*, pp. 77–137

Table A2

Structures of Phenolic Compounds of Solanum torvum

Compounds	Structure	Reference
Methyl caffeate		National Center for Biotechnology Information, 2021
(E)-2,3-dihydroxycyclopentyl-3-(3',4'-dihydroxyphenyl) acrylate		Simaratanamongkol et al., 2014
Salicylic acid		National Center for Biotechnology Information, 2021
2,4,6-Trimethoxyphenol		National Center for Biotechnology Information, 2021
Propionylsyringol		Schauer et al., 2001
Eugenol		National Center for Biotechnology Information, 2021

Appendix C

Figure C1

Calibration Curve