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Aim and Scope

Quality of Life publishes original research papers and reviews and aims to provide a forum for the rapid dissemination of significant novel research in the various disciplines encompassing the Science and technology of food, Public health engineering, Sanitary inspection and control, Environmental and public health. Topics covered by the journal include:

- Dietetics; Nutrition principles applied to foods
- Food Technology; Production and preservation of foodstuffs; Food preservation technique
- Industrial microbiology; Science and technique of applied microbiology; Applied mycology
- Public Health, environment and hygiene
- Hygiene of air, water, soil; Pollution and its control
- Water; Sanitation; Water treatment
- Sewage; Treatment, disposal, utilization of sewage
- Urban hygiene; Wastes; Refuse; Rubbish; Garbage; Collection and disposal of town wastes
- Measures against industrial and other nuisances
- Occupational health hazards; Occupational health and hygiene
- Ecology; Environmental engineering, sustainability and health
- Related topics

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Dear readers,

it is my pleasure to present you the new issue of Quality of Life magazine and to thank you for your trust.15 years ago, we published the first issue of the journal Quality of Life. During that time, we have faced various challenges that have served as guides for progress and improvement in the work and publication of this journal. In the future, we will strive to continue working to provide our readers with quality and interesting research papers from various disciplines that include food technology, health engineering, sanitary inspection and control, environment and public health.

The journal Quality of Life was registered in the Register of Public Media in 2010 by the Decision of the RS Ministry of Education and Culture. Over the past years, this journal has published a large number of original scientific research papers, communications and review papers. Quality of Life is published twice a year by Pan-European University "Apeiron" Banja Luka. All the papers published so far have undergone a thorough review by the editorial board and the reviewers, made up of experts from both RS/B&H, the surrounding and other countries, from proven and recognized university and research institutions. As a result of a professional approach to selecting and reviewing papers, and raising the quality of the journal, Quality of Life was classified in the first category of journals in 2019 by the Ministry of Education and Culture. We are proud to say that Quality of Life has been well received by the scientific and the general public in a relatively short period, which gives the editorial board a strong motivation for further work. The editorial team would like to thank our many reviewers who helped to maintain the journal standard; our many authors who submitted their best work to the journal; and, most importantly, our readers for your continuing support. I assure all our readers that our consistent efforts will be aimed toward increasing the visibility, impact, editorial cycle time, citations and overall quality of our journal. We very much look forward to strengthening the reputation of our publications, and we want to attract more higher-quality submissions.

As always, I would like to thank the authors for their contributions to this issue of the magazine, and express great gratitude to all the reviewers who participated in the editorial process by providing valuable feedback to the editors and authors in a timely manner. We also extend our heartfelt thanks to the numerous authors who submitted their best papers to the magazine, and most importantly, to our readers for their continued support.

In the spirit of continuous improvement, any constructive input on streamlining our processes is very welcome. Please help us grow by citing articles that you read in Quality of Life. We look forward to receiving your contributions in the near future.

Editors

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Original scientific paper

Impact of Migraine on Disability and Quality of Life: Perspective from South Indian Context

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Abstract: Objective: The present study aimed to measure migraine disability scores, severity of depression and quality of life (MIDAS, PHQ-9 and WHOQOL) among migraine patients in South Indian population. **Method:** All participants were examined by a neurologist to confirm the migraine diagnosis. The data collection was conducted at the Bangalore Neuro Centre with a sample of 129 individuals. Pearson Correlation used to explore the relationships between migraine disability, depression severity and quality of life. **Result:** Our results indicated that migraines are significantly associated with depression across different age groups (15-40 years and 41-65 years). Additionally, both migraine and depression were found to impact all aspects of life including physical, psychological, social and environmental functioning. Our study highlighted the interaction between WHOQOL domains suggesting that various aspects of quality of life are interconnected. **Interpretation:** Despite the negative impact of migraines on quality of life, South Indian Population demonstrated better adaption and functioning capabilities compared to other populations.

Keywords: Migraines, Depression, Quality of life and South Indian Population.

INTRODUCTION

Headaches are one of the most common neurological conditions which are affecting individuals globally. It is commonly defined as the pain in any region of the head. The intensity, duration, and etiology of headaches typically vary, ranging from primary headaches like tension headaches and migraines to secondary headaches like sinus headaches. The extent and severity of headaches are underestimated, universally neglected and undertreated (Stovner et al., 2007). Significant declines in overall functioning and quality of life are identified by headaches (D'amico et al., 2013).

The primary headaches, especially migraine affects more than one billion people every year with a high prevalence and morbidity which is mostly seen in young adults and females (Amiri et al., 2022). Migraines are severe, throbbing headaches that frequently are assocaited with light and sound sensitivity, nausea, and vomiting. In addition, a range of syndromes, including cyclic vomiting, abdominal migraine, paroxysmal vertigo, paroxysmal torticollis, and confusional migraine, may be associated with migraines. These syndromes differ in their clinical presentations, durations, and frequencies (Straube & Andreou, 2019). About 12% of Caucasian people suffer from migraines, with women more likely than males to get them (Younger, 2016). In primary care, where it is often underdiagnosed, undertreated, and poorly recognized, it can be challenging to manage (Dowson, 2001). It's a life-threatening illness that interferes with work and school commitments, family relationships, and financial security (Leonardi & Raggi, 2019). The intensity of migraine headaches can range from slight discomfort that does not interfere with daily activities to excruciating agony that causes extended incapacitation, greatly impairing the sufferer's quality of life

(Anand & Sharma, 2007). Adults who are at their most productive years—such as the end of adolescence and the early 1950s—frequently experience primary headaches (Taşkapılıoğlu & Necdet, 2013).

In recent years, there has been a lot of interest in migraine research and how it affects people's quality of life. It is frequently examined using Migraine disability assessment scale -MIDAS (Stewart et al. 1999). This evaluates migraine severity by counting the total number of days in the previous three months when migraines interfered with an individual's productivity and everyday tasks (Stewart et al., 2001). Depression and anxiety, which are typical comorbidities with migraines, are commonly assessed with PHQ. According to studies, greater MIDAS scores, which assess migraine-related impairment, are frequently connected with higher PHQ-9 scores, indicating more severe depressive symptoms. This shows that people who have more severe migraines are more prone to suffer from depression (Dindo et al., 2014).

Assessing a patient's quality of life (QOL) is an excellent technique to measure migraine burden since it targets on activity constraints or short term impairments. (Shaik et al., 2015). The WHOQOL is a comprehensive examination of people's opinions of their place in life, considering their cultural backgrounds and value systems, as well as their personal objectives, standards, and worries (Whoqol Group, 1995). According to research, increased migraine-related disability (higher MIDAS scores) correlates with worse WHOQOL scores, indicating a lower quality of life. Migraines can have a considerable negative impact on everyday activities and general well-being (Leonardi et al., 2010). Higher PHQ-9 scores, showing more serious depressive symptoms, are associated to lower WHOQOL scores, suggesting a poorer quality of life. Depression can have serious consequences in many areas of life, especially one's physical condition, psychological well-being, and social connections (Skevington et al., 2004). Some research investigated the combined correlations of MIDAS, PHQ, and WHOQOL. For example, one study investigated the linked impacts of migraine-related disability, depression, and quality of life (Minen et al., 2016). The study discovered that higher MIDAS scores were strongly related with both higher PHQ scores and lower WHOQOL scores, emphasizing migraines combined deleterious impact on mental health and overall quality of life.

To date, there is no published study on QOL, PHQ and migraine disability among South Indian population. In this study, we aimed to measure all three factors among migraine patients.

METHODOLOGY

The present data was collected in Bangalore Neuro Centre (BNC), which is a neurospeciality and OPD centre in Bangalore. Upon arrival at Bangalore Neuro Centre, the patients were subjected to a full neurological evaluation by qualified neurologist. After the initial screening process using the inclusion and exclusion criteria, the patients were informed about the purpose of the study and consenting patients were asked to complete the written informed consent forms. All participants were then examined by a neurologist to confirm the migraine diagnosis. Sociodemographic information was completed by the researcher. Following the neurological examination and diagnosis, the patients were transferred to the neuropsychology department for additional evaluation of various headache characteristics and their influence on daily functioning. In the neuropsychology unit, we utilised systematic interviews and questionnaires (MIDAS, WHOQOL-BREF and PHQ-9) to learn about the features of their headaches.

A cross-sectional design was used to assess and compare headache characteristics and disability across the migraine patients. The inclusion criteria include patients between 15-65 years of age diagnosed with migraine at least for more than one year by a neurologist and should be familiar with Kannada or English. The exclusion criteria include patients who are not between the age group 15-65 years, patients with any neurological conditions such as epilepsy, strokes and individuals who are not familiar with Kannada or English. The study included South Indian sample of 129 headache patients diagnosed with Migraine

headache. The study sample was divided into two groups. The first group consists of Young to middle aged adults who are aged 15 to 40 years and the second group consists of Middle-Aged to Older adults who are aged 41-65 years.

Tools

1.Migraine Disability Assessment Scale (MIDAS)

It is an often-used tool for measuring the impact of migraines on a person's daily functioning and quality of life. Stewart developed the MIDAS scale, which measures the level of disability caused by migraines over a three-month period with scores ranging from 0 to 92. Based on the overall scores, four disability grades are assigned: grade I, II, III and IV (Stewart et al., 1999).

2. World Health Organization Quality of Life (WHOQOL)

It is frequently used to assess quality of life, especially in the setting of chronic health disorders like migraines. The WHOQOL-BREF is a shorter version with 26 measures that addresses four major domains: physical health (WHOQOL I), psychological health (WHOQOL II), social interactions (WHOQOL III), and environment (WHOQOL IV). Each item is assessed on a 5-point Likert scale, and the scores are converted to a 0-100 scale for comparison. Higher ratings imply a better quality of life (Skevington et al., 2004).

3. Patient Health Questionnaire-9

It is a popular tool for assessing the severity of depression. Each item examines the frequency of depressed symptoms over the previous two weeks, offering a complete picture of the individual's mental health (Kroenke et al., 2001). The PHQ-9 are assessed on a range of 0 to 3. The overall score runs between 0 and 27, with higher numbers indicating more severe depression. The scoring system is commonly divided into five severity levels (Kroenke et al., 2001).

Statistical Analysis

Descriptive statistics, such as means, standard deviations, frequencies were used to summarize the headache characteristics, MIDAS scores, PHQ-9 scores and WHOQOL scores. Pearson Correlation was used to explore the relationships between disability scores, severity of depression and quality of life among migraine patients in two different age groups (15-40 years and 41-65 years). The data was analysed by using IBM SPSS Statistics software 27.0 version.

RESULTS

Table 1 shows that MIDAS score of 25.68 which shows moderate migraine related disability. The high SD (39.03) signifies a vague range of disability levels among patients, from very low to very high. The PHQ-9 score of 6.45 lies within the range for mild depression and SD of 6.74 indicates variability in depressive symptoms, indicating some might have higher levels of depression. A mean score of 56.86 indicates moderate satisfaction with physical health and SD of 13.21 suggests some variability in physical health perceptions among patients. The mean score of 53.27 for psychological health reflects moderate satisfaction, slightly lower than physical health and high SD 17.57 indicates significant variability. A score of 62.69 suggests relatively high satisfaction with social relationships and SD of 21.36 shows substantial variability in social satisfaction. The mean score of 65.73 indicates high satisfaction with environmental conditions and SD of 13.98 points to moderate variability in environmental satisfaction.

Table 1: Descriptive statistics (mean and standard deviation) for MIDAS, PHQ-9 and WHOQOL of Young to middle aged adults

	Mean	SD
MIDAS	25.68	39.03
PHQ-9	6.45	6.74
WHOQOL I	56.86	13.21
WHOQOL II	53.27	17.57
WHOQOL III	62.69	21.36
WHOQOL IV	65.73	13.98

SD = standard deviation

Table 2 illustrates that MIDAS score of 17.75 which shows mild to moderate migraine-related disability and high SD 33.22 shows broad range of responses, with some experiencing very low disability and others experiencing much higher levels. A PHQ-9 score of 3.58 indicates minimal to mild depression and SD of 5.63 shows little variability in depressive symptoms. The mean score of 59.00 indicates a moderate to high level of satisfaction with physical health and SD of 13.20 shows some differences in physical health perceptions. The mean score of 55.94 for psychological health indicates moderate satisfaction. This score is slightly higher in Middle to Older adults, suggesting an improvement in psychological health and SD of 15.89 shows significant variability in psychological health perceptions. The mean score of 67.22 indicates high satisfaction with social relationships and SD of 19.05 shows variability in social satisfaction, but in general patients feel positive about their social relationships. A mean score of 65.72 for the environment domain indicates high satisfaction with environmental conditions and SD of 11.36 suggests moderate variability in environmental satisfaction.

Table 2: Descriptive statistics (mean and standard deviation) for MIDAS, PHQ-9 and WHOQOL of Middle-Aged to Older adults

	Mean	Std. Deviation
MIDAS	17.75	33.22
PHQ	3.58	5.63
WHOQOL I	59.00	13.20
WHOQOL II	55.94	15.89
WHOQOL III	67.22	19.05
WHOQOL IV	65.72	11.36

SD = standard deviation

Table 3 represents that there is a significant positive correlation (0.419) between MIDAS and PHQ-9 scores, indicating that higher migraine-related disability is associated with higher levels of depressive symptoms in young to middle aged adults. It also shows significant negative correlations between MIDAS and WHOQOL I and II (-0.414,-0.380) which suggest that higher migraine-related disability is associated with poorer physical and psychological health. The weak or non-significant correlations with WHOQOL III and IV (-0.012, -0.132) indicate that migraines may have less impact on social relationships and environmental s8atisfaction. Moreover, it shows significant negative correlations between PHQ-9 and WHOQOL I and II (-0.485, -0.561) suggest that higher levels of depression are associated with poorer physical and psychological health. The weak negative correlations with WHOQOL III and IV (-0.117, -0.164) imply a less direct impact of depression on social and environmental satisfaction. Besides the above, the significant

positive correlations among WHOQOL domains (0.672 , 0.380 and 0.536) indicate that better physical health is associated with better psychological health, social relationships, and environmental satisfaction in young to middle aged adults.

Table 3: Relationship between MIDAS, PHQ-9 and WHOQOL scales of Young to middle aged adults

	MIDAS	PHQ-9	WHOQOL I	WHOQOL II	WHOQOL III	WHOQOL IV
MIDAS	0					
PHQ-9	0.419**	0				
WHOQOL I	-0.414**	-0.485**	0			
WHOQOL II	-0.380**	-0.561**	0.672**	0		
WHOQOL III	-0.012	-0.117	0.380**	0.432**	0	
WHOQOL IV	-0.132	-0.164	0.536**	0.560**	0.549**	0

**Significant at 0.01 level.

Table 4 reveals that MIDAS and PHQ-9 have a Pearson coefficient of 0.799 which shows strong positive correlation indicating that higher migraine-related disability is strongly associated with higher levels of depressive symptoms. It shows that there are negative correlations between MIDAS and all WHOQOL domains (-0.525, -0.504, -0.393 and -0.388) suggest that higher migraine-related disability is associated with poorer quality of life across physical, psychological, social, and environmental domains among 41-65 years. Also, the negative correlations between PHQ-9 and all WHOQOL domains (-0.621, -0.570, -0.340 and -0.329) suggest that higher levels of depression are associated with poorer physical, psychological health, environment satisfaction and social ties. Besides the above, the significant positive correlations among WHOQOL domains (0.694,0.694 and 0.513) indicate that better physical health is associated with better psychological health, social relationships, and environmental satisfaction. Quality of life is multifaceted, and improvements in one domain often correlate with improvements in others.

Table 4: Relationship between MIDAS, PHQ-9 and WHOQOL scales of Middle-Aged to Older adults

	MIDAS	PHQ	WHOQOL I	WHOQOL II	WHOQOL III	WHOQOL IV
MIDAS	0					
PHQ	0.799**	0				
WHOQOL I	-0.525**	-0.621**	0			
WHOQOL II	-0.504**	-0.570**	0.694**	0		
WHOQOL III	-0.393*	-0.340*	0.694**	0.606**	0	
WHOQOL IV	-0.388*	-0.329	0.513**	0.650**	0.557**	0

*Significant at 0.05 level; **Significant at 0.01 level.

NOTE: The Raw scores of WHOQOL are converted to transformed scores as per the norms.

DISCUSSION

The present study has explored the relationship between migraine related disability, depressive symptoms and quality of life in adults. The results have shown that migraines are highly associated with depression in younger, middle and older adults. Buse shows the significant comorbidity rates of migraines and psychiatric illnesses, particularly depression, across different age groups, stressing the biopsychosocial variables at play (Buse et al., 2013) whereas Saunders says, while comorbid illnesses such as depression might aggravate migraine-related disability, good comorbidity care can reduce the effects on mental health

(Saunders et al., 2008). Migraines place a significant burden on people, including physical discomfort, emotional suffering, and functional impairment (Lipton et al., 2001).The severity and frequency of migraine attacks can impede everyday activities, work productivity, and social contacts, resulting in a significant drop in QoL whereas Campo reveals that not all children and adolescents with chronic health disorders, such as migraines, have depressed symptoms, implying the availability of resilience elements (Campo et al., 1999). While migraines pose a considerable health cost, not all migraine sufferers, particularly those with excellent coping techniques and treatment, experience depressed symptoms (Bigal et al., 2010)

We found that migraine and depression will affect one's quality of life in all aspects by limiting physical, psychological, social and environmental functioning. For younger adults, migraines depressive symptoms disrupt the developmental milestones such as academic achievement, social relations and establishing independence. It can also lead to feelings of loneliness and isolation eventually. Middle-aged individuals may have less energy, become more irritable, and struggle to manage daily responsibilities as taking care of the kids, or their parents and balancing their work life as well as their personal life, all of which led to a lower quality of life (Buse et al., 2013). The expenditures of treating chronic migraines and depression, such as drugs, medical visits, and missed workdays, quickly add up. This financial stress can further reduce quality of life (Blumenfeld et al., 2011). Multiple chronic health issues are common in older persons, which might interact with migraines and depression to worsen their quality of life. Comorbid disorders can raise the overall disease burden and require more healthcare (Saunders et al., 2008). Moreover, it also reduces mobility and independence in older adults.

Migraines have a major effect on quality of life across all age groups, emphasizing the compounded effect when depression is present (Lipton et al., 2001) whereas migraines are challenging, appropriate management and treatment can reduce their impact on quality of life, emphasizing the significance of proper medical care and support (Bigal et al., 2010). It can cause severe functional impairment, affecting job, family, and social life and this impairment can result in missed work days, lower productivity, and strained relationships, adding to the total cost of the disease for adults.

Our study had interrelations between WHOQOL domains. So, we can say that different aspects of quality of life are interrelated to each other. The factors that determine an individual's quality of life are their surroundings, education, occupation, housing, and health (Taşkapılıoğlu & Necdet, 2013). Migraine sufferers' quality of life is greatly reduced, as it affects many facets of everyday life such as social relationships, mental stability, and physical health. Regular and severe migraines can lead to severe physical pain, persistent discomfort, and disability that can make it difficult for a person to carry out everyday tasks, compromise their physical health, and degrade their quality of life (Lipton et al., 2007). They usually experience increased levels of stress, anxiety, and depression, which negatively affects their emotional health and overall quality of life (Smitherman et al., 2011).

According to a Saudi Arabian study, migraine sufferers had major reductions in their quality of life, especially challenges in continuing their social and professional routines (AlHarbi, 2020). Furthermore, a thorough analysis of migraine studies reveals a negative correlation between a higher frequency of headaches and a lower standard of life and health. This correlation highlights the significance of specific treatment regimens for those suffering from chronic migraines in order to enhance their general quality of life (Leonardi & Raggi, 2019). The intensity of migraine headaches ranges from mild discomfort that does not interfere with daily activities to excruciating pain that causes persistent incapacitation that significantly lowers quality of life (Anand & Sharma, 2007). The general quality of life, mental and emotional well-being, employment, family, and social life are all negatively impacted by migraines and it is associated with feelings of stigma, avoidance behaviour, dread, frustration, guilt, and isolation (Estave et al., 2021). Some

studies employing quality of life (QoL) measurements such as the Migraine-Specific Quality of Life Questionnaire (MSQ), those who suffer from migraines have much lower QoL scores than the general population (Bagley et al., 2012).

Younger adults frequently report a strong correlation between physical and mental health. Physical activity and fitness have a substantial impact on their mood and mental health, and vice versa. Positive physical health can improve psychological results by lowering stress, anxiety, and sadness. Social relationships are critical in this age group, as peer support and social activities are important for psychological well-being. Strong social bonds can buffer against stress and promote mental health, but poor social support can exacerbate psychological difficulties. The environment, which includes access to recreational amenities and safe neighbourhoods, can have an impact on physical health. A supportive atmosphere promotes physical activity and a healthy lifestyle, which improves general well-being (Schulte & Vainio, 2010). Numerous factors affect quality of life (QoL); if these elements are addressed, an individual's QoL may rise in a variety of ways (Zhang et al., 2018).

Chronic health problems in middle-aged adults can have a major impact on psychological well-being. The stress of managing chronic diseases such as migraines can cause melancholy and anxiety, which can worsen physical symptoms (Blumenfeld et al., 2011). Social ties frequently interact with the environmental realm. Conversely, a stressful work environment might have a negative impact on social interactions and psychological health (VanderWeele et al., 2012). Middle-aged persons in good mental health are more likely to have strong social networks, which give emotional support and improve quality of life (Blumenfeld et al., 2011). Middle-aged persons with excellent coping strategies may be able to retain their quality of life in the face of low environmental or social support conditions (Carver et al., 1989).

Physical health in older persons is intimately related to their surroundings. Access to healthcare services, safe housing, and community support can have a substantial impact on their physical health. Poor environmental circumstances can cause physical decline and lower quality of life. Older individuals' psychological health relies heavily on social assistance. Strong social networks can offer emotional support while reducing feelings of loneliness and sadness. Conversely, social isolation can have a harmful impact on mental health. In addition, the environment has an impact on older persons' psychological health. Living in a supportive, safe, and engaging setting can improve mental well-being, but living in hazardous or unstimulating environments can lead to mental health concerns. Research studies have indicated that migraines have a significant detrimental influence on many elements of QoL. Individuals with migraines had poorer scores in physical health, psychological well-being, social interactions, and environmental areas than those without migraines. Individuals who suffer from migraines may struggle to live an active and satisfying life due to the continual pain and impairment they experience (Lipton et al., 2001).

Inspite of migraines clearly causing many obstacles, migraineurs are able to lead a successful and balanced lives. Despite the considerable hardship that migraines cause on people, many persons with this condition exhibit great resilience and adaptability to manage their everyday lives. Our research has shown that, while migraines have a detrimental influence on quality of life (QoL) and give rise to depressive symptoms, a significant proportion of people manage to preserve their functional abilities and live satisfying lives. We have interestingly found that in South Indian Population, even though migraine affects quality of life, they are well adapted and have good functioning capabilities when compared to other populations.

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Data Availability
Upon a reasonable request, the corresponding author will provide the data sets utilized or analysed in the current study.

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Original scientific paper

Comparison of Filtration Capacity of two Non-Metalic Raw Materials for Fine Water Suspended Particles

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ABSTRACT: The basic parameters of two natural non-metallic raw materials from R.N. Macedonia have been defined: white opalized tuff from the locality of Strmosh and, diatomaceous earth from the locality of Slavishko Pole as potential materials for water filtration. Two different sets of water filtrations were carried out for each material with a previously prepared bentonite clay water suspension with a grain size of below 32 μm. A continuous filtration was performed in a column with a well-defined flow, and discontinuous flow under static conditions, i.e. diffusion active system. The percentage of retained clay grains was estimated, namely, by means of continuous filtration with white opalized tuff the percentage of retained clay particles was 12.88%, and 35.00% when diatomaceous earth was used as a filtration material. The filtration capacity under dynamic conditions for diatomaceous earth was 0.028 g/g material, and 0.011 g/g material for white opalized tuff.

Key words: water filtration, white opalized tuff, diatomaceous earth, water suspension, filtration capacity.

INTRODUCTION

Due to the increasingly rapid environmental development, the necessity for water is correspondingly increasing, which imposes the necessity for the application of more efficient methods in the processes of preparation of drinking water. Filtration is one of the oldest and simplest methods for the preparation of drinking water, which denotes a process of removing suspended substances from water by moving through a porous layer (Abdiyev et al., 2007, Wotton, 2002). Non-metallic raw materials are used as potential filtration materials due to their originating features. The R.N. Macedonia is rich in non-metallic raw materials with a wide range of possible use and application. The non-metallic materials play an essential role in enhancing the efficiency of water filtration methods. Primarily, they assist in the reduction of contaminants by acting as catalysts or adsorbents. Depending on the materials and their properties, several characterization studies had been accomplished (Bogoevski et al., 2014, Bogoevski et al., 2016, Reka et al., 2019, Pavlovski et al., 2011, Reka et al., 2012, Bogoevski et al., 2012). Several studies indicate that diatomaceous earth (DE) utilized as a filter have been able to remove microparticles, thus maximizing water quality. This extent of filtration unallowed tiny particles to be passed on including viruses, bacteria, algae, and additional microscale particles (Zhanna et al., 2020, Raunak et al., 2024, Flexicon, 2010, Bhardwaj & Mirliss, 2005). Nevertheless, in numerous studies, tuff has been used as a filtration material due to its properties (Blažev et al., 2014, Savić et al., 2019, Abeer et al., 2017). Therefore, for the sake of the present study, some of the basic parameters of the diatomaceous earth from Slavishko Pole and the white opalized tuff (WOT) from Strmosh were comparatively defined in order to utilize them as filtration materials.

MATERIALS AND METHODS

The white opalized tuff (WOT) from the locality of Strmosh belongs to the group of andesitic tuffs (Figure 1). The size of the pieces that make up the tuffs are different and vary from a few millimeters to a few tens of centimeters. These are gray-white, yellowish, and pinkish rocks. From a mineralogical point

of view, WOT is a raw material predominantly composed of amorphous SiO_2. In minimal amounts, it also contains crystalline modifications of SiO_2 such as tridymite and quartz, as well as finely dispersed ore minerals. The WOT is characterized by high porosity, it is thermally stable up to 1740˚C, so since it exceeds the temperature limit of 1580˚C, it can be classified in the group of the refractory raw materials.

The mineralogical-petrographic examinations of the diatomaceous earth (DE) sample (bulk rock) originating from Slavishko Pole, consists of microscopic and X-ray examinations (Bogoevski et al., 2014, Bogoevski et al., 2016, Boškovski et al., 2015). The DE from the locality of Slavishko Pole is characterized by a white color and a fine-grained structure (Figure 2). It crumbles easily between the fingers, resulting in grains of small size but rough to touch. This suggests that the sample represents a weakly bound rock. The sample easily absorbs water, which indicates significant porosity, and it acquires a grayish-white color. It takes considerable time for it to release the absorbed water and regain its primary white color. With the microscopic examination, it was determined that the cryptocrystalline base mass was maximally represented (over 95%) in the sample. In the basic cryptocrystalline mass (probably predominantly amorphous), several percent of ultra-fine grains with dimensions from approximately 0.005 – 0.10 mm to approximately 0.05-0.1 mm of quartz and feldspar were encountered, i.e. visible (Bogoevski et al., 2014, Bogoevski et al., 2016, Boškovski et al., 2015).

Figure 1. WOT (fraction 2-4 mm)

Figure 2. DE (fraction 2-4 mm)

The average chemical compositions of WOT and DE expressed in mass percent (Bogoevski et al., 2014, Bogoevski et al., 2016, Boškovski et al., 2015) are shown in Tables 1 and 2, respectively.

Table 1. Average chemical composition of WOT (mass %)

Si_O2	90.26
Al_2O_3	2.64
Fe_2O_3	0.38
CaO	2.31
MgO	0.78
Na_2O	0.36
K_2O	0.25
SO_3	0.43
L.w.	2.24
Σ	99.65

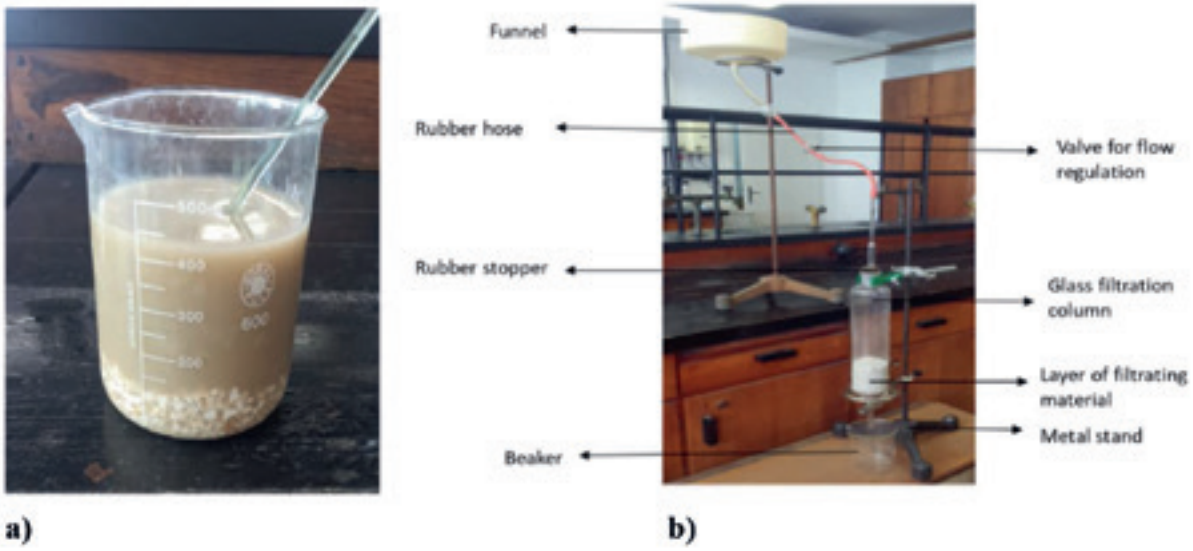
Table 2. Average chemical composition of DE (mass %)

SiO_2	72.07 %
Al_2O_3	12.09 %
Fe_2O_3	1.00 %
CaO	2.95 %
MgO	1.41 %
Na_2O	2.10 %
K_2O	1.90 %
SO_3	tr. %
L.w.	5.76 %
Σ	99.28 %

The preparation of white opalized tuff and diatomaceous earth as materials for the filtration procedure involves crushing and separating the appropriate grain size fractions. The materials were primarily crushed on a jaw crusher and afterward crushed twice on a roller crusher (distance between the rollers being 10 mm and 5 mm). Then, the dimensional fraction of grains (-4+2 mm) was separated via dry sieve process.

A pre-prepared suspension was filtered through the porous materials. The suspension used in the filtration process was consisted of bentonite clay with a grain size of below 32 μm. For this purpose, the appropriate dimensional fraction of bentonite clay grains was previously obtained through wet sieve analysis. The prepared suspension had a mass concentration of 13 g/l. Two types of filtrations were carried out, namely discontinuous and continuous. The discontinuous filtration/batch was realized in a beaker with an occasional stirring (Figure 3a). The continuous filtration was performed under dynamic conditions in a filtration column (Figure 3b). The laboratory apparatus was set up, and the used filtration material (diatomaceous earth and white opalized tuff) was positioned into the filtration column, occupying a volume of 300 cm^3.

Figure 3. Equipments for both methods of filtration



After the filtration materials was placed and moistened, the suspension of bentonite clay was poured through the funnel into the filtration column with a laminar mode and a continuous flow of 100 cm^3/min (Figure 4. Filtration layers of DE, and Figure 5. Filtration layers of WOT). The duration of the filtration was determined at 20 min (filtered 2 litres of suspension).

Figure 4. Filtration layers of DE

Figure 5. Filtration layers of WOT

The effect was determined through gravimetric control and microscopic comparison of the used materials before and after the process of filtration. The filtration efficiency of the materials was determined by defining the retained suspended clay particles.

RESULTS AND DISCUSION

The DE material compared to WOT, under dynamic column filtration conditions, displays higher efficiency. The weight percentage of retained clay particles in diatomaceous earth was 25.15%, and 9.46% in WOT, nearly 2.5 times higher in DE than in WOT (Table 3 and Figure 6). Likewise, the results of the stationary filtration in the beaker indicate the exact outcome. The weight percentage of retained clay particles in DE was 35.00%, and 12.88% in WOT, almost 3 times higher in DE as compared to WOT.

Table 3. Filtration parameters

	White opalized tuff	Diatomaceous earth
Mass of clay in suspension for continuous filtration	26 g	26 g
Mass of retained clay during continuous filtration	2.46 g	6.54 g
Weight percentage of retained clay during continuous filtration	9.46 %	25.15 %
Capacity of retained clay during continuous filtration	0.011 g/g	0.028 g/g
Mass of clay in suspension for discontinuous filtration	5.2 g	5.2 g
Mass of retained clay during discontinuous filtration	0.67 g	1.82 g
Weight percentage of retained clay during discontinuous filtration	12.88 %	35.00 %
Capacity of retained clay during discontinuous filtration	0.008 g/g	0.022 g/g

Both materials exhibit a greater degree of efficiency under static than dynamic filtration conditions. Under static filtration conditions, there is a lower diffusion energy because the material was previously dried, which makes it easier to extract the clay particles in the unclogged pores. For the "empty" macropores, less diffusion energy is needed to push out the air and allow a clay particle to penetrate. In contrast, in non-stationary filtration, the material is moistened before the filtration begins. Because of this, the retention of clay particles is more difficult due to the higher diffusion energy since the pores are filled with water, and thus the diffusion energy is higher.

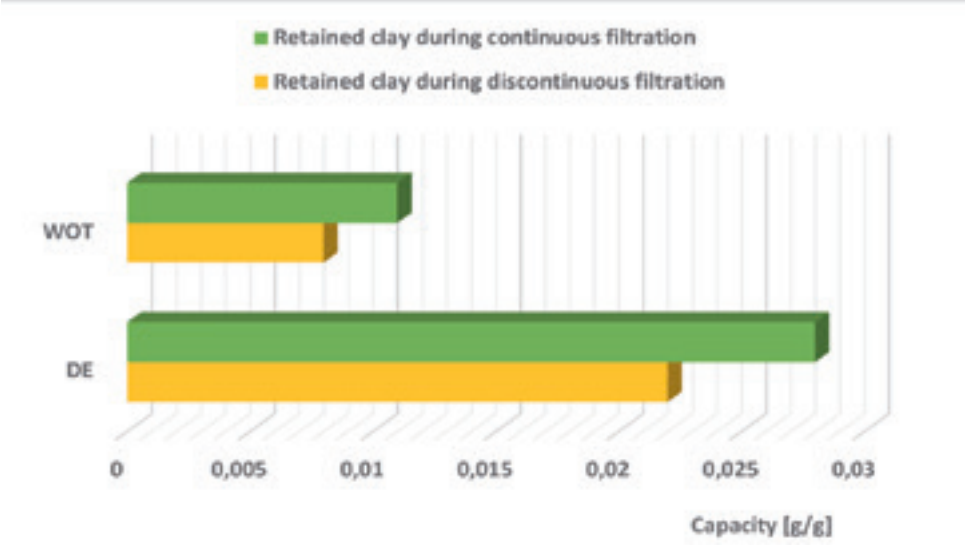
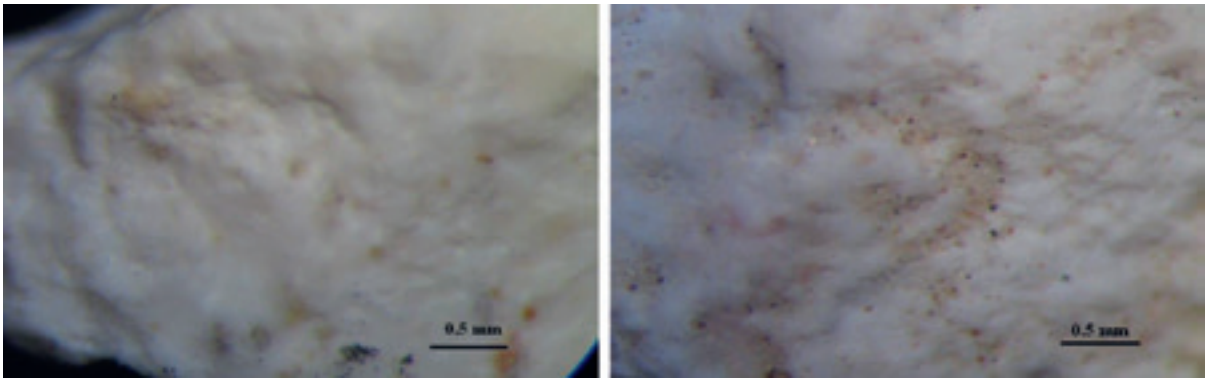


Figure 6. Filtration capacity of WOT and DE

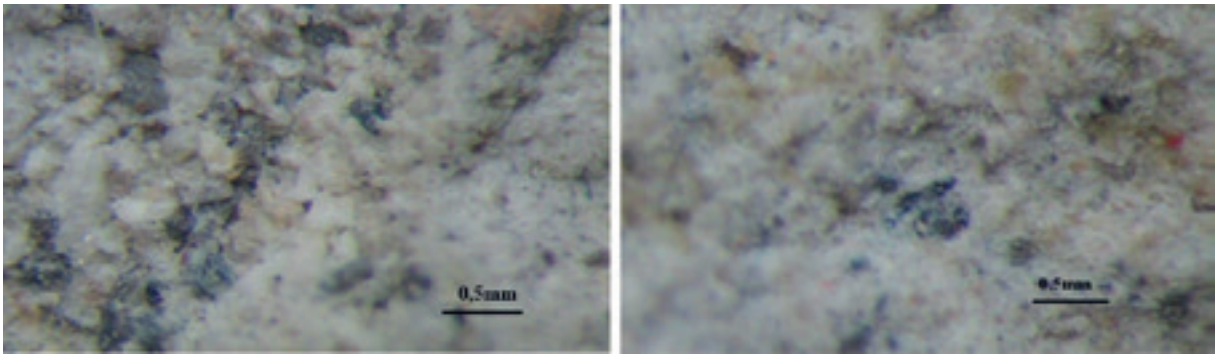
The filtration capacity (Figure 6) of DE was 0.028 g/g material under dynamic conditions and 0.022 g/g material under static conditions. The filtration capacity of WOT was 0.011 g/g material under dynamic conditions and 0.008 g/g material under static conditions. It can be observed that the filtration capacity of DE is much higher than WOT, as in the context of the aforementioned statements.

The figures of WOT and DE grains (Figures 7a and 8a) before filtration naturally show the surface macrostructure and the topography of the materials. With simultaneous examination of the micrographs, it can be observed that DE has a rougher structure and higher macroporosity than WOT.



a) **b)**

Figure 7. Surface of a WOT grain prior to filtration (a); surface of a WOT grain after filtration (b)



a) **b)**

Figure 8. Surface of a DE grain prior to filtration (a); surface of a DE grain after filtration (b)

When examining the figure of a cross-section of a WOT grain after filtration (Figure 7b) one can notice a larger range of distribution of particles of suspended matter, which coincides with the measured value or the filtered mass concerning non-stationary filtration. The same effect was due to the intenser diffusion in the system of pores in the grain that previously were filled only with air.

The particles of the suspended material that are gravimetrically proven to be retained in the porous system, during the filtration process, cannot be visually observed in the grains of DE after filtration, due to the colorfulness and diversity of the grains of the actual material (Figure 8b).

CONCLUSION

Regarding the obtained results, the used diatomaceous earth as a filtration material, shows better filtration capacity characteristics as opposed to the used white opalized tuff. The better efficiency of diatomaceous earth is due to the higher macroporosity, which is an important parameter for the filtration process. In

the figures obtained by optical microscopy, it can be noticed that the DE particles have a rougher morphology than WOT, and the suspended material particles that are verified gravimetrically cannot be visually observed due to the colorfulness and diversity of the original DE material. The weight percentage of retained clay particles were nearly 2.5 times higher in DE than in WOT. After the static filtration, the percentage of retained clay particles was practically 3 times higher in DE compared to WOT. When simultaneously compared (under static and dynamic conditions), a higher degree of filtration efficiency under static conditions can be noticed by both materials. The filtration capacity is correspondingly much higher with DE than WOT, under both filtration regimes. However, both materials show a higher efficiency in static compared to dynamic filtration conditions due to the lower value of the diffusion energy in static compared to dynamic conditions. The low value of the diffusion energy is mainly because the pores of the dried material are filled with air, practically increasing the diffusion potential of the system.

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Original scientific paper

Effect of Cognitive Processing Therapy on Self-Stigma and Quality of Life of Persons Newly Diagnosed of Hiv in Oyo State, Nigeria

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ABSTRACT: HIV/AIDS-related stigma decreases quality of life (QOL) in Persons Living With HIV and AIDS. This study was designed to examine the effects of Cognitive Processing Therapy (CPT) on self-stigma and QOL among persons newly diagnosed of HIV in Oyo State, Nigeria. Pretest-posttest control group quasi-experimental design with 2x5x3 factorial matrix was adopted. Forty-nine persons (male=17; female=32) newly diagnosed of HIV with age range of 20-45 years were purposively drawn from Antiretroviral therapy (ART) centres in three hospitals in Oyo State, Nigeria. The three sites were randomly assigned experimental and control groups. The instruments used were HIV Stigma (r= 0.78), Stigma-9 Questionnaire (r= 0.93), and Rosenberg Self-esteem scale (r=0.83). Analysis of covariance was used to analyse data at 0.05 level of significant. Result show that there was a significant main effect of treatment on self-stigma ($F_{(2; 33)}$ =711.64; partial η^2=0.98). The persons newly diagnosed of HIV in the CPT ($\bar{x}$ =60. 57) benefitted more than their conterpart in the control group ($\bar{x}$ =111.47). There was significant main effect of age on self-stigma ($F_{(2; 33)}$=6.53; partial η^2 =0.30). The participants in the age range of 30-34 benefitted more ($\bar{x}$ =73.08) than their counterparts in the other age ranges. There was also a main effect of self-esteem on self-stigma ($F_{(2; 33)}$ =13.08; partial η^2=0.46). The participants with high self-esteem benefited more than their counterpart with low and moderate self-esteem ($\bar{x}$ =82.86). CPT is an effective therapy for decreasing self-stigma among PLHIV.

Keywords: People living with HIV, HIV self-stigma, quality of life, Cognitive processing therapy, self-esteem

INTRODUCTION

The stigma associated with Human Immunodeficiency Virus (HIV) is a significant global public health concern. Most people living with or affected by HIV/AIDS in Nigeria have suffered one form of stigma or discrimination at either the community level, workplace, place of worship etc. There is no gain-saying that stigma and discrimination is the biggest battle people living or affected by HIV/AIDS fight (Adekoya, et al. 2024). People living with Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDs) (PLHIV) do not only face medical problems, they also face social problems associated with being infected with HIV. On one hand, the individual struggles with the symptoms that result from the virus and on the other, the same person is challenged by the stereotypes and prejudice that result from misconceptions about HIV and AIDS. As a result of both, people living with HIV are robbed of the opportunities that define a quality life such as good jobs, safe housing, satisfactory health care, and affiliation with a diverse group of people (Ofole, 2014).

According to Joint United Nations Programme on HIV/AIDS (UNAIDS) (2024) report, as at 2023 there were 39.9 million people across the globe with HIV, of these, 38.6 million were adults (>15 years old), and 1.4 million were children (<15 years old) while 53% of them were women and girls. It was also documented that around 630,000 people died from AIDS-related illnesses worldwide in 2023. HIV is still a major public health challenge in Nigeria as the country currently ranks fourth in the world with regards

to HIV burden. The country has an estimated 1.8 million people living with HIV (PLHIV) (UNAIDS, 2024) and an estimated 107,112 new HIV infections which is about 38% of new infections in West and Central African region. The Nigerian HIV prevalence rate is declining however, stigma indices does not show corresponding decline. Stigma and discrimination have become major stumbling blocks to HIV and AIDS mitigation programs as they discourage people from using HIV Testing Services (HTS) and keep those living with HIV from accessing ART. A recent study conducted by Adekoya et al. (2024) in Nigeria show that People living with HIV often experience stigma, hostility, denial of gainful employment, forced resignation or retirement, reception of poor quality treatment and segregation in hospital wards. The study further revealed that of the 215 respondents drawn from PLHIV in Akwa Ibom State, Nigeria, 50.4% had been denied access to health care services, because of their HIV status. Respondents also reported being afraid of: gossip (78%), being verbally abused (17%), or being physically harassed or assaulted because of their positive status (13%). Self-stigmatization was also evident; respondents reported being ashamed because of their positive HIV status (29%), exhibiting self-guilt (16%), having low self-esteem (38%), and experiencing self-isolation (36%). It was surprising that this level of stigma and discrimination still exist in Nigeria depite several actions taken to mitigate stigma and discrimination in the past.

HIV stigma is defined as negative attitudes, beliefs, and behaviours towards people living with or at risk of HIV (Restall, et al. 2023). It can also include the discrimination that results from these attitudes and beliefs. Attitudes toward the devalued attribute is often manifested as prejudice, stereotyping, and discrimination against PLHIV within families, communities and healthcare facilities (Restall, et al. 2023). Restall, et al. (2023) described self-stigma as a multi-faceted construct that can impact the degree to which people living with HIV choose to make their status known given the negative social consequences of such disclosure. Sometimes such stigmatisation of PLHIV is reflected in the derogatory description ascribed to this group in many countries. For instance, in many communities in Nigeria, living with HIV is synonymous with receiving a death sentence. For example, the Igbos in eastern Nigeria calls HIV ***obiri na aja ocha***, a disease that ends in the grave (Maduike & Care, 2010). While the yoruba in southwestern Nigeria describe HIV as a sexually transmitted infection (STIs) that is why it is referred to as "akoatosi" (virulent gonorrhea) in yoruba language. This is as a result of the wrong assumption that HIV is transmitted only through sexual intercourse thus, PLHIV are seen as sexually immoral individuals. Consequently, the PLHIV cannot disclose their status or even seek treatment because the iperson would be ridiculed as someone who is sexually immoral.

Earnshaw et al. (2009) opined that being newly diagnosed of HIV result to three primary stigma mechanisms, namely; enacted, felt (or anticipated, perceived), and internalized stigma *Enacted stigma* refers to experiences of prejudice or discrimination by an individual because of his/her HIV status; *Felt (or anticipated, perceived) stigma* refers to the expectation of experiencing stigmatisation because of HIV, and is often influenced by the perception of attitudes that others have towards PLHIV; and *Internalised stigma* refers to the endorsement of negative beliefs and feelings about oneself because of one's HIV-positive status. Steward et al. (2008) further introduced *Vicarious stigma* as a fourth stigma mechanism. It is defined as hearing or otherwise learning about prejudice or discrimination towards other people with HIV. For PLHIV, the combination of vicarious stigma and one's own experiences leads to *felt stigma*. It is well documented that health care providers, family, friends, or others in the community can serve as the sources of stigma (*Steward* et al. 2008; *Rutledge,* et al. 2011). Systematic reviews have highlighted previous attempts to reduce stigma and its impacts, primarily through education, skill building, and support (Dunbar. et al. 2020; Feyissa et al. 2019). Moreover, some stigma reduction strategies have demonstrated success, though the evidence is not robust. This could be because previous interventions failed to modify the pathological fear

structures that maintain self-stigma. As a result of this gap, this study was designed to examine the effects of cognitive processing therapy on reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria.

Previous studies show that Cognitive Processing Therapy (CPT) is an effective treatment for post-traumatic stress disorder (PTSD) (Nishith et al. 2024; LoSavio et al. 2022). This suggests that CPT can be effective for self-stigma because both PTSD and self-stigma are associated with higher levels of anxiety, depression, and traumatic stress symptoms. Cognitive processing therapy (CPT) is a manualised therapy originally developed to help clients recover from posttraumatic stress disorder and related conditions (D'Zurilla & Nezu, 2007). The assuption behind CPT is that individual's beliefs about the causes and consequences of traumatic events produce strong negative emotions, which prevent accurate processing of the traumatic memory and the emotions resulting from the events (Young, et al. 2003). CPT incorporates trauma-specific cognitive techniques to help individuals with stigma more accurately appraise these "stuck points" and progress towards recovery. This suggest that persons newly diagnosed with HIV will benefit from exposure to CPT because this therapy helps people challenge and change negative thought patterns and develop coping strategies which can promote recovery from shock of being disagnosed with HIV. This therapy also directly modify maladaptive cognitions that have developed due to HIV diagnosis. These maladaptive cognitions includes erroneous interpretations of the event (e.g., self-blame) or distorted views of the self or world (e.g., "nobody can be trusted"). By repeatedly challenging the maladaptive cognitions through the use of cognitive processing techniques, individuals are able to develop more balanced and healthy appraisals of being HIV positive, themselves, and the world. Thus, the restoration of adaptive appraisals promotes recovery of self esteem.

There is evidence that age could moderate treatment of stigma (Emlet, 2006; Moore, 2012), however, it is unclear whether HIV in older age is considered more or less stigmatizing than in younger age or whether older adults with HIV are more or less able to resist and challenge stigma than their younger counterparts (Emlet, et al. 2015). Nevertheless, it is widely anticipated that HIV-related stigma is produced about, and experienced by, older and younger people. Limited evidence available from sub-Saharan Africa confirms that some older adults with HIV anticipate both HIV- and age-related stigma. Fear of gossip, stigma and discrimination prevented more than a third of old people from disclosing their HIV serostatus (Moore, 2012). Kuteesa (2014) show that older adults' experience higher HIV related stigma due to higher level of depenecy for physical and financial supports. Further, HIV-related stigma has been reported to induce maladaptive responses in young adults, such as sex and substance abuse (Swendeman, et al., 2016).

Literature suggests that self-esteem can moderate treatment outcomes for CPT among PLHIV. Self-esteem is confidence in one's own worth, abilities, or morals. The construct of self-esteem has been shown to be a desirable one that is associated with a variety of positive outcomes, such as academic achievement, relationship satisfaction, happiness and lower rates of criminal behaviour (Hewitt et al. 2008). Recent evidence suggest that perceived and enacted stigma were negatively correlated with high self-esteem and stigma can contribute to low self-esteem (Kohli, et al. 2023) howerevr, the mechnaism that explains the relationship iy yet to be fully understood.

Purpose of the Study

This study was designed to broadly examine the effectiveness of cognitive processing therapy on reduction of self-stigma and quality of life among persons newly diagnosed HIV in Oyo State, Nigeria. Specifically, this study examined the;

i. The significant main effect of cognitive processing therapy on reduction of self-stigma among

persons newly diagnosed of HIV in Oyo State, Nigeria.

ii. The siginificant main effect of age on reduction of self –stigma among persons newly diagnosed HIV in Oyo State, Nigeria.

iii. The significant main effect of self-esteem on reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria

Hypotheses

Three null hypotheses were tested at 0.05 level of significant.

Ho_1: There is no significant main effect of cognitive processing therapy on reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria.

Ho_2: There is no significant main effect of age in the reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria**.**

Ho_3: There is no significant main effect of self-esteem in the reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria.

METHODS AND MATERIALS

Design

Pretest-posttest, control group quasi experimental design was adopted to execute the study. The column consist of the treatment (Cognitive Processing Therapy (A1) and a control group (A2), while the row was webbed with two moderating variables, namely; self-esteem at two levels (high, and low) and age range at 5 levels.

Table 1: Schematic representation of treatment conditions

0_1	XA_1	0_4
0_2		0_5

Where 0_1, and 0_2 are pre-tests
$0_{4,}$ and 0_5 are post-tests
XA_1 = Treatment with Cognitive Processing Therapy
$0_{2=}$ Control group

Ethical Clearance

The reseachers obtained ethnical approval from University of Ibadan Social Science and Human Research Ethics Committee (UI/SSHREC) with registration number; UI/2017/0017. In addition, to enable the researchers have access to ART centres in Oyo State, approval was also obtained from the Oyo State Ministry of Health (AD/13/479/1096). To ensure the principle of voluntariness, only participants who volunteered to partcipate were recruited. The volunteers were fully informed of the research purpose and the activities which have no health harm. Only those who signed informed consent form partcipated in the study and they were told they have the right to *opt out* at at any stage if they feel that their rights were violated. The partcipants were also not exploited but were given transport fares and modest meals during sessions. In order to guarantee anonymity of each participant, their names and other identity information were not included in the questionnaires but codes were used to collect data. To ensure that the principles of

accountability and transparency was observed, the research was conducted in a fair, honest, impartial and transparent manner using only PLWHIV who have done full disclosure.

Partcipants

Forty-nine PLHIV(male=17 female=32) with age range of 20 to 45 years and mean age 29 years who met the inclusioin criteria were purposively drawn from three ARV centres located in Oyo State, Nigeria The following criteria were used in selecting the participants for the study: (1) being newly diagnosed of HIV (seropositive confirmation not more than one year) (2) attendance of ART Centres located in Oyo State (3) being 20 years and above (4) not bed ridden but with stable state of heath and (5), scored 34 and above in the screening questionnaire and (6) signed and returned consent form.

Measures

HIV felt-stigma scale by Jimenez et al. (2010) was adopted to screen PLHIV for self-stigma. It was a 17-item self report questionnaire. The instrument measureed four dimensions of stigma, namely; personalised stigma, disclosure concerns, negative self-image, and concern with public attitudes. The personalised stigma dimension has five items and addresses the perceived consequences of other people knowing that one has HIV. The disclosure sub section has four items relating to withholding information, keeping one's HIV status secret, or worrying about others knowing one's HIV status. The negative self-image dimension was a five-item dimension related to the respondent's feelings of being unclean, inferior, or immoral as a result of having HIV. The concern with public attitudes dimension has three items referring to other people's attitudes or the consequences of others knowing one's HIV-positive status. Sample items include; *"I feel guilty because I have HIV"; "People with HIV are treated like a public nuisance"; "I feel the need to hide my HIV + status".*All items were anchored on a modified 4-point Likert scale ranging from strongly agreed (4), agreed (3), disagreed (2) and strongly disagreed (1). The items of the questionnaire were negatively worded, the higher the scores, the more the likelihood of having HIV self-stigma. The highest obtainable score was 68 while lowest obtainable score was 17. Those who scored from 34 and above met a criterium of selection for the study, because they reached the threshold of having HIV self-stigma. To ensure that the instrument was culturally relevant, it was pilot tested on randomly selected PLHIV in Osun State (a neigbouring State to Oyo). The test- retest reliability index after one week interval was r = 0.78.

Stigma-9 Questionnaire (STIG-9) by Gierk et al. (2018) was a self-report questionnaire utilised to measure perceived health stigma. It assessed the extent to which respondents expect negative societal beliefs, feelings, and behaviours towards people who are supposed to have a health challenge. It was used to measure self-stigma at pre and post intervention to compare the differences.. The STIG-9 consists of nine items assessing cognitive, behavioural and affective aspects of perceived health-related stigma. The nine items were anchored on a four-point Likert scale. Respondents indicated the degree to which they expect negative societal beliefs, feelings, and behaviorus towards someone who has health challenge. Response categories were: disagree [0], somewhat disagree [1], somewhat agree [2] agree [3]. The psychometric properties of the instrument were analyzed in a study conducted at the Hamburg-Eppendorf University Medical Center in Germany by Gierk, et al. (2018). They found excellent high internal consistency, and evidence for validity. To further re-establish the psychometric property of the scale in relation to the Nigerian culture and language usage in the scale, the researchers revalidated the instrument using volunteers from Osun State. The result was analysed with Pearson Product Moment Correlation. It revealed high reliability index of r = 0.93 which suggests that the questionnaire was reliable.

Rosenberg Self-Esteem Scale (RSES) developed by Rosenberg (1963) was used to classify the participants into three types of self esteem, (high, moderate, low) . The original RSES has 63 items with 12 subscales. In this study, one of the subscales relevant for the purpose was adopted. The scale measures global self-worth by measuring both positive and negative feelings about the self. Sample items of the scale are; *"I feel that I am a person of worth, at least on an equal plane with others". "On the whole, I am satisfied with myself"."I certainly feel useless at times"* All items were answered using a 4- point Likert type scale format ranging from strongly agree to strongly disagree. Scoring: Items 2, 5, 6, 8, and 9 are reverse scored. This scale has been widely used by Nigerian researcherss who reported high reliability index For example, Uba and Oluwatelure (2016) used CPT to examine self-esteem and they obtained r= 0.92 showing that the instrument has a good internal consistency. In the present study, tets retest was used to revalidate the instrument . The data obtained was analysed with PPMC. The reliability index obtained was r=0.83 which suggests that the instrument is relaible to be used for data collection.

Procedure for Data Collection

The study was carried out in 3 sysetematic phases namely, pretreatment, treatment and follow up. At the pretreatment phase, approval was obtained from the Oyo State Ministry of Health as well as from the University of Ibadan Social Science and Human Research Ethics Committee (UI/SSHREC). Therafter, the researchers pilot tested the instruments on randomly selected PLHIV in Osun State (not the state of intervention) to ensure the feasibilty of the study. Three research assistants who could speak two other Nigerian languages (Igbo and Hausa) were trained to support in collection and other logistics.

At the treatment phase, partcipants who met the inclusion criteria were informed about the purpose of the study and they were assured of confidentiality and right to *opt out* at any phase of the study if they were not satisfatied with the activities. The centres selected for the study were thereafter randomly assigned into treatment conditions (Cognitive Processing Therapy and Control Group). Baseline data was collected from both groups. The experimental group was exposed to cognitive processing therapy using the The PLHIV clinic days as approved by the ARV centres. The treatments was held for ten weeks. Each session lasted for $1^{1}/_{2}$ hours. The goal of treatment was to help the partcipants to identify and address errors or *stuck points* in their lives by sensitising them to gather evidence for and against those thoughts. Such stuck points and errors in thinking, included thoughts *like "HIV positive serves me right" or "I did something to deserve being HIV positive"* . In the first session the partcipants were taught about effects of stigma and consequences of internalising self-stigma. They were empowered with the skill of how to recognize and label automatic thoughts or other thoughts that may be contributing to self- stigma. In the second session, the partcipants beliefs and feelings were challenged and changed by asking them to break a pattern of avoiding feelings and thoughts associated with the stigma.

During this phase, questionning, role plays and vidio shows were used They were suppported to identify unhelpful or maladapted thoughts and feelings associated with the HIV/self-stigma. In the third-fifth sessions the partcipants learnt new skills of negotiating, communicating, and resolving conflicts. In order to actively engage the partcipants, they used group work and role played different scenarios. The sixth-seventh sessions were used to improve the partcipants assertiveness skill. The essence of this sessions were to relieve them of sel-stigma and replace it with a more matured and responsible adult behaviours. The eight and ninths sessions were on improving the partciapnts self-esteem by encouraging them to avoid 'should' and 'must' statements instead they should focus on the positive aspects of their lives. In the final session, all the sessions were summariseed by volunteers. The researchers explained to them how to retain treatment gains. The participants were thereafter, appreciated and therapy was terminated. The control group was not

treated but baseline and post intervention data was collected from them. In order to compensate them for their time, they were given a lecture on domestic safety.

RESULTS

Demographic profile of Participants

Table 1 was used to present the respondents demogrphic profile.

Table 1 : Distribution of the respondents by Socio-Demographic Profile

Variable	Categories	Frequency	Percentage%
Gender	Male	17	32.69
	Female	32	65.30
	Total	49	100.0
Age	20-24	06	12.25
	25-29	09	18.37
	30-34	16	32.65
	35-39	11	22.45
	40 and above	07	14.29
	Total	49	100.0
Marital Status	Single	2	4.10
	Married	10	20.40
	Separated	20	40.80
	Widow	11	12.25
	Widower	06	22.45
	Total	49	100.00
Religion	Christianity	18	36.70
	Islam	30	61.20
	Traditional	1	2.10
	Others	0	0.00
	Total	49	100.0
Educational Qualification	Primary Education	28	55.10
	Secondary Education	19	38.80
	Higher Education	2	4.10

The result presented in Table 4.1 revealed that out of the forty-nine participants that took part in the study, there were three males 17 representing 32.69% of the study sample while thirty-two were females' 32 (65.30%) . It revealed that out of the forty-nine participants in the study, (20–24) years of age accounted for 6 (12.25%); 09 (18.37%) fall within the ages of (25-29) years old while 16 (32.65%) were (30-34) years old. Others participants between the ages of (35-39), and were 11(22.45%). The results revealed that out of forty nine participants in the study 2 (4.1%) were single; 10(20.4%) were married; 20 (40.8%) participants were separated. Those that were widow 11(22.45%) and Widower, 6(12.25%). The results of analysed data shows that out of forty nine newly diagnosed HIV individuals that participated in the study, eighteen 18 (36.7%) were Christian; thirty 30(61.2%) were Muslim and one 1(2.0%) was a traditionalist. With regards to educational status, 28 representing 55.10% of the sample had primary education while those with secondary and higher education were 19 (38,80%) and 2 (4.10%) respectively. The implication of this demographic profile is that anyone can be diagnosed of HIV ireespective of gender, age, marital or educactional status

Ho_1: Hypothesis one predicted no significant main effect of cognitive processing therapy on reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria Analysis of Covariance (ANCOVA) was used to test this hypothesis. The result is presented in Table 2.

Table: 2: Analysis of Covariance (ANCOVA) of pre-test and post-test on effects of treatment on self-stigma of participants in the three groups, (treatment, age and self-esteem)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	21688.626[a]	8	2711..078	240.519	.000	.992
Intercept	580.656	1	580.656	109.468	.000	.779
Covariate	307.577	1	307.577	57.986	.000	.652
Treatment group	7549.640	2	3774.820	711.644	.000	.979
Treatment x Age	69.259	2	34.629	6.528	.004	.296
Treatment x Self esteem	138.730	2	69.365	13.077	.000	.458
Error	164.435	33	5.304			
Total	420916.000	49				
Corrected Total	21853.061	48				

a. R Squared = .992 (Adjusted R Squared = .988)

The results displayed in Table 2 showed a significant main effect of treatment in the reduction of self-stigma among persons newly diagnose of HIV($F_{2, 33}$ = 711.644; P < 0.05, ῆ = 0.98). This means that there was significant difference in the mean score of self-stigma among PLHIV that were in cognitive processing therapy group and those in the control group. Hence hypothesis one was rejected. Moreover, to ascertain the direction of the differences and determine the magnitude of the mean scores of the participants in the treatment and the control group, Sheffe post-hoc analysis was used. The result is displayed in Table 3.

Table 3: Sheffe post-test analysis on stigma between the treatment and Control Group

Trtgrp	N	Subset for alpha = 0.05	
		1	2
Cognitive Processing Therapy (CPT)	28	60.5714	
Control	21		111.4737
Sig.		1.000	1.000

The result in Table 3 revealed that control group obtained the highest adjusted post-test mean score on self-stigma ($\bar{x}\bar{x}$ = 111.4737, SD = 0.71) while the CPC group had lower means score ($\bar{x}\bar{x}$ = 60.5714, SD = 0.91). The implication of this was that the Cognitive processing therapy was effective in the reduction of self-stigma of partcipants exposed to cognitive processing therapy unlike their counterpart in the control group.

Ho_2: The second hypothesis predicted no significant main effect of age in the reduction of self-stigma among persons newly diagnosed of HIV. The result is presented in Table 1 (ANCOVA Table). The Table shows a significant effect of age on self-stigma among persons newly diagnosed of HIV ($F_{2, 33}$= 6.528; P < 0.050, ῆ = 0.30). Hence hypothesis two was statistically rejected. To identify the direction of the differences, sheffe post hoc test was utilised as shown on Table 4.

Table 4: Sheffe Post-test on age effect age in reduction of self-stigma among persons newly diagnosed of HIVwith Age range

Age (Year)	N	Subset for alpha = 0.05				
		1	2	3	4	5
20-24	6	63.0769				
25-29	9		61.3210			
30-34	16			56.8908		
35-39	11				87.3856	
40 and above Sig.	7					98.5556
		1.000	1.000	1.000	1.000	1.000

ANCOVA Table showed there was significant effect of age on self-stigma among persons newly diagnosed of HIV (**(**$F_{2, 33}$= 6.528; P < 0.050, ñ = 0.30). Hence the null hypothesis was statistically rejected. The implications was that treatment gains were different on the basis of partcipants age range. Table 4 showed that partcipants between ages (30-34) benefited optimally from the thrapy ($\bar{x}$= 56.89). Ages range of 20-30 and 35 -39 years also benefitted ($\bar{x}$= 61.32); ($\bar{x}$=87.3856) respectively. There is evidence to suggest that partcipants between ages 40 and above who participated in the study benefited less from the treatment ($\bar{x}$=. 98.56).

H0$_3$: The third hypothesis predicted no significant main effect of self-esteem on reduction of self-stigma among persons newly diagnosed of HIV in Oyo State, Nigeria. The result of ANCOVA presented on Table 1 revealed **t**here was significant main effect of self-esteem on self-stigma among persons newly diagnosed of HIV ($F_{2,33}$ = 13.077; P < 0.05, ñ = 0.46). Hence hypothesis three was rejected. To ascertain the direction of the differences, Scheffe post hoc test was utilised as presented on Table 4.

Table 4: Scheffe post-test of self-esteem on self-stigma among persons newly diagnosed of HIV with self-esteem

Self-Esteem	N	Subset for alpha = 0.05	
		1	2
High Self-Esteem	14	82.8571	
Moderate Self-Esteem	23		92.9130
Low Self-Esteem	12		93.7500
Sig.		1.000	.378

Result in Table 4 revealed that self-esteem of partcipants have impact on the treatment gains. It showed that partciapnts with high, moderate and those with low self-esteem differ significantly in the treatment outcomes. Further, Table 4 shows that partcipants with high self-esteem participants benefited optimally from the treatment (($\bar{x}$ = 82.857), followed by the moderate and low self-esteem participants with ($\bar{x}$ = 92.91 and 93.75) respectively.

DISCUSSION

The result obtained from the study suggests that there was significant main effect of cognitive processing therapy in reducing self-stigma among persons newly diagnosed of HIV. This implies that those exposed to therapy are less likely to have self-stigma when compared to their counterpart in the control group. The possible reason for this finding could be as a result of the fact that CPT is a therapy that is well documented to have the capacity to assist individuals organise information into schemas (categories of information) to make sense of the world, interpret new information, and exert some level of prediction and control

over their experiences. This is because self-stigma could disrupt schemas, particularly around beliefs related to safety, trust, power, esteem, and intimacy. This disruptions manifest in inaccurate self-statements, called "stuck points," that interrupt normal recovery from the self-stigma experience. Moreover, CPT has a reported efficacy when administred in group as was done in this study. This outcome corroborates that of LoSavio and colleagues (2022) who reported that CPT can be effective for many different types of problems with a diverse clients, providing them relief from symptoms experienced. CPT was also reported to outperformed inactive control conditions on PTSD outcome measures at posttreatment. They reported that CPT-treated participant fared better than 89% of those in inactive control conditions at posttreatment and 82% at follow-up. The outcome corroborated the recent finding of Nishith et al. (2024) who found statistical significant changes in clients treated with CPT when compared with their untreatede counterpart.

The second finding of the study was that there was significant main effect of age in the treatment outcome. The implications was that treatment gains were different on the basis of age range of partcipants. There was evidence to suggest that partcipants between ages ages (30-34) benefited more than other groups. While the older group (40 and above) gained less in the therapy. This outcome corroborates that of Hou et al (2020) who reported age differences in treatment outcomes. However, unlike, Hou et al. (2020) study which compared treatment ouctome using only women, the present study utilised both male and feamle partcipants. There is also evidence to support that elderly patients might have poor prognosis or similar treatment gaons, when compared with younger patients (Eggemann, et al. 2019). Age was thus seen to have the likelihood of contributing to adverse effect on the prognosis of elderly patients (Eggemann, et al. 2019).

The third outcome that emanted from this study showed that there was significant main effect of self-esteem in reducing self-stigma among newly diagnosed HIV individuals in Oyo State. There was evidence that partcipants with high self-esteem benefited more than their counterpart with low and moderate self-esteem. The implication is that peoples's type of self-esteem will affect their gains from therapy. This outcome of this study corroborated with multiple studies which reported positive relationship between self-esteem and HIV stigma. Interventions (Wang et al. 2018; Rossi et al. 2020.). The scholars found that higher self-esteem has the capacity to asist people with HIV (PLHIV) cope with stress and trauma, which can reduce the likelihood of developing depression. This outcome is not surprising because stable self-esteem have the likelihood of of supporting an individul in tackling life stress. People with greater self-esteem are reported to be more likely to be good problem solvers and have greater resilience when dealing with stressors (Wang et al. 2018). Self-esteem has also proven to buffer negative emotions at special times, e.g., coronavirus disease 2019 (COVID-19) and quarantine period in various populations (Rossi et al. 2020). This outcome is plausinle because self-esteem is essential in maintaining hope for the future, good health, and quality of life in living with HIV/AIDS. Many people living with HIV have challenges with self-esteem, which can impact their self-care and eventually their success in achieving viral suppression . Low self-esteem have been documented to increase engagement in risk-taking behaviours (e.g., substance abuse and sexual risk; Trzesniewski et al., 2006). Higher levels of self-esteem have been related to lower levels of HIV-related stigma (Pantelic et al., 2015).

CONCLUSION

There is robust evidence that stigma negatively impacts both persons living with HIV. The outcome of the study showed that cognitive processing therapy was effective in reucing self-stigma which impacts on the quality of life persons newly diagnosed of HIV in Oyo State, Nigeria. It also revealed that both age and self-estem have effect on the treatment and both are therefore, factors to consider when instituting CPT intervention.

RECOMMENDATIONS

On the basis of the outcome of this study, the following recommendations are made to improve the quality of life of PLHIV;

1. CPT should be incoprated into programs for training healthcare workers.
2. Counselling psychologist using CPT should consider the partcipants age and sel-esteem in order to obtain a better outcome.
3. The Nigerian HIV/AIDS anti-discrimination Act of 2014 should be domesticated in all the States in Nigeria. At present, the law has been domesticated in 17 states across Nigeria. Penalties for violations of the law can include fines and/or imprisonment. This law makes it illegal to discriminate against people based on their HIV status in employment, education, health, and other settings. It also prohibits requiring an HIV test for employment or services. This states that Every individual, community, institution and employer shall take steps to protect the human rights of people living with or affected by HIV or AIDS by eliminating HIV-related discriminations in all settings, including employment, health and educational institutions, policies and practices.
4. National Workplace Policy on HIV and AIDS should be made to be effective. This policy aims to create a safe and healthy workplace by eliminating discrimination and stigmatization of workers based on their HIV status. It also promotes HIV testing and counseling, and provides access to information and commodities like condom

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Original scientific paper

Identifying Migraine Triggers profile in the Indian Context: Insights for Global Perspective

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ABSTRACT: Objective: This study examines the association between the Migraine Disability Assessment scale and various aggravating triggers in migraine patients. **Method:** A total of 129 Indian migraine patients, aged 15-65, were recruited from the Bangalore Neuro Centre for this cross-sectional study. An extensive list of possible migraine triggers along with the Migraine Disability Assessment scale was included in a self-administered questionnaire to gather important demographic and migraine-related data. Each subject's diagnosis of migraine was confirmed by a neurologist. The Chi Square test was used to determine the significant association between Migraine Disability Assessment grades and specific triggering factors. **Result:** Our results indicate that there is significant relationship between Migraine Disability Assessment scale and various aggravating triggers in migraine patients. The specific triggers that affect migraine includes food items (e.g., nuts and chicken), sensory stimuli (e.g., loud noises and strong smells), weather variations (e.g., rain), stress-related factors (e.g., night shifts), and other factors (e.g., head banging and solitude). **Interpretation:** This present study suggests that by identifying and managing these triggers, migraine suffers may see a reduction in their Migraine Disability Assessment scores and an improvement in their overall quality of life. Understanding these relationship is essential for clinicians to develop effective, personalised management strategies for migraine patients.

Key words: *Migraine triggers, Migraine Disability Assessment scale, and Indian population*

INTRODUCTION

Millions of individuals worldwide endure the prevalent and debilitating neurological disorder known to be migraines. Migraine sufferers' quality of life is greatly affected by these severe, recurrent headaches, which are frequently accompanied by light and sound sensitivity, nausea, and vomiting (Goadsby, Holland, Martins-Oliveira, Hoffmann, Schankin, & Akerman, 2017). According to global epidemiological statistics collected in 2016 from 132 countries, 1.04 billion people worldwide suffer from migraines (Adnyana, Suherlim, & Widyadharma, 2024). Over the years, migraine has presented a challenge to medicine and is one of the most prevalent conditions worldwide. In Egypt, the one-year prevalence rate is 17.3%, while the global prevalence of migraine is currently 14% (Tana et al., 2024). Although it has been observed that gastrointestinal issues can affect migraine, the precise processes governing this condition remain unknown. The gut microbiome, inflammatory mediators, stress hormones, the serotonin pathway, neuropeptides, and nutritional ingredients are some of the variables that fuel the link between food and migraine. A deeper comprehension of the gut-brain-immune (GBI) axis could result in the creation of innovative treatment targets for headache disorders. Given the close relationship between the intestinal and central nervous systems, food may in fact cause migraines (Tana et al., 2024).

To enhance patient outcomes and determine suitable management strategies understanding the factors that worsen migraines are crucial. According to a study done on 200 migraine sufferers, every single

one of them had at least one trigger factor, while 95.5% had at least two (Mollaoğlu, 2013). Foods, hormone imbalances, stress, irregular sleep patterns, and environmental variables are some of the triggers. While there is considerable individual variation in migraine aggravating variables, environmental, nutritional, and lifestyle triggers are frequently mentioned. It has been demonstrated that environmental variables such temperature fluctuations, bright light exposure, and loud noises can trigger migraine attacks (Haut, Bigal, & Lipton 2006). Migraine sufferers often report dietary triggers, such as caffeine, alcohol, and specific foods like chocolate and aged cheeses. In addition, lifestyle variables such stress, sleep deprivation, and erratic eating habits are important causes of migraines, certain smells, like perfumes, smoke, and chemicals, can also trigger migraines in sensitive individuals (Kelman, 2007). Although the factors that aggravate migraines vary greatly from person to person, environmental, dietary, and lifestyle triggers are commonly identified.

Dehydration lowers blood volume, which reduces oxygen and blood flow to the brain. Because the brain is sensitive to variations in oxygen and blood flow, this may set off migraine headaches. Dehydration is cited as a trigger by about one-third of migraine sufferers, and for some, even a small amount of dehydration can precipitate severe headache pain. It is ironic that taking acute drugs over 10 days in a month can result in headaches if a person often has migraine headaches; this condition is called Medication Overuse Headache (MOH). Hormonal variations, especially in women, have been shown in recent research to exacerbate migraine attacks. The frequency and intensity of migraines are highly correlated with changes in estrogen levels during menstrual cycles, pregnancy, and menopause (MacGregor, 2015). A person's genetic predisposition is a significant component in determining their vulnerability to migraines; some gene variants have been discovered as potential risk factors.

The MIDAS (Migraine Disability Assessment) scale is a widely used tool for quantifying the influence of migraines on a patient's daily life, focusing on work, school, and social activities. Key studies indicate that stress, sleep disturbances, dietary triggers, hormonal fluctuations, and environmental factors like bright lights and strong odours are significant aggravating factors that can influence MIDAS scores (Stewart, Lipton, Dowson, & Sawyer, 2001). (Stewart et al., 2001) developed the MIDAS scale to provide a quantitative measure of migraine-related disability, which has since been validated in various populations. (Lipton, Stewart, Diamond, Diamond, & Reed 2001) further explored the relationship between migraine triggers and disability, demonstrating that effective management of these factors can lead to improved MIDAS scores and overall quality of life for sufferers. Understanding these connections is crucial for clinicians to develop comprehensive management plans that address both the frequency and impact of migraines. Comprehending and recognizing these exacerbating elements is important for customized migraine treatment. By recognizing and avoiding specific triggers, patients can reduce the frequency and severity of their migraine attacks, which will drastically enhance their overall quality of life.

Knowledge gap

Given that cultural, nutritional, and environmental factors may differ greatly from those found in other contexts, the study fills a knowledge gap about migraine triggers unique to the Indian population. Although a variety of migraine triggers have been found in earlier research, the relationship between these triggers and the Migraine Disability Assessment (MIDAS) scale in an Indian context has not been thoroughly investigated. In order to pinpoint certain triggers, the study aims to assess the correlation between the MIDAS scale and other migraine aggravating factors among Indian patients.

METHODOLOGY

Study design - The cross-sectional strategy used in this study was intended to evaluate and contrast the headache features and disability experienced by the migraine patients on various aggravating factors. A cross-sectional survey gathers information at one particular moment in time, providing an overview of the characteristics and experiences of the participants. A range of instruments and surveys were utilized to collect pertinent information. And demographic information was gathered, such as age, gender, and educational background.

Study population and sample size - The study population was patients from the age group 15 to 65 years who had a migraine diagnosis for more than a year, from a neurologist were eligible to participate if they met certain requirements and could communicate in Kannada or English. Patients who don't meet the age range of 15 to 65, patients with neurological disorders like epilepsy or strokes, and people who did not speak Kannada or English fluently were excluded. A sample of 129 Indian patients with migraine headaches was included in the study. The sample consisted of participants that were both male and female. These patients were referred to Bangalore Neuro Centre in Bangalore from the community, indicating that the sample represents individuals seeking medical attention for their headache conditions.

Assessments - A self-administered questionnaire was designed to collect the data. The questionnaire include 1. Basic participant's characteristics, 2. MIDAS and 3. Aggravating factors of migraine assessed by present investigators.

The basic participant characteristics included gender, age, height and weight, neighbourhood of living, and migraine family history, and people who had a migraine diagnosis for more than a year from a neurologist were eligible to participate.

The second part it is a regularly used tool for measuring the impact of migraines on a person's daily functioning and quality of life. Stewart et al. (2001) developed the MIDAS scale, which measures the level of disability caused by migraines over a three-month period with scores ranging from 0 to 92. Based on the overall scores, four disability grades are assigned: that is I – little or no disability, II – mild disability, III – moderate disability and IV – severe disability in the current study grades has been used.

The Aggravating triggers that was divided into 12 categories by the present researchers that is **Food and beverages** (chocolate/ cocoa items, milk/cheese and dairy products, yeast, nuts, dry fruits, chapatti, masala items, chicken, cool drinks, cold food, caffeine; **Smoking** (cigarette, bidi); **Drugs; Drinks; hunger or dehydration; Stress** (changes in wake-sleep patterns, night-shift, rotational shift, hormones, OCP, premenstrual, menstrual cycle, menopausal); **Sensory stimuli** (sunshine/bright light, noise/ loud sounds, odd or strong smells that is perfume/ petrol/ nail polish, physical activity/ workout, sports); **Environmental factors** (high altitude, fog, smoke, dust); **Changes in the environment** (empathy public space, traffic, crowded area); **Changes in weather** (sunny, windy, rainy); **Emotions** (mood swings, anger, laughing, crying) and **other factors** (dental problems, cold, coughing, sneezing, running nose, bending over, bowel movement, constipation, head banding, sexual activity, travelling, head bath, fan , AC, sleep, solitude, doing academic homework).

Data collection - The data was collected in Bangalore Neuro Centre, an OPD and neurospecialty centre in Bangalore. When the patients arrived to Bangalore Neuro Centre, skilled neurologist performed a thorough neurological evaluation on them. Confirming the diagnosis of migraine headache and ruling out any other potential underlying neurological illnesses. Patients were orally informed about the goal of the study following the first screening procedure against the inclusion and exclusion criteria, and those who gave their assent were requested to fill out formal informed consent forms. A neurologist then evaluated

each subject to confirm the diagnosis of migraine. The present researcher took the sociodemographic data. Following the neurological examination and diagnosis, the patients were transferred to the neuropsychology department for additional evaluation of various headache characteristics and their influence on daily functioning. Patients in the neuropsychology unit performed systematic interviews and questionnaires (MIDAS and various aggravating triggers) to learn about the triggers that affect migraines.

Data analysis - In the present study, Descriptive statistics, is used to summarize the headache characteristics. Crosstabs are used to display the frequency distribution of two variables and Chi Square is used to determine if there is a significant association between two variables such as MIDAS Grades and aggravating triggers. All data were analysed by using IBM SPSS Statistics software 27.0 version.

RESULT

Table – 1 – Shows the association between MIDAS grades and aggravating triggers

MIDAS GRADES AGGRAVATING TRIGGERS	MIDAS – I (N = 65)	MIDAS - II (N = 11)	MIDAS - III (N = 16)	MIDAS - IV (N = 37)	Pearson Chi - Square
Food & beverage					
Chocolate/ coca items	2 (3.1%)	-	2(12.5%)	-	0.100
Milk/ cheese and dairy products	3(4.6%)	-	1(6.3%)	3(8.1%)	0.740
Yeast	-	-	-	1(2.7%)	0.489
Nuts	-	-	2(12.5%)	1(2.7%)	0.028*
Dry fruits	-	-	-	1(2.7%)	0.474
Chapatti	-	-	1(6.3%)	-	0.068
Masala items	4(6.2%)	-	-	1(2.7%)	0.546
Chicken	-	1(9.1%)	-	-	0.013**
Cool drinks	2(3.1%)	-	-	2(5.4%)	0.681
Cold food	1(1.6%)	-	1(6.3%)	-	0.384
Caffeine	1(1.6%)	-	-	1(2.7%)	0.863
Smoking					
Cigarette	1(1.5%)	-	-	-	0.803
Bidi	-	-	-	-	-
Drugs	-	-	-	-	-
Drinks	-	1(9.1%)	-	2(5.4%)	0.131
Huger or dehydration	28(43.1%)	5(45.5%)	12(75%)	18(48.6%)	0.151
Stress					
Changes in wake-sleep patterns	39(60%)	6(54.5%)	10(62.5%)	26(70.3%)	0.700
Night shift	-	-	-	3(8.1%)	0.054*
Rotational shift	1(1.5%)	2(5.4%)	-	-	0.500
Hormones	-	-	-	1(2.7%)	0.474
OCP	-	-	-	-	-
Premenstrual	4(6.2%)	1(9.1%)	3(18.8%)	3(8.1%)	0.453
Menstrual cycle	2(3.1%)		2(12.5%)	3(8.1%)	0.333
Menopausal	-	-	-	-	-
Sensory stimuli					
Sunshine/ bright light	33(50.8%)	7(66.6%)	11(68.8%)	25(67.6%)	0.300
Nosie/ loud sounds	36(55.4%)	4(36.4%)	13(81.3%)	28(75.7%)	0.021*
Odd or strong smells that is perfume/ petrol/nail polish	23(35.4%)	2(18.2%)	11(68.8%)	21(56.8%)	0.010**
Physical activity/ workout	3(4.6%)	1(9.1%)	2(12.5%)	5(13.5%)	0.426
Sports	2(3.1%)	1(9.1%)	2(12.5%)	3(8.1%)	0.463

Environmental factors					
High altitude	15(23.1)	1(9.1%)	6(37.5%)	7(18.9%)	0.323
Fog	6(9.2%)	1(9.1%)	1(6.3%)	5(13.5%)	0.849
Smoke	9(13.8%)	4(36.4%)	4(25%)	8(21.6%)	0.290
Dust					
Changes in environment	33(50.8%)	4(36.4%)	6(37.5%)	18(48.6%)	0.686
Empathy public space	2(3.1%)	-	1(6.3%)	-	0.496
Traffic	30(46.2%)	3(27.3)	5(31.3%)	17(45.9%)	0.493
Crowded area	30(46.2%)	2(18.2%)	7(43.8%)	14(37.8%)	0.350
Changes in weather					
Sunny	26(40%)	5(45.5%)	8(50%)	21(56.8%)	0.431
Windy	17(26.2%)	4(36.4%)	4(25%)	15(40.5%)	0.439
Rainy	7(10.8%)	1(9.1%)	4(25%)	13(35.1%)	0.018**
Emotions					
Mood swings	23(35.4%)	4(36.4%)	10(62.5%)	19(51.4%)	0.154
Anger	28(43.1%)	4(36.4%)	7(43.8%)	23(62.2%)	0.229
Laughing	5(7.7%)	2(18.2)	2(12.5%)	3(8.1%)	0.686
Crying	16(24.6%)	3(27.3%)	7(43.8%)	14(37.8%)	0.343
Other factors					
Dental problems	3(4.6%)	-	1(6.3%)	2(5.4%)	0.879
Cold	2(3.1%)	-	-	1(2.7%)	0.843
Coughing	3(4.6%)	-	-	-	0.388
Sneezing	3(4.6%)	1(9.1%)	2(12.5%)	4(10.5%)	0.591
Running nose	-	-	-	2(5.4%)	0.168
Bending over	13(20.3%)	1(9.1%)	1(6.3%)	8(21.6%)	0.448
Bowel movement	3(4.6%)	-	-	1(2.7%)	0.710
Constipation	2(3.1%)	-	-	1(2.7%)	0.843
Head banging	13(20%)	7(63.3%)	5(31.3%)	11(29.7%)	0.027*
Sexual activity	1(1.5%)	-	1(6.3%)	-	0.381
Travelling	34(52.3%)	3(27.3%)	8(50%)	17(45.9%)	0.482
Head bath	27(41.5%)	3(27.3%)	6(37.5%)	13(35.1%)	0.798
Fan	3(4.6%)	-	-	-	0.388
AC	19(29.2%)	2(18.2%)	8(50%)	14(37.8%)	0.265
Sleep	13(20%)	1(9.1%)	2(12.5%)	5(13.5%)	0.693
Solitude	10(15.4%)	4(36.4%)	3(18.8%)	15(40.5%)	0.028*
Doing academic homework	2(3.1%)	-	-	-	0.572

*Significant at 0.05 level; **Significant at 0.01 level.
Note – N is the number of patients marked that respective Midas grades.

The migraine patients' trigger factors are displayed in the table. The most frequent trigger factors as per the current study are Odd or strong smells that is perfume/petrol/nail polish" (0.010) in sensory stimuli, "chicken" (0.013) a food, "rainy" (0.018) in changes in weather, "noise/ loud sounds" (0.021) in sensory stimuli , "head banging" (0.027) and "solitude" (0.028) in other factors, "nuts" (0.028) a food and "night shift" (0.054) in stress.

DISCUSSION

The current study evaluated the association between several migraine aggravating triggers and MIDAS grades. Our results are consistent with earlier studies showing a broad range of triggers can cause mi-

graines. Notably, we found that among the most frequent triggers were strange or overpowering scents, like those from gasoline, perfume, and nail polish. It is thought that these smells activate the trigeminal nerve, which in turn triggers migraine symptoms (Kelman, 2007). People who have migraines are more vulnerable to osmophobia or a sensitivity to smell, which can precipitate or intensify attacks. Certain scents, such as those from cigarettes, perfumes, car exhaust, and some cleaning supplies and foods, have been shown to cause panic attacks. A study found that 72% of participants reported strong odours, including perfumes and cleaning products, as triggers (Lindelof, Ellrich, & Svensson 2020). A person with a migraine may have a neurological system that is especially sensitive to certain everyday sensory events. But a few days to hours before a headache attack, during the prodromal phase (the first of four separate migraine phases), individuals may become considerably more sensitive to specific stimuli, including scents (Goadsby et al., 2017). Within the industry, toluene, formaldehyde, and dibutyl phthalate are occasionally referred to as the "toxic trio". Nail paint, also known as fingernail adhesive, contains toluene, which can cause dry or cracked skin, migraines, vertigo, and numbness, as well as irritation of the eyes, nose, throat, and lungs, liver and kidney damage, and effects on unborn babies during pregnancy (Roelofs & Do, 2012).

A number of items, including chicken and nuts, were consistently mentioned as triggers. (Zivadinov, Willheim, Sepic-Grahovac, Jurjevic, & Bucuk, 2003), mentioned these foods may contain tyramine, which might alter blood vessel activity and cause migraines. There are numerous studies on dietary triggers for migraine specifically research focusing on chicken as a trigger is less common. Based on the present study chicken is in the second most for causing of migraine this may be because of the overuse of antibiotics can lead to drug-resistant bacteria, which may cause infections that are harder to treat and potentially trigger headache as a symptom of these infection and it can affect other health issues that could trigger headaches (Landers, Cohen, Wittum, & Larson, 2012). Also, while growth hormones in poultry may not be first linked to headaches, hormonal imbalance can be a potential trigger for headaches. The study from Bangladesh analysed dietary triggers among migraine patients and certain foods, including chicken were reported as trigger by about 12% of the participants (Haque, Rahman, Hoque, Hasan, Chowdhury, Khan, 2013).

Despite being widely regarded as healthful, some people paradoxically experience migraines when they consume nuts because of a number of biochemical variables. The presence of tyramine, a naturally occurring substance present in a variety of foods, including nuts, is one of the main mechanisms. According to (Bartolini, Hernandez, Kamboj & Rieck 2015), tyramine is known to cause headaches in those who are sensitive to it via altering the brain's levels of neurotransmitters, especially norepinephrine. When its levels change as a result of food, this neurotransmitter may play a part in the onset of migraines. Higher levels of tyramine can cause headaches by changing neurotransmitter release and blood vessel dilatation, two processes connected to the pathophysiology of migraines. These foods include aged or fermented foods like nuts. (Bartolini et al., 2015). These substances may influence vascular reactions and neurotransmitter levels, which may contribute to the development of migraines. (Zaeem, Zhou, Dilli, & Headache, 2014). Omega-6 fatty acids, which are abundant in nuts, have the potential to increase inflammation in the body. It is getting better acknowledged that chronic low-grade inflammation influences blood vessel function and neural sensitivity to pain in the etiology of migraines.

A big part was also played by environmental factors. One significant trigger was rainy weather, which can alter atmospheric pressure. The present study also show that rainy weather is a significant trigger for migraine. Rainy weather often brings high humidity and changes in temperature. High humidity levels can cause dehydration, a known risk factor for migraine, sudden temperature changes can also disrupt body's homeostasis. These can lead to physiological stress and dehydration, both of which can have migraine attacks. High humidity and sudden temperature changes are linked to increased migraine frequency.

52% of participants experienced migraine from rain as it leads to changes in air quality that can stir up allergens, spores which lead to migraine. (Xu, Liu & Zhang. 2019). Study found that there was no strong, consistent evidence linking rainy weather specifically to increased migraine headache (Wang, Schoerning, & Nelsen, 2015).

(Vingen, Sand, & Stovner, 1999), found that loud noises and continuous sounds were also frequently detected. This is probably because they might lead to sensory overload and tension, two factors that are known to trigger migraines. However, a number of earlier investigations carried out in the US (Kelman, 2007). Geographical disparities could be the cause of this variance. Cities in south India, such as Bangalore, Chennai, and Hyderabad, have reported high levels of noise pollution. But a study in Hong Kong supported the present paper findings, as it mentions residential districts in Hong Kong are packed. The mental strain and annoyance brought on by loud noises from nearby construction sites, traffic, intruder alarm systems, and neighbours may be made worse by this illness (Xie, Lin, Wong, Yan, Zhang & Gao 2022). European federation of neurological society's guidelines on the treatment of tension type headache emphasized that noise and loud sounds are common triggers for migraine and other headache. Kelman also found that 76% of patients reported noise as a trigger factor for migraine (Kelman, 2007).

Head banging a form of repetitive and forceful head movement. Studies have explored various physical activities and their association with migraine onset have been shown to make headaches worse. This may be because they put physical stress and pressure on the muscles in the head and neck. Although research is limited on head banging, a study found that strenuous physical activities, including sudden head movements, can trigger migraines due to the stress they place on the body and the resulting changes in blood flow and pressure within the brain (Parikh, Silberstein, Young, & Nahas, 2011). A systematic review of various triggers, including physical strain and sudden movements, support the idea that head banging could serve as a migraine trigger (Kelman, 2007). Focused research specifically on head banging would be needed for better understanding.

Significant triggers included aspects of the lifestyle like working night hours and being alone. Isolation may raise stress levels, which in turn may contribute to the occurrence of migraines. Stress and the disruption of circadian rhythms that come with working night shifts can cause migraines. A well-known migraine cause, insufficient and fragmented sleep is a result of the disruption of sleep patterns brought on by night shift work. Working night shifts frequently exposes workers to artificial illumination and blue light-emitting devices, which can disrupt melatonin production and worsen sleep disorders (Czeisler, 2013).The dietary practices and erratic meal schedules frequently connected to night shift work can impact migraine vulnerability. Increased tension and anxiety are recognized migraine triggers in susceptible individuals, and they can be further exacerbated by the stress of adjusting to a nocturnal schedule and the social isolation sometimes associated with night shifts.

(Coplan, Bowker, & Nelson 2021), suggests that social contacts are essential for controlling stress reactions because they trigger the release of neurotransmitters like oxytocin and serotonin, which lessen anxiety and encourage relaxation. These neurochemical pathways may be disturbed in people who spend a lot of time alone themselves or who don't have strong social ties, which can increase stress and aggravate migraine symptoms. The principal stress hormone, cortisol, is linked to higher levels of activation of the hypothalamic-pituitary-adrenal (HPA) axis and loneliness, which can be exacerbated by social isolation (Cacioppo & Hawkley, 2009). Changes in pain processing pathways and higher sensitivity to pain stimuli have been associated to chronic HPA axis activation and elevated cortisol levels. These changes may precipitate or exacerbate migraine attacks (Burstein, Noseda & Borsook, 2015). Psychosocial factors also affect coping mechanisms and emotional control, which contributes to migraine. Social support networks

mitigate the detrimental effects of stress on health outcomes by offering practical help and emotional comfort during tough times.

Current research indicates that other triggers are not important enough to cause migraines. (Wang, Jin, & Shen. 2013) found no consistent evidence that all people have migraines when the weather changes. (Burtscher, Likar, Nachbauer & Philadelphy, 2011) investigated how altitude affected headaches, including migraines, and discovered that while some people report that changes in altitude cause their migraines, there is insufficient evidence to conclude that this is a common cause. Although red wine in particular is frequently mentioned as a migraine trigger, the research supporting this claim is not always clear. According to other research, not all migraine sufferers consistently experience alcohol as a trigger, and the type of alcohol taken may not have a major impact (Panconesi, 2008). While smoking may not cause migraines directly, some research indicates that it may increase their frequency or severity (Zaeem, Zhou, & Dilli 2016). (Spierings, Ranke, & Honkoop 2001) concluded that not all migraine sufferers regularly experience dehydration as a trigger. Several studies concentrate on how overusing medications might exacerbate migraines. Certain medications have the potential to indirectly trigger migraines by modifying blood flow or having an impact on the central nervous system. (Zaeem, et.al, 2016).

CONCLUSION

Our results underscore the complex nature of migraine triggers by highlighting a wide range of plausible causes. Based on our research, we can conclude that strong or peculiar smells, including those from gasoline, perfume, nail polish, and some meals like chicken and nuts, as well as environmental elements like loud sounds and wet weather, are major aggravating factors that might cause migraines. Migraine triggers include physical acts such as head banging, social factors such as social isolation, and occupational factors such as working night shifts. Individuals with migraine who are from India demonstrate great perseverance and adaptation in coping with their daily lives, despite the severity and variety of triggers. They exhibit remarkable tenacity and fortitude in juggling their obligations to their families, careers, and personal lives. They continue to function at a good level in their personal, professional, and family life despite difficult circumstances and numerous triggers. Their capacity to flourish under these conditions is indicative of their resiliency and the potency of their coping mechanisms. This emphasizes how crucial it is to have a supportive environment and employ efficient management techniques in order to lessen the impact of migraine triggers and allow people to continue productive lives in spite of their migraine burden.

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Data Availability
The data sets used or analysed during the current study are available from the corresponding author on reasonable request.

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Original scientific paper

Correlation of Nutrition and Physical Activity on BMI Values in Adolescents

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ABSTRACT: Proper nutrition and regular physical activity from early childhood are important prerequisites for healthy growing up. Conversely, in children and adolescents, over time, there may be an increase in the body mass index (BMI), which results in the development of obesity. **The goal**. The main goal of the paper is to point out the correlation between proper nutrition and BMI values in adolescents of the secondary medical school in Bihać. **Methods**. The respondents are students of both sexes, from the first to the third grade of the secondary medical school in Bihać, aged 15 to 17. The total number of students included in the research was 120. The time of data collection is 04.11. - 29.11.2022. year The respondents were divided into two groups, working and control, with 60 students in each group. The working group consisted of students from first to third grade who had irregular food intake during the week (≤ 1x-2x a week) and were physically inactive. The control group consisted of students from the first to the third grade who had a proper food intake (2x or ≥3x a week) and were physically active (≥3x a week for 60 min). **Results**. Mean values of BMI (29.14 kg/m^2) in students of the work group from I-III grades who had irregular food intake (≤ 1x-2x a week) and were not physically active in relation to BMI (21.79 kg/m^2) of the control group of I-III graders who were physically active and had a proper food intake (≥ 3x per week) is statistically significantly different in favor of the control group of students (p=0.039). **Conclusion.** Proper food intake with regular physical activity in adolescents has positive effects on BMI values and represents an important segment in the prevention of obesity in adults and older people.

Key words. Proper nutrition, body mass index, physical activity, adolescents

INTRODUCTION

Nutrition, in addition to physical activity, is a very important segment in the proper growth of children and adolescents, ie. their proper growth and development from early childhood. The need for food is a feature of all living beings, and it takes place constantly through the process of changing certain substances, i.e. the process of the death of some and the creation of other, new cells needed for the proper functioning of the organism. For that process, it is necessary to ingest food in order to "draw" certain building materials from it and create the necessary energy for proper growth and development. For the proper functioning of the organism, it is necessary to make a proper choice of ingested food because proper nutrition is considered one of the most important factors of human life, health and development in general (Dobročinac et al., 2019). The term food refers primarily to foodstuffs in raw, semi-processed or combined form for the purpose of human nutrition. Foods that are most common in the human diet include cereals, milk and milk products, meat, fish, vegetables, fruits, visible fats and oils, sugars and concentrates. Food also includes additives used in preparation, water and various types of beverages that come in different forms. The modern food production industry enables the production of improved quality foodstuffs as well as the adjustment of their nutritional content, i.e. value, and the production of a large number of foods (organically produced food or genetically modified food) (Backović et al., 2014). According to Grujić et al., (2007) there are different criteria for the division of foodstuffs, so in relation to their origin, foodstuffs are divided into: foodstuffs of plant, animal and mineral origin. All of them are very important for the proper growth and development of

children and adolescents and must be equally represented in their daily diet. A proper, balanced diet, which is important for the normal growth of children and adolescents, and which consists of three main meals and two snacks, supplies the body with all the necessary substances such as proteins, carbohydrates, vitamins and minerals (Petraš, 2022). The modern way of life has a negative effect on nutrition because people do not have time to cook and therefore eat "fast food" which is easily available and unfortunately unhealthy. Children's eating habits are acquired in early childhood and are influenced first by the parents with their behavior model and later by the environment and peers with the dominance of one or the other depending on the age of the child (Stojisavljević et al., 2013). That is why Bogl (2020) believes that parents represent the primary social context and pattern of behavior in the approach to nutrition and physical activity that children adopt and develop as healthy or unhealthy lifestyles. In children, we find that the most common form of behavioral change is a change in eating habits (Stojisavljević et al. 2013). Imbalance in caloric intake and physical activity in childhood is the main cause of obesity in children and adolescents with a significant role of environmental factors (Lee, Yoon. 2018). In accordance with these theses, Lobstin and Jackson-Leach (2006) claim that obesity in childhood can be the beginning of the development of chronic conditions and diseases in adulthood and old age. Therefore, against the obesity epidemic, it is necessary to create a healthy environment and preventive measures at the level of the social community (WHO, 2011). In most countries, according to scientific data, children and adolescents have a low prevalence of the overall level of physical activity, i.e. a high prevalence of sedentary behavior, which includes time spent awake, sitting or lying down with low energy expenditure (watching television, working on a computer, using smartphones and etc.) which ultimately leads to a serious increase in the prevalence of obesity (Zhu et al., 2019). It is considered that physical inactivity with inadequate nutrition is the main cause of health problems in children and adolescents and can lead to serious diseases, including heart diseases, so Štimac et al. (2017) recommend developing a proper nutrition program in cooperation with doctors. Also, in accordance with the previous one, the recommendation of the World Health Organization (WHO) is that children and young people spend at least 60 minutes a day in some physical activity of medium intensity, all with the aim of preventing obesity (WHO, 2022). However, considering the worrying epidemiological data in the direction of the increase in obesity and obesity among children and adolescents, the member states of the WHO set an important goal until 2025 in order to stop this negative trend and approved the project under the slogan "No increase in excess body weight and obesity" (Baran, 2022; WHO, 2022). Improper nutrition accompanied by a lack of physical activity in childhood and adolescence leads to an increase in overweight and the appearance of obesity already in preschool age, which will represent a very serious health problem in the 21st century (Jurić, 2023).

Objective

The objective of our work is to examine the correlation of proper nutrition and physical activity on BMI values in adolescents of the secondary medical school in Bihać.

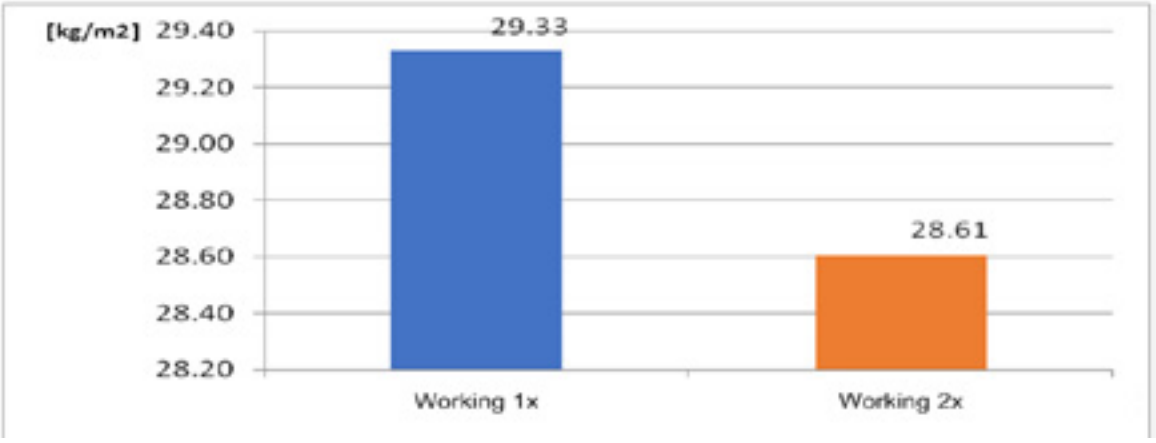
METHODS AND RESPONDENTS

The respondents were students from the first to the third grade of the secondary medical school in Bihać, aged 15 to 17, of both sexes. The total number of students in the research was 120. The time of data collection is the period from 04.11. - 29.11.2022. year. The respondents were divided into two groups, working and control, with 60 students in each group. The working group consisted of students from first to third grade who did not engage in any physical activity in their free time and whose food intake was insufficient (≤ 1x-2x a week). The control group consisted of students from the first to the third grade who en-

gaged in physical activity 1x-3x a week for up to 60 minutes, during free time and had a proper food intake (≥ 3x a week). Anthropometric measurements of body height and weight were performed on the subjects in order to calculate the BMI value, and were carried out on an Omron scale (BF 511/201-107-00214F/ 2018/ Amsterdam). In order to investigate the relationship between BMI on the one hand and dietary intake and physical activity on the other hand, a separate survey questionnaire was created in the form of a test with provided answers. For the purpose of data processing, the arithmetic mean method was applied, and the results were presented graphically. The data were processed in MS EXCEL to determine the arithmetic mean (AVERGE) and the statistical value p (STAT-p).

RESULTS

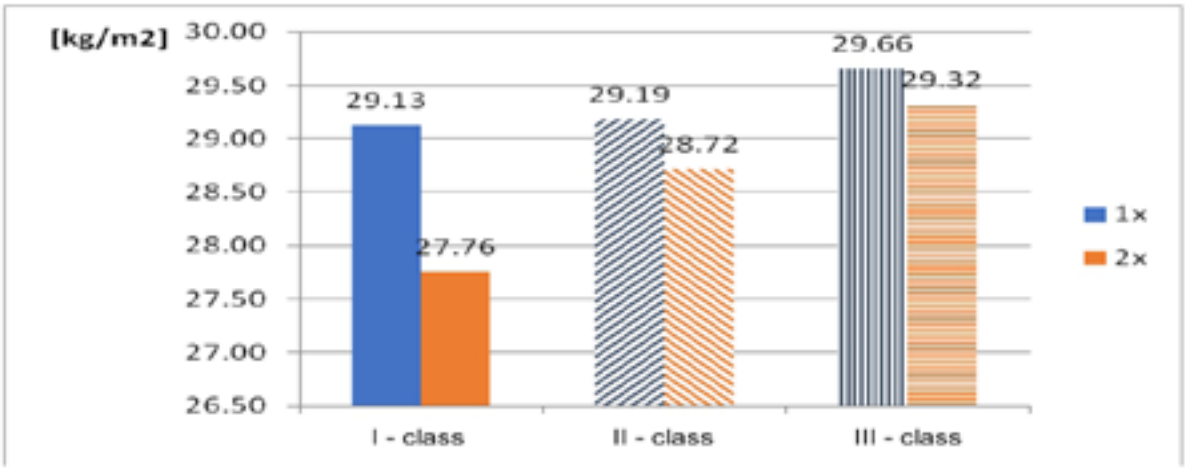
In our study, 120 students of both sexes, from the 1st to the 3rd grade of the secondary medical school in Bihać, aged 15-17 years, were included. The respondents were divided into two groups - a working group and a control group, 60 students each. The working group consisted of 29 boys and 31 girls who did not have proper food intake during the week (≤ 1x-2x) and were physically inactive. The control group consisted of 28 boys and 32 girls, who had a proper food intake during the week (≥ 3x a week) and were physically active (1x-3x a week, min. 60 minutes). Graph 1 shows the mean BMI value of the working group with irregular food intake (≤1x per week and no physical activity) and is 29.33 kg/m², while the BMI value of the working group with 2x weekly food intake was 28. 61 kg/m².



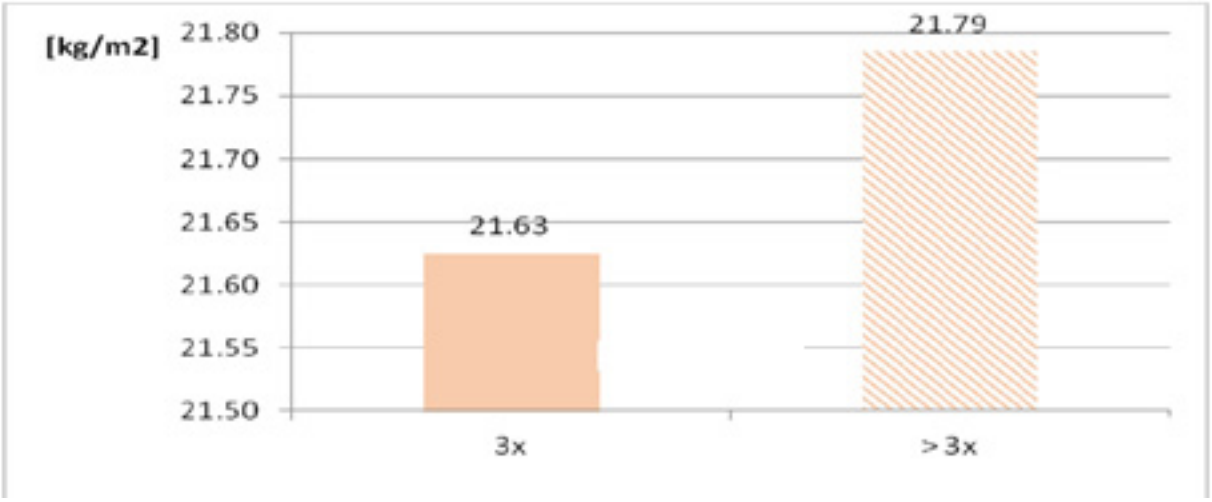
Graph 1. BMI values of the working group of subjects with proper food intake 1x & 2x a week

Graph 2 shows the mean values of BMI in the working group from I to III grades in relation to insufficient food intake ≤1x and 2x per week. When we compare the mean values of BMI, we see that the biggest statistically significant difference is in the first grade (p= 0.025), and the smallest in the third grade, i.e. Grades I have the lowest mean BMI, and Grades III the highest. In classes that have a more regular food intake during the week (2x per week), the mean BMI value is lower compared to the BMI values of classes that have insufficient food intake (≤1x per week).

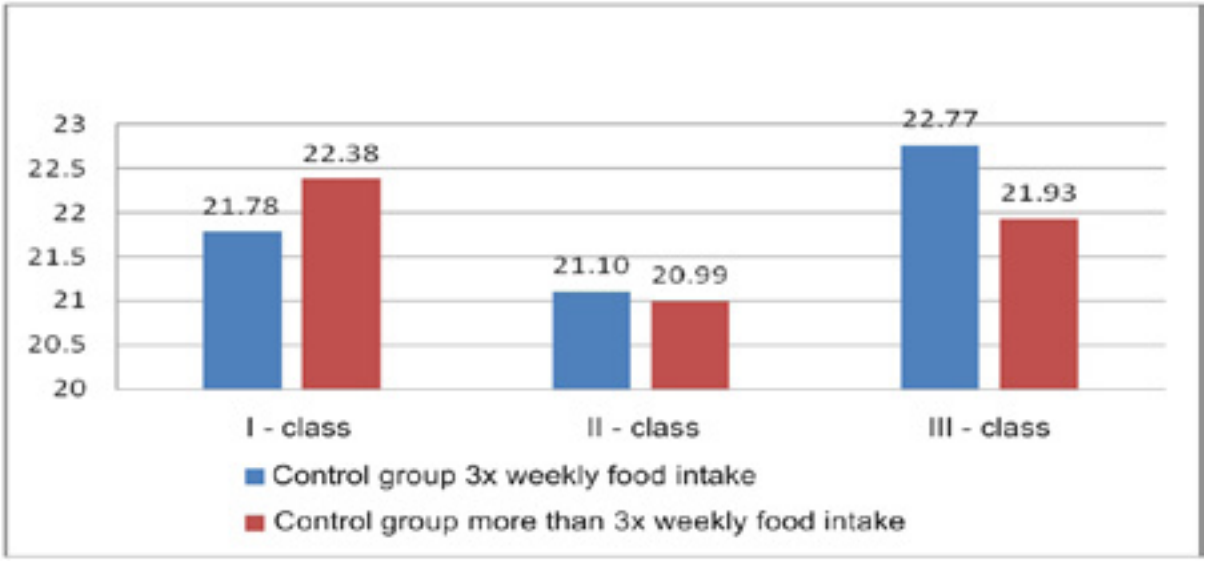
A comparison was also made of the mean value of BMI in subjects of the control group who have a proper food intake (3x and > 3x per week) and are physically active, which is presented in Graph 3. The mean value of BMI in subjects who consume food 3x per week is 21.63 kg/m², and for respondents who eat food more than 3 times a week, it is 21.79 kg/m², which does not represent a significant statistical difference (p=2.043). The study showed that there is no significant difference in BMI values between classes I-III in this regard (graph 4).



Graph 2. BMI values in the working group I-III class according to food intake 1x and 2x a week

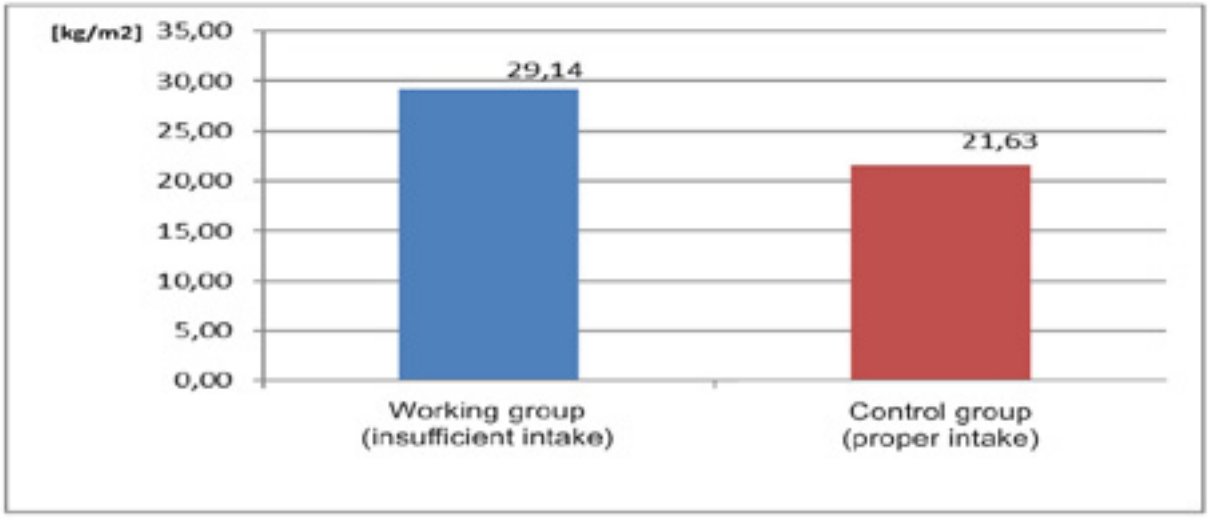


Graph 3. BMI values of the control group with food intake 3x and >3x a week



Graph 4. BMI values of the control group I-III classes in relation to food intake 3x or > 3x a week

Comparing the BMI values of the working group of subjects who have an insufficient food intake and are not physically active, with the BMI values of the control group of subjects, who have a proper food intake (≥ 3x) per week and are physically active (1x-3x per week up to 60 minutes) the results obtained show that there is a statistically significant difference between these two groups in this respect. The BMI value of the working group was 29.14 kg/m², compared to the control group where the BMI value was 21.63 kg/m² (p= 0.039) (graph 5).



Graph 5. Mean value of BMI of the working and control groups

DISCUSSION

Our research involved 120 students, of both sexes, from the secondary medical school in Bihać, aged 15 to 17. They were divided, 60 students each, into a work group and a control group. The study showed that students in the work group, who were physically inactive and had irregular/insufficient food intake during the week (≤ 1x-2x per week) had increased BMI values, i.e. they were obese. The results of the study showed that the mean value of BMI among the students of the working group by grade was: in the first grade 29.13 kg/m², in the second grade 29.19 kg/m², and in the third grade 29.66 kg/m², without statistical significance (p= 2.029). Our results are in line with other scientific studies that confirm that the absence of physical activity, along with improper food intake and a sedentary lifestyle, plays a very significant role in the development of obesity among young people, especially in urban areas (Petrinjak, 2021). Literature data show that 80% of adolescents worldwide are insufficiently physically active (Guthold et al., 2020), and that regular physical activity reduces the risk of heart disease, obesity and cancer (Coyle, 2009) and has a positive effect on psychological well-being. well-being, lower stress levels and better cognitive function (Dewi et al., 2021). However, despite numerous examples of the positive effect on people's health of engaging in physical activity, the number of people who regularly exercise is declining, according to the results of a study by Armstrong and associates (2000). Namely, already in adolescence, the level of physical activity begins to decline, which is confirmed by the results of longitudinal studies that indicate that the decrease in physical activity begins at an earlier age, around the age of 9 (Armstrong et al., 2000).

Our study showed a positive correlation of proper nutrition and physical activity on BMI values in adolescents of the secondary Medical School. Namely, the research showed that the BMI values of the control group of respondents were significantly lower (21.63 kg/m2) compared to the BMI values of the

working group (29.14 kg/m2) (p= 0.039). Literary data show that a proper, balanced diet is very important for the physical and psychological well-being of children. And in order for children to be healthy and in good physical condition, the best way to achieve this is to provide them with a healthy diet from the earliest childhood and to point out its importance to them so that even later in life as adults they will know how to choose properly (Kellow , 2006). Physical activity is always added to a healthy diet as an important health factor for the development of bones, muscles and internal organs in children and adolescents, and of course it also affects the mental health of the individual, which allows him to feel good and raise his mood (Pejčić and Trajkovski, 2018). Numerous scientific studies, including the study by Maslad (2020), show that physical inactivity and improper diet, as well as artificially grown food, are decisive risk factors for obesity, i.e. their elimination is important in the prevention of overweight and obesity in adolescents. That is why parents have a great responsibility to positively influence the formation of proper eating habits of their children with essential physical activity from the earliest childhood with their behavior model.

Busy lifestyle, stress, lack of time and will lead many families to often eat unhealthy food, so-called "fast food" or order from restaurants, and cook less and less at home (Jurić, 2023). Children often adopt these irregular eating patterns or change their eating habits under the influence of their peers, which can lead to serious health problems and the development of obesity already in elementary school children. As in adults, obesity in childhood can lead to the development of cardiovascular problems, childhood hypertension, diabetes, problems related to joint diseases, and breathing problems during sleep (Komnenović, 2010). Type 2 diabetes (T2D) used to be very rare in children and adolescents, but unfortunately the number of affected children is increasing every year, ie the number of children with insulin resistance and T2D is doubling every year. These diseases in later life can be an important risk factor for the development of heart disease, stroke and kidney failure. Research by Gavin and colleagues, unfortunately, indicates that diabetes can increase the risk of developing Alzheimer's disease (Gavin et al., 2007). It is important to emphasize that energy and nutritional needs are greatest during adolescence, that is, in this period of human life they reach their maximum. These needs certainly vary and depend on many factors such as growth, development, body size and physical activity. The difference in energy needs also exists between the sexes, in the male sex they are increased because they grow and develop faster than the female sex, especially if we consider the aspect of increasing the mass of muscle tissue. Also, the level of physical activity and diet play an important role in the formation of body composition, its metabolic composition and BMI values in children and adolescents (Kim OY et al., 2020). The results of some scientific studies have shown that proper nutrition of children and adolescents has a greater influence on BMI values than physical activity (Šabanović et al. 2012), without diminishing the importance of physical activity. The results showed that only 3.79% of the respondents had a quality diet, even 75.35% of the respondents needed to correct their diet, while 20.96% of the respondents had an unsatisfactory diet. About 90% of respondents had a moderate and low rate of physical activity, and 13.13% of respondents were obese. Proper food intake and physical activity remain a "winning combination" for healthy growth, i.e. proper growth and development of children and adolescents.

CONCLUSION

Proper food intake during the week with regular physical activity in adolescents has positive effects on BMI values and represents an important segment in the prevention of obesity in children and adolescents, which can be reflected later in adulthood and old age.

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Professional paper

Hydropower as a Hidden Source of Greenhouse Gases

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ABSTRACT: Hydropower is widely considered one of the cleanest forms of renewable energy, but recent research highlights its contribution to greenhouse gas (GHG) emissions, challenging this perception. This study quantifies the indirect emissions of carbon dioxide (CO_2) and methane (CH_4) linked to hydropower facilities, focusing on emissions from the anaerobic decomposition of organic matter in reservoirs. The findings reveal that hydropower reservoirs emit approximately 1 billion tonnes of GHGs annually, which accounts for 1.3% of global anthropogenic emissions. Notably, methane, a greenhouse gas with a global warming potential 28 times greater than CO_2 over a 100-year period, represents a substantial part of these emissions. Around 22 million tonnes of CH_4 are released annually from reservoirs due to the decay of submerged vegetation and organic material from inflowing rivers. To assess these emissions, methodologies such as floating chamber measurements and remote sensing techniques were employed, providing accurate, site-specific emission data across various geographic regions. The study also explores mitigation strategies, including optimizing reservoir design and enhancing water management practices to reduce methane production. These results highlight the need to address the environmental impacts of hydropower and suggest that, without such interventions, hydropower's role in climate change mitigation could be undermined by its contribution to GHG emissions. Therefore, achieving true sustainability in hydropower development requires integrating these findings into policy and design frameworks.

Key words: greenhouse gases, methane, carbon dioxide,mitigation strategies

INTRODUCTION

Often referred to as one of the cleaner and more dependable renewable energy resources, hydropower does not use fossil fuel directly but rather the natural water cycle to generate electrical power. Its carbon emissions are, therefore, not emitted at the facility itself, which has positioned it as one of the keys to the worldwide transition into sustainable energy. However, broader environmental impacts of hydropower, most particularly its contribution to GHG emissions, are increasingly coming under scrutiny. While there is broad consensus that the generation of electricity by hydropower does not emit CO_2 directly, there is an increasing amount of research that suggests hydropower may not be as environmentally benign as has often been assumed, particularly in the case of CH_4 emissions from reservoirs.

Methane is an extremely powerful greenhouse gas, 28 times more effective at trapping heat in the atmosphere than CO_2 over a 100-year period. Methane emissions from hydropower reservoirs are mainly given out through anaerobic decomposition of organic matter in reservoir water, including submerged vegetation and sediment. Since this organic material decomposes without oxygen, large amounts of methane are emitted into the atmosphere. This process is increased in tropical and subtropical regions because of increasing temperatures, which again increase the rate of decomposition. Indeed, recent studies have estimated that methane emissions from hydropower reservoirs could have the potential to compose a significant portion of total GHG emissions attributed to the hydropower sector, going as far as 30% of the contribution responsible for the current rise in global temperatures.

Despite increased awareness of methane production associated with hydropower, the issue remains unaddressed by policy or in environmental impact assessments. Methane is a "short-lived" GHG because it

stays in the atmosphere for about 12 years, whereas CO_2 can be present in the atmosphere even after centuries. (Doğan et al. 2020) This feature makes the reduction of methane emission an effective and crucial strategy toward near-term climate mitigation. It is possible that significant reduction of methane emission from hydropower reservoirs can provide measurable impacts on global warming in several decades. On the other hand, much of the current discourse on hydropower continues to be based on low-carbon profiles, failing to take into account considerable GHG emissions concerning reservoir management and organic matter decomposition.

This is a literature gap, and the full environmental impact of hydropower is hardly understood, especially as the world increasingly looks at renewable energy sources to meet climate goals. Hydropower is most likely to form part of any strategy that seeks to reduce reliance on fossil fuels, but not being accountable for its hidden emissions means that the actual price of this source of energy remains obfuscated. Therefore, one of the research gaps that this study tries to address is the emission of greenhouse gases, especially methane, from hydropower reservoirs. This study attempts to quantify the emissions, based on which factors influence the magnitude of emissions, and accordingly proposes mitigation strategies to reduce their impact.

This research goes against conventional wisdom, which has positioned hydropower as a source of purely clean energy, by examining the indirect GHG emissions from hydropower. Beyond this, it also aims to emphasize the need for embedding reservoir-related methane emission into environmental impact assessments for hydropower projects. In so doing, this study provides a wide perspective into the role of hydropower in climate change and underlines enhanced management as necessary to make sure hydropower aligns with global sustainability goals.

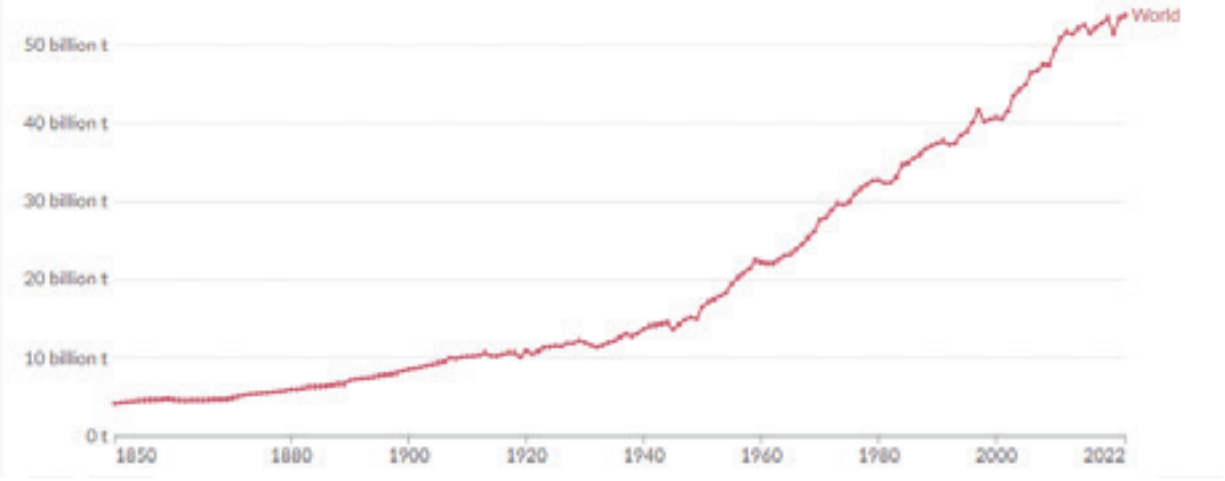

Figure 1. Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources

MATERIALS AND METHODS

Factors that determine the quantity of methane and CO2 Reservoir Emissions

A key source of GHG emissions from hydropower is through artificial reservoirs created by dams. Flooding of land to create a reservoir submerges organic material like plants and soils, which begin anoxic decomposition. This process follows the pathway of CH_4 and CO_2 generation. Methane is itself an extremely GHG gas with global warming potential of about 28-36 times higher than that of CO_2 over a period of 100 years.

Methane dissolved in the water can be released into the atmosphere when water passes through turbines or over spillways. This process is known as degassing and can significantly contribute to a hydropower plant's total GHG emissions (Abril et al., 2005).

Factors that determine the quantity of methane and CO_2 emissions from these systems include the type of vegetation submerged, depth of water, water temperature, and age of the reservoir. Together, for instance, tropical reservoirs are high producers of methane because of the warm temperatures and an increase in organic content in the submerged biomass. Some articles have reported that tropical reservoirs can emit as much methane as a fossil fuel power plant with comparable capacity.

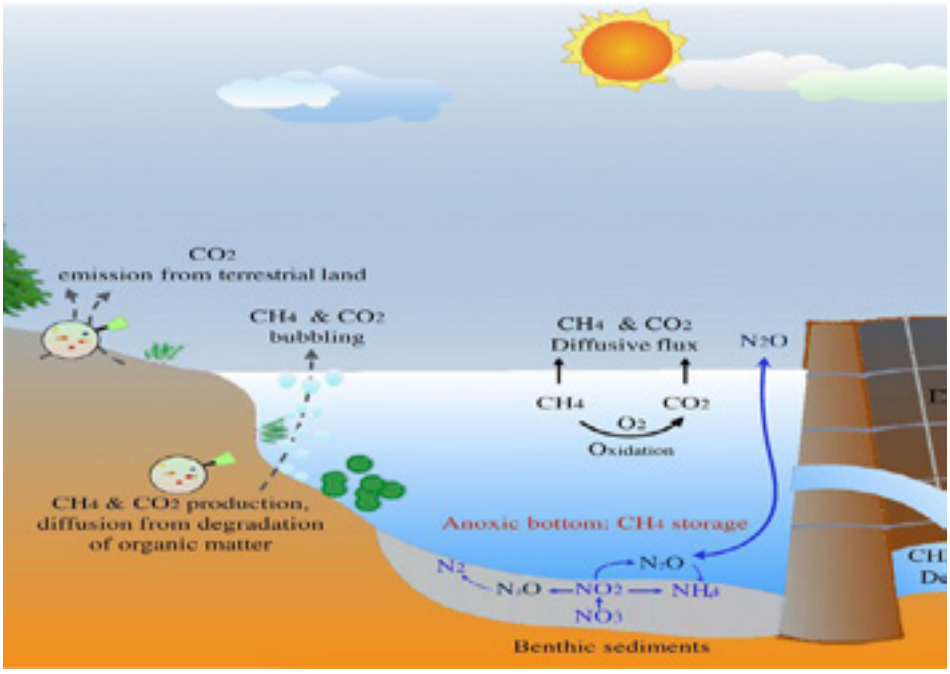

Figure 2. GHG emission pathways from hydropower

GHG emissions are also related to the construction of hydropower plants. Huge quantities of concrete and steel are required for the process, both are polluting, in terms of carbon emission, at their production sites. Extraction activities, machine operations, and transportation of materials, etc. result in the emission of CO_2 and other GHG. Though these are one-time evolutions and not continuous as in the case of fossil fuel plants, still emissions can be quite considerable. Also, maintenance activities during the life cycle contribute to GHG emissions from the hydropower plant. Needless to say, infrastructure upkeep, equipment replacement, and periodic dredging of sediment from reservoirs require energy and materials, which add to the overall GHG envisaged. (Yiming et al. 2024)

Maintenance activities during the life cycle also contribute to GHG emissions from the hydropower plant. Needless to say, infrastructure upkeep, equipment replacement, and periodic dredging of sediment from reservoirs require energy and materials, which add to the overall GHG envisaged.

MEASSURING GHG EMISSIONS

Due to the difficulty in correctly estimating actual GHG emissions from the hydropower plant, measuring procedures are complex. There are many methodologies dependent on the nature of gas emissions as:

Floating Chambers

Testing for GHG in water bodies, including hydropower reservoirs, is done by one of the most common techniques: floating chambers. It is a technique well-suited to measuring the two most important GHG constituents, that is, carbon dioxide and methane, considered critical to climate change. The technique involves placing a sealed chamber in contact with the water surface to capture the gases diffusing from the water into the chamber. In this context, application of floating chambers for measurement of hydropower-related GHG emissions is overviewed, discussing their advantages, limitations, and application (Fearnside and Pueyo, 2012).

Floating chambers are usually simple, cost-effective devices used to measure gas fluxes between water surfaces (e.g., reservoirs) and the atmosphere. Typically made from materials like PVC or other lightweight plastics, these chambers float on the water surface and capture a known volume of gas over a set period.

Deployment: A floating chamber is placed on the water surface at the measurement site.

Gas capture: The chamber traps a sample of the gases emitted from the water surface.

Sampling: Gas samples are periodically collected from the chamber using syringes or sampling ports.

Analysis: The collected gas samples are analyzed in a laboratory to determine concentrations of target GHGs (e.g., CH_4, CO_2).

Flux calculation: By measuring the rate of gas accumulation within the chamber over time, researchers calculate the flux (e.g., mg CH_4 m^{-2} day^{-1})

The headspace of the incubation vessels are sampled with a syringe or any other appropriate sampling device for gas samples after a selected incubation time. Multiple sampling can be done to develop a curve for the rate of accumulation of gases. It is then possible to determine the concentrations of CO2 and CH4 using gas chromatography or other analytical procedures from the collected gas samples.

Although the material expenditure for their construction and deployment is minimal, and they can be used in inaccessible areas, they do have certain drawbacks. For instance, they are limited to specific points and may not capture spatial variations in large reservoirs. Primarily, they are used for measuring CH_4 and CO_2, while being less effective at measuring other GHG gases, and their physical presence can disturb natural gas flows.

Ebullition measurements

Ebullition is the process by which gas bubbles are emitted from sediments into the water column, eventually reaching the atmosphere. It is one of the important pathways for emissions of methane (CH4) from aquatic systems, including hydropower reservoirs. For this reason, measuring ebullition is necessary for correctly quantifying total GHG emissions from these environments. (Tremblay et al. 2005) The present paper aims to give a general view on the methodology of ebullition measurements for estimated GHG emission assessments in hydropower reservoirs, together with their advantages, limitations, and areas of application. (DelSontro et al. 2015)

The rate of methane ebullition depends on various factors, including:

- Sediment type and organic matter content
- Water depth and temperature
- Seasonal variations (ebullition tends to be higher during warmer periods)

Instrumentation and Setup:

1. **Bubble Trap Design**:

Methane ebullition is captured and quantified by deploying what is variously called bubble traps, gas traps, or ebullition collectors on the reservoir bed. These traps capture rising methane bubbles and allow the researcher to quantify volume and rate of bubble release over time.

These are usually devices, funnel-shaped, made of transparent or opaque material such as plastic or glass. The funnel directs the rising bubbles into a collection chamber where they are stored for later measurement.

A typical trap is a floating inverted funnel commonly ranging between 20–50 cm in diameter, attached to a collection tube or chamber. It is fastened strongly to the sediment in order not to wobble during long deployments.

2. Trap Deployment:

The bubble traps are set in depth in the hydropower reservoirs, taking into account the character of the reservoir and different study objectives. This might be zones with high accumulation of organic matter or deeper zones where methane production is expected to be high. Depth and number of traps are selected to capture changes in sediment type and environmental conditions throughout the reservoir.

3. **Data Collection Process:**

a) Methane Collection:

The bubbles rise through the water column and are captured by the funnel trap into a gas-tight chamber.

This gas accumulates in the chamber over time, usually over periods ranging from hours up to several days. The periodic retrieval of gas samples by the researcher is done by drawing with a syringe or through tubing the accumulated gas in the trap. (**Bastviken et al. 2020)**

b) Gas Volume and Concentration Measurement:

The volume of gas collected in each trap is measured, and the gas is analyzed to determine the methane concentration. This is done using gas chromatography or portable gas analyzers.

Knowing the volume of gas and methane concentration, rates of methane ebullition can be determined on a mass per unit area per unit time basis, for example mg CH_4 m^2 day^{-1}, by the researcher.

Collected data can then be used to extrapolate the rates of ebullition measured at each trap to estimate total methane emissions from ebullition over the entire reservoir surface. (Prairie and Mercier-Blais ,2021)

Several factors influence the rate of methane ebullition from the reservoir sediments: temperature, water level changes in the reservoir, sediment characteristics and reservoir management practices.

Remote sensing

Remote sensing is an advanced method for monitoring greenhouse gas (GHG) emissions from hydropower reservoirs. This technique involves the use of satellite, aerial, and ground-based sensors to detect and measure GHG emissions over large spatial scales and extended time periods. Remote sensing offers a powerful tool for assessing the environmental impact of hydropower projects by providing comprehensive and continuous data. Next part provides an overview of the application of remote sensing in measuring hydropower-related GHG emissions, discussing the methodology, advantages, limitations, and applications (Harrison et al., 2021).

Instrumentation and Platforms:

1. Satellite-Based Sensors:

- Satellite platforms are equipped with sophisticated instruments designed to detect and measure atmospheric gases from space. Satellites allow for the monitoring of GHG emissions on a global scale and provide repeated measurements over time.
- Key satellite instruments used for GHG measurements include:

• **Greenhouse Gases Observing Satellite (GOSAT):** Launched by the Japan Aerospace Exploration Agency (JAXA), GOSAT monitors concentrations of CO_2 and CH_4 in the Earth's atmosphere. The satellite uses **Fourier Transform Spectrometers** (FTS) to detect gas absorption of solar radiation reflected by the Earth's surface.

• **Orbiting Carbon Observatory-2 (OCO-2):** Managed by NASA, OCO-2 provides high-resolution measurements of CO_2 concentrations. It uses spectrometers to measure the absorption of sunlight by CO_2 molecules.

• **TROPOspheric Monitoring Instrument (TROPOMI):** Onboard the European Space Agency's Sentinel-5P satellite, TROPOMI detects atmospheric trace gases, including CH_4 and CO_2, with high spatial resolution. It uses spectrometers to measure gas concentrations based on their absorption spectra.

Figure 3. Greenhouse Gases Observing Satellite (GOSAT)

2. Aerial-Based Sensors:

Aerial platforms like drones, planes, or helicopters equipped with sensors-can be used for ground-truthing valuable data on GHG emissions at high resolution and spatially focused over areas of interest. (Prairie, Y.T. and Mercier-Blais S. ,2021)

These platforms are very useful in reservoir monitoring where the satellite data may not be effective due to cloud cover or limitation of spatial resolution. These aerial sensors often are equipped with infrared gas analyzers or lidar systems that can detect methane plumes or CO_2 concentrations directly above the reservoir.

METHODOLOGY:

Satellites, aerial platforms, or ground-based sensors gather the spectral data over the hydropower reservoir. The sensors measure the absorption and scattering of sunlight-or other sources of radiation-by GHGs in the atmosphere.

This spectral data of sensors is converted into concentration values, such as CH_4 and CO_2, with the help of algorithms that utilize atmospheric conditions, surface reflectance, and sensor calibration data.

The raw spectral data collected by the sensors go through algorithmic processing, which corrects for the interfering factors-cloud cover, water vapor, and aerosols-standing in the way of the GHG detection. (Pavelko R. G. 2012)

Advanced models, such as radiative transfer models, then model the absorption and scattering of light as it passes through the atmosphere. These allow only the GHG signal to be separated from background noise and give accurate estimates of gas concentration.

This finally allows development of high-resolution GHG concentration maps for the reservoir area at given time and space, revealing methane or carbon dioxide emissions.

Awareness of GHG emissions from hydropower

Research from 2022 by L. Parlons Bentata and N. Rueda-Vallejo of Bluemethane, UK, found that despite the relatively high awareness of methane and other GHG emissions from hydropower among energy companies (including dam owners, operators, and integrated energy companies), environmentalists, engineers, academics, and government officials, these emissions are not widely measured.

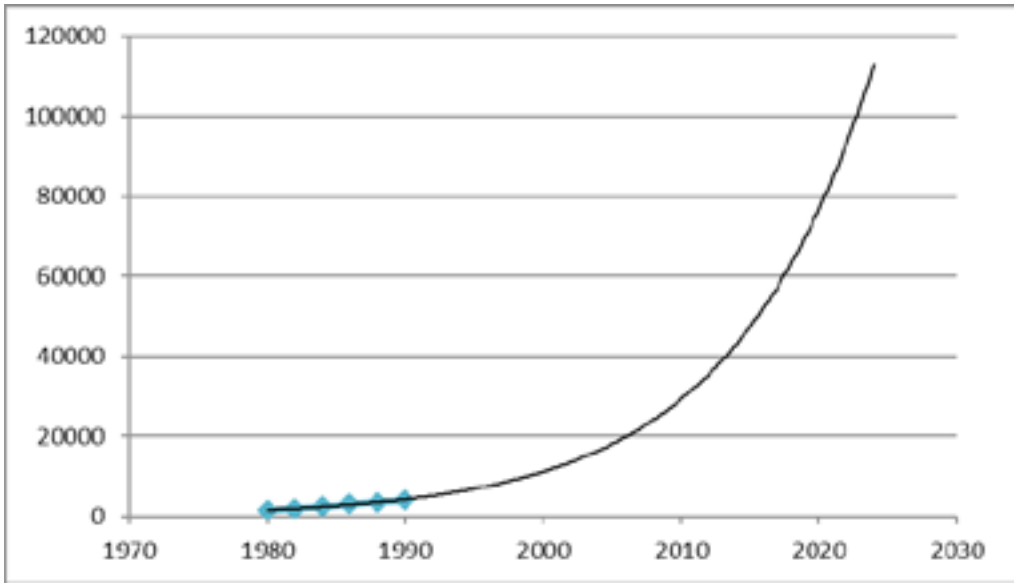

Figure 4. The evolution of world hydropower generation since 1980

Mitigation Strategies

Since we cannot yet avoid or reduce all greenhouse gases (GHG) emissions from reservoirs, carbon capture and utilization (CCU) offers an alternative solution. Many carbon capture technologies are already in use or being developed. These technologies are primarily designed to remove carbon dioxide (CO_2) from the atmosphere, which is challenging and costly because CO_2 is present in low concentrations.

However, unlike CO_2, methane is an energy source that reservoirs continuously produce. This means capturing and using methane could provide significant environmental and financial advantages.

There are several strategies that can help mitigate the GHG emissions associated with hydropower:

1. Smaller reservoir sizes: Run-of-river systems and those with small reservoirs have less land area being flooded; therefore, there is reduced organic material decomposing to form GHG.

Small-sized reservoirs submerge less organic matter, hence directly limiting the amount of material available for decomposition. This reduces methane production at its very source. With the surface area of water being small, it presents a reduced area through which methane could escape into the atmosphere. This further limits diffusive and bubble emissions that might be prominent in large tropical reservoirs. (Doğan et al., 2020)

Also, smaller reservoirs are normally shallower, and oxygenation is better, and anoxic conditions can hardly appear-developing, which are the most favorable conditions for methane-producing microorganisms.

2. Vegetation management: **Vegetation management** is a key mitigation strategy to reduce greenhouse gas (GHG) emissions, particularly methane, from hydropower reservoirs. When vegetation is removed from areas about to be flooded, it will immensely reduce methane emissions. However, this process is labor-intensive and costly.

Probably the most efficient technique to minimize the amount of methane production in reservoirs is with preimpoundment clearing-vegetation removal before the land is flooded. This reduces the carbon available for microbial breakdown by removing biomass that would have otherwise decomposed underwater and thus directly limits methane emissions.

Studies such as those of Fearnside (2005) and the more recent work by Deemer et al. (2016) have shown that reservoirs where vegetation was cleared before flooding produced significantly less methane than those where vegetation was left to decay in place. Clearing reduces the substrate available for methane-producing microbes.

In most cases, selective or partial vegetation removal can be employed, usually in portions most prone to methane generation. It can be the removal of highly dense biomass only or large woody vegetations while leaving behind residual natural vegetation.

The cost-benefit balance in this approach means lower methane emission, while the costs remain lower than in the case of full clearing. Besides, selective clearing helps to preserve a part of the ecological functions of the landscape, which may be quite important for biodiversity.

3. Aeration Methods: Intrusion of oxygen in water to enhance aerobic decomposition of organic matter resulting in CO_2 rather than methane. Mechanical aeration or induced mixing procedures may be used to enhance the natural mixed circulation of the water body.

Artificial Aeration (Mechanical)

- Plume aerators or diffusers: This is one of the most common techniques; it uses bubble diffusers that release the air or oxygen along the bottom of the reservoir. The rising bubbles oxygenate the water by breaking down methane through oxidation and preventing its formation by creating aerobic conditions.

- Mixing Vertically: This involves pumps that move water between the surface and the layers at depth to make sure oxygen-rich surface water reaches the bottom of the reservoir. Vertical mixing reduces stratification of water, resulting in minimal production of methane by maintaining oxygen levels throughout the reservoir.

Surface Aerators

These are devices that function from the surface of the reservoir, causing ripples and mixing the uppermost layers of the water. Although their influence is generally confined to the top layers of a reservoir, surface aerators can prevent the formation of stagnant zones of water in which anaerobic conditions might otherwise develop.

Aeration prevents the production of methane by the decomposition of organic materials by oxygenating the water. Moreover, since these bacteria are aerobic that make this conversion of methane to carbon dioxide, it means less potent GHGs are being released to the atmosphere, since CO_2 has a very low global warming potential compared with methane. Aeration can improve the general quality of the water in reservoirs by reducing the development of hydrogen sulfide (H_2S) and other toxic materials that develop under anoxic conditions.

4. Water Level Management: Stabilization of water levels, without frequent drying and reflooding, will reduce methane production.

Water level manipulation, for example, at different times of the year, can disrupt the conditions under which methane is produced.

Periodically, the operators should draw down the water level to expose submerged organic matter to air. This will lead to an aerobic decomposition of organic material by means of aerobic bacteria, producing much less harmful CO_2 instead of methane.

For example, in cases of high organic input, such as after heavy rains or flooding, operators can lower the water level to reduce the inundation of organic matter. This practice can decrease the development of anaerobic conditions and, consequently, methane production (Yiming et al. 2024).

5. Enhanced Monitoring: Advanced monitoring and modeling to project and manage GHG emissions, including continued water quality and GHG level monitoring activities to identify and address points of high GHG emission.

CO_2 and methane gas can even be utilized in hydropower plants as part of an original idea in reducing greenhouse gases and producing energy. A few ways in which CO_2 and methane could be utilized are as follows:

Biological sequestration of CO_2:

Microalgae use: Microalgae have the ability to absorb CO2 either from the atmosphere or directly from the emissions of hydroelectric power plants. Such algae can be used in the production of biofuels or other bioproducts. (Fearnside, 2002)

Plant use: CO_2 – gaseous can be consumed from the atmosphere by fast-growing plants planted close to a hydroelectric power plant. Later trees and plants produced can be used for producing biomass.

Chemical CO_2 Sequestration:

Mineralization: In this, stable mineral carbonates are produced by reacting CO_2 with certain minerals like basalt or serpentine.

Solutions: Water may be used to dissolve CO_2, which results in carbonic acid which again can be neutralized using bases.

Methane Utilization

Combustion of methane: CH4 methane recovered from hydroelectric reservoirs can be used as fuel to produce electricity.

Biofuels: Through methanogenesis methane is converted into liquid or gaseous biofuels

Gas-to-Liquid, GTL: Methane can be processed into liquid fuels with liquefaction in what is referred to as GTL. Sometimes this occurs through Fischer-Tropsch synthesis.

CCS technology devices for CO2 capture and storage in hydroelectric power stations contribute to reducing the emissions of greenhouse gases. This makes such plants more sustainable, it decreases GHG emissions and extra production is allowed by reusing waste gases. The requirement for further investigation and development in this line cannot be underestimated for further prospective application. (Giles, J. 2006)

RESULTS AND DISCUSSIONS

Region	Energy emissions (MT CO_2e) in 2023	Share	YoY Change
Asia Pacific	21,057.6	52.1%	+4.9%
North America	6,289.3	15.6%	-1.8%
Europe	3,775.8	9.3%	-5.3%
CIS	3,008.4	7.4%	+3.0%
Middle East	2,899.5	7.2%	+0.4%
Africa	1,788.3	4.4%	+1.1%
South & Central America	1,599.1	4.0%	+4.3%
Global Total	**40,417.9**	**100.0%**	**+6.4%**

Figure 5. Energy emissions worldwide in 2023

1. Methane Released from Hydropower Storage Facilities

The hydrpower reservoirs have emerged as a leading methane culprit in research over the last few years, especially for tropics. Decades of investigation worldwide have found that, in certain reservoirs at least, methane emissions exceed those due to some other greenhouse gases emitted during plant decomposition and this has significance when we take into account the warming potential of carbon dioxide. To cite just one example, some large tropical reservoirs emit methane in amounts up to the order of 104 mg CH_4/m^2/day (i.e., comparable with or even exceeding per kilowatt-hour emissions from fossil fuel-based energy generation).

2. Influences factors on methane emission

There are numerous influences on how much and at what rate the methane enters hydropower reservoirs, among them:

Temperature and Climate – Reservoirs in warm climates, such as tropical areas where organic material decomposes rapidly, often emit substantial amounts of methane (because it is a by-product of decomposition), whereas reservoirs from temperate or colder regions tend to release less methane. The substantial methane emissions observed in tropical reservoirs can be attributed to several key mechanisms related to the tropical climate and reservoir characteristics. (**Abril & Guérin (2005))** Warm temperatures in tropical regions accelerate the decomposition of organic matter within reservoirs. In these conditions, organic material such as plant matter, vegetation, and soil, submerged during reservoir creation, decomposes more rapidly under anaerobic conditions, producing methane. The lack of oxygen in deeper waters, combined with higher temperatures, creates an ideal environment for methane generation, particularly through microbial activity (methanogenesis).

Young reservoirs, particularly in the early flooding stage due to a lot of organic matter present for decay -- greater amounts of methane being released —higher flow rates. Even so, older reservoirs may

remain a source of methane if they are shallow or have large amounts of organic material decaying photogenically.

Latest data also point to the importance of pre-impoundment land management in mitigating methane emissions. Methane outputs were considerably lower for those reservoirs whose vegetation was removed before impoundment in comparison with those reservoirs that were impounded without such interventions. This would, therefore, suggest that appropriate management of biomass-for example, removal or burning of vegetation-reduces the quantity of organic matter available for decomposition and hence minimizes the overall production of methane.

These findings thus hold considerable implications for the global assessment of hydropower's environmental impact. Given that there are already a great and increasing number of hydropower projects in the tropics, any calculation of their carbon footprint should definitely take methane emissions from these reservoirs into consideration. Mitigation strategies, such as technologies for aeration or organic matter removal, should therefore be targeted at tropical hydropower projects with a view to offsetting the great GHG emissions these systems produce.

CONCLUSION

This study highlights the significant, but largely overlooked, contribution of hydropower reservoirs to global emissions of the most potent greenhouse gases, methane and CO_2. Hydropower is a valuable renewable energy source that offers significant benefits in terms of reducing direct GHG emissions compared to fossil fuels. However, the full environmental impact, particularly concerning GHG emissions from reservoirs, construction, and maintenance, must be carefully considered and managed. Our estimates indicate that methane emission from tropical reservoirs could match or even outpace that of fossil fuel-based energy sources when measured on a per-kilowatt-hour basis. These are mostly mediated by increased decomposition of organic matter in anoxic, warm-water conditions and is compounded in most tropical regions due to lack of pre-impoundment land management practices.

By employing mitigation strategies, advancing technology, and implementing supportive policies, it is possible to reduce the carbon footprint of hydropower and ensure its role in a sustainable energy future.

Strategies like pre-impoundment vegetation clearing, better management of reservoirs, and various technologies, oxygenation or methane capture, could significantly mitigate those emissions. It shows that pre-impoundment vegetation clearing before flooding drastically reduces methane emission in some reservoirs. For this reason, this study is fundamental to designing and building future hydropower projects, particularly those in tropical regions with high potentials for methane release.

The policy implications of the study are clear: governments and energy stakeholders across the world have to go back to the drawing board and reconsider the environmental costs of hydropower. Policymakers should make sure that methane mitigation strategies are inserted into licensing procedures for new hydropower projects, especially for those involving new reservoirs to be constructed. Requirements for pre-impoundment vegetation removal, regular monitoring of reservoirs, and the introduction of methane-capture technologies would go a long way toward reducing the emissions of this gas.

Governments and hydropower operators should mandate vegetation management as part of the environmental assessment and approval processes for new reservoirs, especially in tropical regions where methane emissions are highest. Requiring pre-impoundment clearing or harvesting as a condition for project approval would help ensure that hydropower projects minimize their carbon footprint.

Future research should focus on refining methane measurement techniques in reservoirs, particularly those in tropical regions, to better understand the seasonal and operational variables that affect emis-

sion rates. Additionally, research into innovative methane mitigation technologies for existing reservoirs is essential to reduce the climate impact of hydropower without undermining its energy potential.

In conclusion, while hydropower remains an essential component of the global energy mix, this study highlights the urgent need for more nuanced assessments of its environmental footprint. With targeted interventions and robust policy frameworks, the negative climate impacts of hydropower in tropical regions can be mitigated, ensuring that it truly contributes to sustainable energy goals.

Understanding the complexities and challenges associated with hydropower emissions is essential for making informed decisions and promoting a balanced approach to renewable energy development.

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Review

The Connection Between Covid-19 Infection and Microvascular Complications in Diabetic Patients

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ABSTRACT: This paper investigates the connection between COVID-19 and microvascular complications in diabetic patients. Through a systematic review of the literature, databases such as PubMed, Medline, Embase, Scopus, and Web of Science were utilized to identify relevant studies. Research questions and keywords were first defined, including "COVID-19," "diabetes," "microvascular complications," "cytokine storm," and "blood clots." Inclusion criteria encompassed clinical studies, health organization guidelines, and peer-reviewed articles in English published since 2020. After the initial review and removal of duplicates, relevant articles were analyzed to identify key risk factors and mechanisms contributing to the development of severe symptoms in diabetics infected with COVID-19. The results indicate a significantly increased risk of severe outcomes, including cytokine storm and a tendency toward blood clot formation, further exacerbating the compromised immune system in diabetics. A bidirectional relationship between COVID-19 and diabetes was also established, where COVID-19 may accelerate the onset of type 1 and type 2 diabetes and cause serious metabolic complications such as diabetic ketoacidosis and hyperosmolar coma. Based on the findings, diabetic patients who recover from COVID-19 require special medical attention and tailored therapy to reduce the risk of further complications. Stricter glycemic control and caution in the use of corticosteroids in COVID-19 treatment are recommended due to the potential increased risk of diabetic complications. These findings highlight the need for targeted healthcare and further research to better understand the long-term effects of COVID-19 on diabetic patients.

Keywords: COVID-19, microvascular complications, post-COVID, risk.

INTRODUCTION

COVID-19, caused by the SARS-CoV-2 virus, can significantly impact the vascular system. This virus has the ability to attack and damage endothelial cells, which form the inner layer of blood vessels. This leads to various vascular manifestations and complications in infected patients (Simić-Ogrizović & Kuzmanović-Pfićurica, 2015). One of the main vascular manifestations of COVID-19 is endothelial dysfunction. Endothelial cells play a key role in regulating blood flow, maintaining normal vascular function, and preventing blood clotting. Damage to the endothelium can disrupt normal function and lead to vasoconstriction (narrowing of blood vessels) or vasodilation (widening of blood vessels), resulting in disturbances in blood flow (Jovičić, Milutinović, 2018). Another important vascular manifestation is hypercoagulability, or the tendency of COVID-19 patients to develop blood clots. Endothelial dysfunction can stimulate clot formation in blood vessels, which can lead to serious complications such as pulmonary embolism or stroke. Vascular inflammation (vasculitis) can also occur in some COVID-19 patients. This immune response to infection can cause damage and inflammation in blood vessels, further worsening vascular complications. Thrombosis, or the formation of blood clots in blood vessels, is a common complication in severe cases of COVID-19. Endothelial damage, hypercoagulability, and vascular inflammation can contribute to the development of thrombosis, especially in the lungs, brain, heart, and other organs (Simić-Ogrizović, Kuzmanović-Pfićurica, 2015). Dysregulation of vasoconstrictor and vasodilator molecules has also been observed in COVID-19 patients. An imbalance of these molecules can disrupt blood flow regulation and lead to abnormal vascular responses (Stanković et al., 2018). All these vascular manifestations of

COVID-19 contribute to the severity of the disease and can have serious consequences for infected patients. Understanding the mechanisms by which the virus affects the vascular system is crucial for developing targeted therapies and preventing complications in COVID-19 patients (Simić-Ogrizović, Kuzmanović-Pfićurica, 2015).

Research Subject, Problem, Aim, and Methodology

The subject of this study is the connection between COVID-19 and microvascular complications in diabetic patients, with a focus on specific microvascular complications such as retinopathy, nephropathy, and neuropathy, and their role in the development of severe symptoms in COVID-19-infected individuals with diabetes. The aim of this research is to analyze clinical studies investigating this relationship through a systematic literature review, focusing on the risk and mechanisms of complication development.

Data Collection Methodology: This paper is a systematic review of the literature, and the approach to data collection was structured in accordance with PRISMA guidelines. Relevant databases, including PubMed, Medline, Embase, Scopus, and Web of Science, were searched using predefined keywords: "COVID-19," "diabetes," "microvascular complications," "retinopathy," "nephropathy," "neuropathy," "cytokine storm," and "blood clots." The search included clinical studies and peer-reviewed articles in English published since 2020 to cover the latest information. Inclusion criteria involved studies examining the correlation between COVID-19 and microvascular complications in diabetic individuals. After the initial review, duplicates were removed, and relevant articles were assessed according to set criteria. Only articles that met quality and validity criteria were included in the final analysis to provide a reliable picture of the current state of research.

This systematic approach identified key risk factors and mechanisms contributing to the development of severe symptoms and complications, enabling a deeper understanding of the impact of COVID-19 on microvascular complications in diabetic patients. Special attention was given to specific microvascular complications, such as retinopathy, nephropathy, and neuropathy, and their role in the development of severe symptoms and complications in diabetic patients infected with COVID-19.

Through a detailed analysis of clinical study results, the research aims to better understand the connection between COVID-19 and microvascular complications and to identify potential risk factors and mechanisms that may explain this relationship. Based on the findings, the study also aims to highlight the importance of special attention and tailored care for patients after recovering from COVID-19 and to provide guidelines for improving healthcare for this population.

The problem addressed by this research lies in the growing body of evidence suggesting that COVID-19 affects not only the respiratory system but also numerous other organs, including the microvascular system. It is particularly concerning that individuals with diabetes are at an increased risk of developing more severe complications following COVID-19 infection. Existing research has not fully explained the mechanisms behind the connection between COVID-19 and microvascular complications such as retinopathy, nephropathy, and neuropathy, which creates a lack of clear guidelines for clinical management of this condition. This issue is further complicated by regional variations in the prevalence of microvascular complications, which may indicate the existence of factors that have not yet been sufficiently explored. This lack of detailed data makes it difficult to optimize medical care and long-term support for individuals who have recovered from COVID-19 and are burdened with microvascular complications.

To gather relevant information for this research, a method of systematic review of literature and research articles was used. The analysis of available data included identifying the prevalence of microvascular complications, risk factors associated with their occurrence, and examining the connection between

these complications and the recovery process in patients. Additionally, data on microvascular complications across different regions were compared to obtain a more comprehensive picture of the situation and any potential regional trends. It is important to note that all data were used in accordance with ethical guidelines and that proper credit was given to sources in line with citation practices.

Structure of COVID-19 and its relationship with other coronaviruses

COVID-19 is a disease caused by the SARS-CoV-2 virus, which belongs to the coronavirus (CoV) family and can lead to the development of severe acute respiratory syndrome. This virus family consists of single-stranded RNA viruses with an envelope, divided into four genera: Alpha, Beta, Delta, and Gamma CoV. The Alpha and Beta genera are primarily associated with infections in mammals (Perlman, Netland, 2021). Generally, the structure of coronaviruses consists of four proteins: nucleocapsid protein (N), spike protein (S), membrane protein (M), and envelope protein (E). SARS-CoV1, SARS-CoV2, and MERS-CoV belong to the Beta genus of coronaviruses (Zhao, Li, 2020). SARS-CoV1 and SARS-CoV2 share approximately 79% genome sequence similarity and cause similar symptoms. These overlapping symptoms are due to structural similarity in the viral S protein, which mediates the virus's entry into host cells (Li et al., 2003).

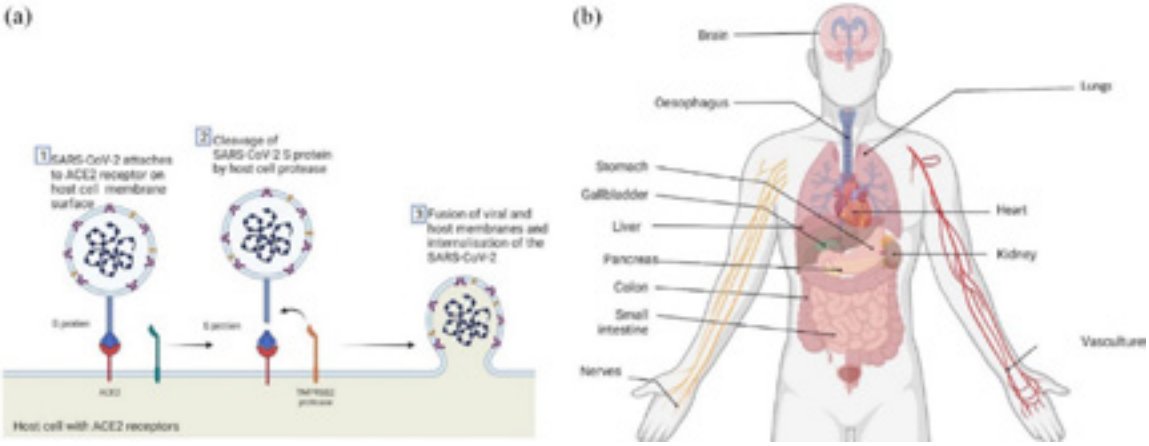

Figure 1. Mechanism of SARS-CoV-2 Entry into Host Cells and ACE2 Expression in Human Tissues (Hamming I, Timens W, Bulthuis ML, 2004)

Numerous studies have identified ACE2 as the functional receptor for SARS-CoV-1, which mediates viral infection and transmission processes (Liu et al., 2020). A comparison of the COVID-19 virus's S-protein sequence with that of SARS-CoV1 shows overall similarities of approximately 76-78% for the entire protein, 73-76% for the receptor-binding domain (RBD), and 50-53% for the receptor-binding motif (RBM). These high similarities indicate that both viruses use the same entry pathway through ACE2 receptors in host cells. Similar to the observed link between diabetes and COVID-19, diabetes was also an independent risk factor for complications and mortality during the SARS-CoV-1 outbreak in 2002-2003 and was present in nearly 50% of MERS-CoV patients in 2012 (Singh, Gupta, Ghosh, 2020).

Research results

The first case of coronavirus disease 2019 (COVID-19) was identified in China in December 2019. It quickly spread worldwide, and the World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020 (Guan et al., 2020). As of October 2024, COVID-19 has affected over 200 million people globally, causing nearly 5 million deaths (Worldometer, 2021). Individuals with pre-existing health

conditions such as obesity, cardiovascular disease (CVD), and diabetes are at greater risk of complications and mortality (Wu L, Peng, 2020). Before the COVID-19 pandemic, we had already experienced the Severe Acute Respiratory Syndrome Coronavirus 1 (SARS-CoV-1) in 2002 and the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in 2012, though neither reached pandemic proportions.

Diabetes poses a serious global health threat that has reached pandemic proportions. The International Diabetes Federation (IDF) estimates that in 2021, 537 million adults were living with diabetes, and by 2030, this number is expected to rise to 643 million and to 784 million by 2045 (Wit, Doremalen, Falzarano, 2016). The estimated healthcare costs associated with diabetes for 2021 were approximately $966 billion (IDF, 2021).

Based on data from previous acute respiratory infection outbreaks, diabetes was quickly recognized as a major risk factor for negative outcomes associated with COVID-19, a link that has since been confirmed (Yang, Feng, Yuan, 2006). A high percentage of COVID-19 patients have concurrent diabetes. The primary mechanisms leading to poor outcomes in patients with diabetes and COVID-19 include the binding of the virus to the angiotensin-converting enzyme 2 (ACE2) receptor, which triggers acute inflammation and cytokine release (Alqahtani, Aleanizy, Mohamed, 2019). In individuals with diabetes, this further weakens an already compromised immune system and increases the risk of a cytokine storm, creating an inflammatory, prothrombotic state. Additionally, age, gender, and the presence of other health issues such as hypertension, CVD, and obesity also contribute to increased risk (Apicella, Campopiano, Mantuano, 2020). Data from China show that mortality among patients with both diabetes and COVID-19 was close to 10% (Zhu, She, Cheng, 2020). Another study showed that the mortality rate from COVID-19 was 50% higher in individuals with diabetes than in those without, and good glycemic control was associated with better outcomes (Rubino, Amiel, Zimmet, 2020). Evidence also suggests a bidirectional relationship between COVID-19 and diabetes, where COVID-19 may influence the development and progression of diabetes. Some studies suggest that SARS-CoV1 may have triggered the acute onset of type 1 diabetes (T1DM) by entering pancreatic islet cells via ACE2 receptors, while COVID-19 may similarly initiate an immune-mediated onset of T1DM in genetically predisposed individuals (Yang, Lin, Ji, 2010). During the COVID-19 pandemic, an increase in newly diagnosed T1DM cases was observed, and similar findings emerged in other patient populations (Rubino et al., 2020). Severe metabolic complications in patients with diabetes and COVID-19, such as diabetic ketoacidosis (DKA) and hyperosmolar coma, have also been reported (Caruso, Longo, Esposito, 2020). In one study, patients with diabetes infected with COVID-19 had a 3.6 times higher risk of death than those without COVID-19 infection (Spanakis, Yoo, Ajayi, 2021). Additionally, reports indicate that COVID-19 may increase the risk of developing type 2 diabetes (T2DM) (Narayan, Staimez, 2022), and corticosteroid therapy used to treat severe COVID-19 infection can lead to the development of DKA in patients with T2DM, particularly in those with poor glycemic control (Mondal, DasGupta, Lodh, 2021).

Pathology and epidemiology overlap in COVID-19 and diabetes

Generally, SARS-CoV-2 is known to enter cells through ACE2 receptors, a key regulator of the renin-angiotensin system (RAS), which controls systemic vascular resistance (Dimitrov DS, 2003). ACE2 is present in most organs, particularly highly expressed in lung cells, providing an entry point for the virus in humans (Hamming I, Timens W, Bulthuis ML, 2004). SARS-CoV-2 binds its S-protein to ACE2 receptors on lung cell surfaces. Host cells then break down the viral S-protein and ACE2 receptor, leading to virus internalization. The infection causes cell death, triggering the release of inflammatory cytokines and attracting immune cells (Hoffmann M, Kleine-Weber H, Schroeder S., 2021). Infected circulating immune cells also undergo apoptosis, releasing cytokines and resulting in a “cytokine storm” that contributes to SARS-

CoV-2-induced multi-organ damage and disrupted endocrine signaling (Felsenstein S, Herbert JA, McNamara PS, 2020). ACE2 expression in extrapulmonary tissues may also contribute to multi-organ damage (Bindom SM and Lazartigues E, 2009). ACE2 is also found in metabolically important organs such as the liver, pancreas, adipose tissue, and small intestine, potentially playing a role in the development of insulin resistance, reduced insulin secretion, and worsening hyperglycemia (Felsenstein S, Herbert JA, McNamara PS, 2020). Pulmonary microvascular thrombosis also plays an important role in the clinical severity of COVID-19, and the acute respiratory distress syndrome (ARDS) caused by COVID-19 differs from typical ARDS (Puelles VG, Lütgehetmann M, Lindenmeyer MT, 2020). Diabetic patients have a higher predisposition for microvascular complications that can affect the lungs. Diabetes is characterized by chronic inflammation, poor glycemic control, endothelial dysfunction, hypercoagulability, and the progression of microvascular and macrovascular complications. Pathological changes seen in diabetes resemble the acute changes occurring during COVID-19 infection but with a longer duration. Consequently, pre-existing inflammation, dysglycemia, and multi-organ damage may be exacerbated in COVID-19-infected diabetic patients (Bindom SM and Lazartigues E., 2009). Epidemiological data confirm and explain the mechanistic link between COVID-19 and diabetes. Numerous studies have shown that COVID-19 is more common in diabetic patients, with prevalence rates ranging from 5.3% to 36% (Feldman EL, Savelieff MG, Hayek SS, 2020). During the acute phase of COVID-19, strict glucose control is essential to prevent the development and progression of diabetic complications. However, care must be taken with pharmacological agents used in COVID-19 treatment, such as corticosteroids, as they can affect glucose metabolism, requiring careful monitoring of glucose levels (Gattinoni L, Coppola S, Cressoni M., 2020).

Relationship between microvascular complications and COVID-19

Early data from China indicated an association between diabetes in COVID-19 patients and poorer outcomes, and this link has been confirmed by data worldwide (Goyal P, Choi JJ, Pinheiro LC, 2020). A study conducted in Scotland by McGurnaghan et al. (McGurnaghan SJ, Weir A, Bishop J, 2021) compared the entire Scottish population (n = 5,463,300) with individuals with diabetes (n = 319,349) during the first wave of the pandemic, showing that people with diabetes, hypertension, and severe obesity had a higher risk of COVID-19 infection, with an odds ratio (OR) of 1.40 [95% confidence interval (CI): 1.30-1.50, $p < 0.0001$] for individuals with diabetes compared to those without diabetes. Additionally, people with diabetes and microvascular complications (nephropathy and retinopathy) who contracted COVID-19 were more likely to experience mortality or require critical care (Liang W, Liang H, Ou L, 2020). The CORONADO study conducted in France (n = 1317) showed that the risk of death on day seven was associated with age (OR = 2.48, 95% CI: 1.74-3.53, $p < 0.0001$), microvascular complications (OR = 2.14, 95% CI: 1.16-3.94, $p = 0.0153$), macrovascular complications (OR = 2.54, 95% CI: 1.44-4.50, $p = 0.0013$), and treated obstructive sleep apnea (OR = 2.80, 95% CI: 1.46-5.38, $p = 0.0020$) (Cariou B, Hadjadj S, Wargny M., 2020). Moreover, a composite index of microvascular disease, defined as advanced retinopathy, diabetic kidney disease, and a history of diabetic foot, was associated with early mortality.

Macrovascular and microvascular complications place a significant burden on diabetes management. The most common microvascular complications include neuropathy, nephropathy, and retinopathy, resulting from metabolic disorders in endothelial cells of retinal vessels, mesangial cells in the kidneys, and axons and Schwann cells of peripheral nerves (Li et al., 2015). Studies such as the Diabetes Control and Complications Trial (DCCT) for type 1 diabetes and the UK Prospective Diabetes Study (UKPDS) for type 2 diabetes demonstrate that intensive blood glucose control delays the onset and progression of diabetic microvascular complications (Nathan, Genuth, Lachin, 1993). It is acknowledged that endothelial damage

caused by elevated glucose levels, oxidative stress due to excessive superoxide production, as well as the formation of sorbitol and advanced glycation end products (AGE) resulting from hyperglycemia, contribute to these microvascular complications (Inzucchi, Bergenstal, Buse, 2012). Recent research indicates that microvascular diseases also affect the risk of cardiovascular disease development in people with type 1 and type 2 diabetes (Brownrigg, Hughes, Burleigh, 2016). Data from a 2016 study conducted on a population of individuals with type 2 diabetes, including 49,027 participants from the UK Clinical Practice Research Datalink, showed that the presence of retinopathy (HR = 1.39, 95% CI: 1.09-1.76), peripheral neuropathy (HR = 1.40, 95% CI: 1.19-1.66), and nephropathy (HR = 1.35, 95% CI: 1.15-1) (Gardner, Antonetti, Barber, 2002) was associated with an increased risk of the first major cardiovascular event (defined as cardiovascular death, nonfatal myocardial infarction, or nonfatal ischemic stroke) (Garofolo, Gualdani, Giannarelli, 2020). This risk was dose-dependent, with the presence of one, two, or three microvascular complications leading to a progressively higher risk of cardiovascular events. Similarly, a study conducted on individuals with type 1 diabetes (n = 774) showed that the presence of microvascular diseases increases the risk of major cardiovascular events and all-cause mortality (Garofolo, Gualdani, Giannarelli., 2019).

Overall, these data highlight the importance of microvascular diseases in the context of diabetes. They not only contribute significantly to the disease burden but also increase the risk of cardiovascular events. Additionally, recent data show that patients with microvascular complications of diabetes have poorer outcomes when infected with COVID-19. Studies have shown that such patients are more likely to develop severe symptoms, experience mortality, or require critical care (Porte, Sherwin, Baron, 2003). This association between microvascular complications, COVID-19, and poor outcomes underscores the need for special attention and treatment for diabetic patients with such complications.

The following table presents clinical studies investigating the relationship between COVID-19 and diabetic microvascular complications:

Table 1. Clinical studies on the association between COVID-19 and diabetic microvascular complications

Auhtor	Study	Findings
Cariou et al.	National multicenter observational study	The 7-day mortality risk was associated with microvascular complications; a composite index of microvascular disease was associated with early mortality.
Corcillo et al.	Single-center study	Retinopathy was independently associated with an increased risk of intubation.
Landecho et al.	Asymptomatic COVID-19 subjects	Twenty percent had cotton wool spots, without signs of vitreoretinal inflammation.
Leon-Abarca et al.	Data from the Mexican Open COVID-19 Registry	Patients with diabetic nephropathy had higher odds of developing COVID-19 pneumonia, requiring intubation, and dying.
Marinho et al.	Case studies of tested subjects	Four subjects had subtle cotton wool spots and microhemorrhages.
McGurnaghan et al.	Cohort study	People with diabetes and microvascular complications infected with COVID-19 had significantly worse outcomes.
Odriozola et al.	Observational study	Widespread sensory neuropathy was observed in all four patients.
Rivero et al.	Multicenter observational study	Postmortem kidney biopsies revealed diabetic nephropathy.
Schiller et al.	Observational study	Severe acute kidney failure and diabetic nephropathy were found in biopsies.

The listed studies provide significant insights into the relationship between COVID-19 and diabetic microvascular complications, as well as their impact on disease outcomes.

CONCLUSION

Research has shown that patients who have recovered from COVID-19 may develop various microvascular complications that impact their post-COVID recovery. Some of the most common microvascular complications in the post-COVID period include:

1. **Endothelial Dysfunction**: COVID-19 can cause damage to endothelial cells lining the blood vessels, leading to vascular dysfunction. This can result in reduced blood flow, an increased risk of thrombosis, and other vascular disorders.
2. **Microthrombosis**: COVID-19 patients may be prone to the formation of microthrombi, small blood clots, within their microvascular systems. This can cause reduced blood flow and organ damage.
3. **Capillary Dysfunction**: COVID-19 can affect capillaries, the smallest blood vessels in the body, which can disrupt the adequate exchange of nutrients and oxygen between blood and tissues.

These microvascular complications can have long-term health consequences for patients following a COVID-19 infection. They may experience symptoms such as fatigue, shortness of breath, reduced cognitive function, concentration issues, and mental health problems. These symptoms are sometimes referred to as post-COVID syndrome or long COVID. It is important to note that research on microvascular complications in the post-COVID period is still ongoing, and more detailed information can be found in professional literature and research papers on this topic.

Based on the analysis of clinical studies investigating the link between COVID-19 and microvascular complications, we can conclude that there is a clear association between diabetes and more severe COVID-19 symptoms, as well as worse outcomes in infected individuals with diabetes. Diabetic patients, especially those with microvascular complications such as retinopathy, nephropathy, and neuropathy, are at a higher risk of severe complications and mortality associated with COVID-19. These findings highlight the need for special attention and tailored protection for diabetic patients during the COVID-19 pandemic. Glycemic control, monitoring of microvascular complications, and timely management of other risk factors such as hypertension and obesity may be key to reducing the severity of the disease and improving outcomes in infected individuals with diabetes.

Further research is needed to better understand the mechanistic link between COVID-19 and diabetic microvascular complications. Identifying specific pathological mechanisms that explain this connection could lead to the development of targeted therapies and preventive measures for this vulnerable population.

Overall, these conclusions emphasize the importance of an integrated approach to caring for diabetic patients during the COVID-19 pandemic and the need for further research to better understand the complex interaction between diabetes and COVID-19.

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Experimental part should be written clearly and in sufficient detail to allow the work to be repeated. Detailed description is required only for new techniques

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Conclusion

It should indicate the significant contribution of the manuscript with its applications.

Acknowledgements

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