DOI: https://doi.org/10.52756/ijerr.2024.v38.015 *Int. J. Exp. Res. Rev.*, Vol. 38: 164-172(2024)

Original Article | *Peer Reviewed* | *Open Access*

International Journal of Experimental Research and Review (IJERR)

ISSN: 2455-4855 (Online)
www.iaph.in
ISSN 2455-4855

Effectiveness of Nursing Strategies on Risk for Pneumonia Among Patients Connected to Mechanical Ventilator in Intensive Care Unit

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Article History:

Received: 6th Feb., 2024
Accepted: 15th Apr., 2024
Published: 30th Apr., 2024

Keywords:
Nursing strategies, Ventilator associated pneumonia, Mechanical ventilator, ICU.

How to cite this Article:
Gopinath Duraivelu, Porkodi Arjunan, Kavitha Ramanathan, Shenbaga Sundaram Subramanian Manjula Annamalai, and Poongodi Ramalingam (2024). Effectiveness of Nursing Strategies on Risk for Pneumonia Among Patients Connected to Mechanical Ventilator in Intensive Care Unit. *International Journal of Experimental Research and Review*, *38*, 164-172.
DOI:
https://doi.org/10.52756/ijerr.2024.v38.015

Abstract: It has been reported that the incidence of nosocomial infections in the ICU is about 2–5 times higher than in the general in-patient hospital population. The study's objective was to evaluate the effectiveness of Nursing Strategies on Risk for Pneumonia among Patients connected to Mechanical Ventilator in Intensive Care Unit. The study adopted randomized controlled trial. Forty patients were enrolled in the study after screening using CPIS scale. If the score <6 the patients were included in the study and eligibility criteria were age between 25 to 60 years, duration of ventilator 48 hours and medical patients with respiratory, renal, MODS, and sepsis diagnosis. Patients subjected to surgery and connected with non-invasive ventilation were excluded from the study. Standardized questionnaire such as demographic variables, clinical variables, and Clinical Pulmonary Infection Scoring (CPIS). The data was analyzed using descriptive statistics, independent 't' test, paired t test and ANOVA were used to analyze the data. Seven (35%) of them were in the age group of 51-60 years in the study group, whereas six (30%) of the patients were in the age group of 61-70 years in the control group. 12(60%) of the patients were male and eight (40%) of them were female in the study group and 10(50%) of patients were male and female respectively in the control group. Regarding mode of ventilation, 12(50%) and six (30%) of patients ventilator setting were CMV and ASV respectively, in the study group, whereas seven (35%) and six (30%) of patients ventilator settings were ASV and CMV respectively in the control group. The pretest CPIS mean score was 4.40 with a standard deviation of 0.59 and the post-test III mean value was 2.60 with a standard deviation of 0.58 and the mean difference was 1.80 between the pretest and the post-test III, which was statistically significant at $p<0.001$ in the study group. Nursing strategies such as demand suctioning, second hourly position change, changing ventilator flow sensor every 72 hours, and oral care every fourth hour with chlorhexidine help reduce ventilator-associated pneumonia.

Introduction

Nosocomial pneumonia (NP) is a parenchymal lung infection that occurs after the first 48 hours of hospital admission (Alp et al., 2006). It accounts for 13–18% of all hospital-acquired infections but is the leading cause of death from nosocomial infections (Alp et al., 2006; Da Silva et al., 2014; Febbo and Ketai, 2021). Despite the clinical experience and major advances in diagnostic techniques and management, VAP remains a significant problem for intensivists (Mishra et al., 2023). It is a major

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threat to patients admitted to intensive care units (ICU) and receiving mechanical ventilation (MV). Patients in intensive care units (ICU) are usually at high risk of mortality not only from their critical illness but also from secondary complications such as nosocomial infection. Ventilator-associated pneumonia (VAP) is the most common nosocomial infection that affects 28% of patients hospitalized in the intensive care unit (ICU) (Ghezeljeh et al., 2017). Nosocomial pneumonia, a common ICU infection, affects 27% of all critically ill patients, where 86% of it is associated with mechanical ventilation (Richards et al., 1999). VAP occurs in 28% of patients who receive mechanical ventilation, where its rate of occurrence varies with the duration of mechanical ventilation. Estimated rates are 3% per day for the first 5 days, 2% per day for days 6–10, and 1% per day after day 10 (Baker et al., 1996). The study aimed to assess the risk for pneumonia among patients connected to mechanical ventilators, assess the effectiveness of nursing strategies on risk for pneumonia among patients connected to mechanical ventilators and associate the risk for pneumonia with background variables among patients connected to mechanical ventilators.

It appears that "hospital-acquired infections" or "health care-associated infections" (HCAIs) can occur during the delivery of health care. Ventilator-associated pneumonia (VAP) is responsible for significant morbidity, mortality and economic costs (Ling et al., 2015). Ventilator-associated pneumonia (VAP) is among the most frequently occurring nosocomial infections, accounting for 25% of ICU-acquired infections (Nusrat et al., 2020). VAP is a relatively common nosocomial infection developed in critically ill patients, with a pooled incidence ranging from 23.8% to 36.0% (Li et al., 2020), according to recent systematic reviews. Prompt initiation of appropriate antibiotics is a cornerstone of the treatment of VAP. Invasive devices such as ventilators used in healthcare are associated with these infections (Khan et al., 2017). Mechanical ventilators are commonly used in the intensive care units (ICU) to keep the patients alive (Junaidy et al., 2018; Luo et al., 2021; Noraini and Wahab, 2022). However, patients under mechanical ventilation are exposed to a wide range of preventable pulmonary complications, including ventilator-associated pneumonia (Sungurlu and Balk, 2024; Teng et al., 2022). The risk of VAP increases by 5–65% per day in patients under mechanical ventilation (Wu et al., 2019). Various strategies have been proposed to prevent VAP, including elevating the head of the bed and maintaining the tracheal cuff pressure between 20 and 30 cmH_2O (Izadi et al., 2024; Manchal et al., 2021; Niederman and Soulountsi, 2011; Safiriyu et al., 2023; Shen et al., 2021; Klompas et al., 2022). VAP can be prevented by various strategies, including basic nursing principles such as hand washing, wearing gloves when performing nursing procedures, oral hygiene using an antiseptic solution and mouthwash, applying a mouth moisturizer and sucking and cleaning the secret (Vanhems et al., 2011; Grap et al., 2011; Havlucu et al., 2012; Izadi et al., 2023). In our setting, a busy ICU in a private sector tertiary care teaching hospital, a strategy to reduce nosocomial infection has not been carried out recently. Therefore, the investigator realized the importance of nursing strategies on the risk for pneumonia among the patients connected with mechanical ventilator.

Methods and materials

A randomized controlled trial was used to conduct the study. The study was conducted in the multidisciplinary intensive care unit of Sri Ramachandra Medical Centre, Tertiary Care Hospital, Chennai, comparing the effect of nursing strategies on the risk for pneumonia to the control group. Intensive Care Unit has 27 beds and admits patients with critical problems such as poisoning, crush injuries, major trauma, multiple organ dysfunction syndrome and end-stage renal disease. The average number of patients on ventilator are about 60 to 70 per month.

The sample size for the study was 40 (20 in the control group and 20 in the intervention group). The samples were the samples of patients who were mechanically ventilated in the multidisciplinary ICU of Sri Ramachandra Medical Centre and those who met the inclusion criteria. Block randomization was used to allocate the study participants into intervention and control groups. Block randomization was adopted and divided into 2 blocks, with each block consisting of 10 patients in the control group and 10 patients in the intervention group. Patients were randomly allotted into intervention and control groups. When the assignment of samples to the first block was completed, the second block was considered. Patients were consecutively assigned to the study according to eligibility criteria.

The investigator reviewed the patients' health records to determine eligibility criteria and then screened the patients using the CPIS scale. If the score <6, the patients are included in the study and aged between 25 to 60 years, with a duration of ventilator 48 hours and medical patients with respiratory, renal, MODS, and sepsis diagnoses were included in the study. Patients subjected to surgery and connected with non-invasive ventilation were excluded from the study. The tool used for the study consists of two sections. Section A consists of demographic variables such as age, gender, occupation, family income, residence and

DOI: https://doi.org/10.52756/ijerr.2024.v38.015

education and Clinical variables such as diagnosis, duration of ventilation, mode of ventilator, and medications. Section B consists of Clinical Pulmonary Infection Scoring (CPIS). CPIS was constructed and standardized by Pugin in 1991. This is a standardized tool consisting of six components as Tracheal secretions, Leukocyte count (mm3), Temperature (°C), PaO_2/FIO_2 ratio (mmHg), Chest radiograph and Culture of tracheal aspirate. Each component has 2–3 items and a maximum score of two and a minimum score of zero was given to each component and the total score was 12. A score of more than six in CPIS indicates the patient was at risk for ventilator-associated pneumonia, and a score of less than six in CPIS indicates no risk for pneumonia. The reliability score of the tool was 0.84. The pilot study was conducted in the multidisciplinary critical care unit of Sri Ramachandra Medical Centre, Tertiary Care Hospital, Chennai. The result showed that the study was feasible to be conducted by the investigator. During data collection, the researcher assessed eligibility and randomization. The investigator has implemented a nursing strategy that includes need-based endotracheal suctioning, changes in every 2nd hourly position, oral care using 0.2% chlorhexidine every 4th hour, and changes in ventilator circuits every 72 hours.

The investigator has obtained official permission from the Head of the Department and Medical director of the hospital. The Institutional Ethical Committee's permission was also obtained to conduct the study. The investigator visits ICU daily and checks the nominal register to get information about the list of patients on mechanical ventilator. Informed consent was obtained from patients' family members. Then, the patients who fulfilled the inclusion criteria were included as participants in the study. The investigator carried out the intervention for three days and assessed the post-test from the third day of intervention for three consecutive days.

The data were analysed using both descriptive and inferential statistics. Descriptive statistics such as frequency, percentage, mean and standard deviation were used to assess the baseline characteristics of the study participants. Inferential statistics such as the independent 't' test was used to compare the clinical pulmonary infection score between study and control groups, paired 't' test was used to compare the clinical pulmonary infection score within the group, and ANOVA was used to associate the risk for pneumonia with the background variables.

Table 1. Frequency and percentage distribution of demographic variables among patients connected to mechanical ventilator (N=40).

Sl.No	Demographic variables	Study group (n=20)		Control group (n=20)	
		f	%	f	%
1.	**Age (in years)** a. 31-40 b. 41-50 c. 51-60 d. 61-70	 06 01 07 06	 30 05 35 30	 05 04 05 06	 25 20 25 30
2.	**Gender** a. Male b. Female	 12 08	 60 40	 10 10	 50 50
3.	**Education** a. No formal education b. Primary c. High school d. Professional	 03 08 05 04	 15 40 25 20	 07 07 06 -	 35 35 30 -
4.	**Occupation** a. Business b. Retired c. Home maker d. Skilled	 06 02 06 06	 30 10 30 30	 08 03 08 01	 40 15 40 05
5.	**Monthly family income (in Rs)** a.<10,000 b.10,000-20,000 c.21,000-30,000 d.>30,000	 - 06 13 01	 - 30 65 05	 - 12 07 01	 - 60 35 05

DOI: https://doi.org/10.52756/ijerr.2024.v38.015

Table 2. Frequency and percentage distribution of clinical variables among patients connected to mechanical ventilator (N=40).

Sl.No	Clinical variables	Study group (n=20)		Control group (n=20)	
		f	%	f	%
1.	**Diagnosis**				
	a. Respiratory conditions	01	05	01	05
	b. Renal failure	05	25	02	10
	c. Multiple organ failure	02	10	02	10
	d. Sepsis	03	15	03	15
	e. Any other	09	45	12	60
2.	**Mode of ventilator**				
	a. SIMV	02	10	04	20
	b. ASV	06	30	07	35
	c. CMV	10	50	06	30
	d. Others	02	10	03	15
3.	**Number of days on ventilator**				
	a. 2-3 days	12	60	08	40
	b. 3-4 days	-	-	-	-
	c. 4-5 days	08	40	12	60
4.	**Medication**				
	a. Antibiotics	09	45	11	55
	b. Sedatives	01	05	-	-
	c. Anticoagulants	03	15	02	10
	d. Inotropes	07	35	07	35

Results

Results of the study are presented following the research objectives. The frequency and percentage distribution of background variables of patients connected to mechanical ventilator are discussed in the following tables (Table 1 & Table 2).

Discussion

The first objective was to assess the risk for pneumonia among patients connected to mechanical ventilator. In the study group, all the patients, 20 (100%), had CPIS negative in pretest and post-test III, respectively. Meanwhile, in the control group patients, only one (5%) patient had CPIS positive, and in post-test III, three (15%) patients had CPIS positive (Table 3).

Table 3. Frequency and percentage distribution of CPIS on risk for pneumonia among patients connected to mechanical ventilator in the study and the control group (N=40).

CPIS	Study group (n=20)								Control group (n=20)							
	Pretest		Posttest I		Posttest II		Posttest III		Pre test		Posttest I		Posttest II		Posttest III	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
< 6	20	100	20	100	20	100	20	100	20	100	18	90	17	85	17	85
> 6	-	-	-	-	-	-	-	-	-	-	2	10	3	15	3	15

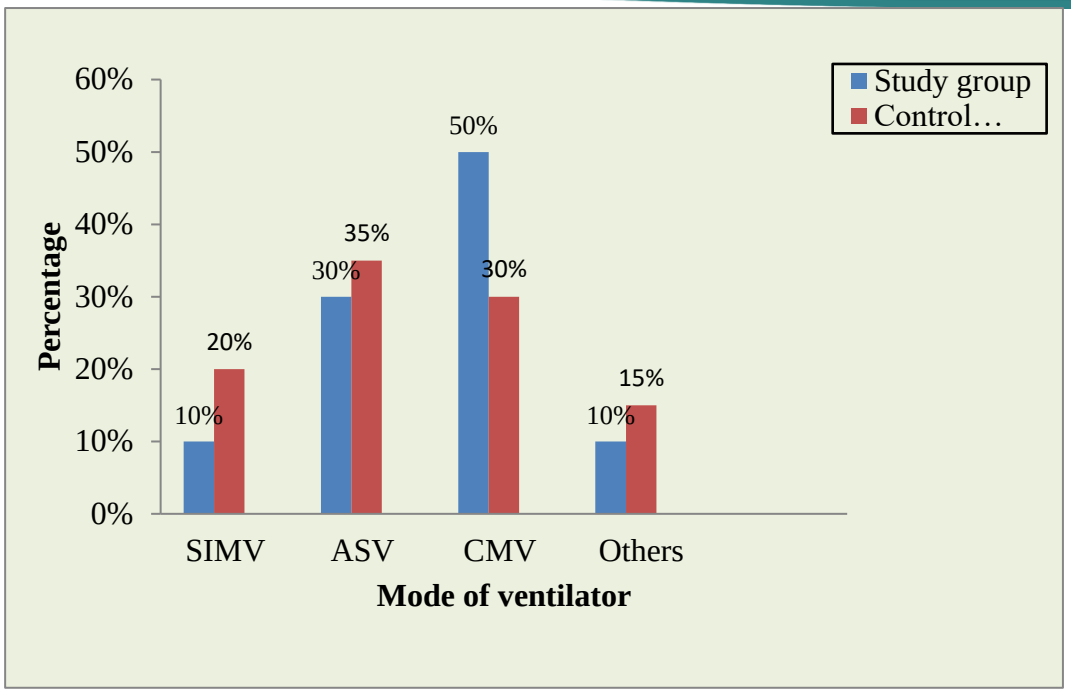

Figure 1. Percentage distribution of mode of ventilator (N=40).

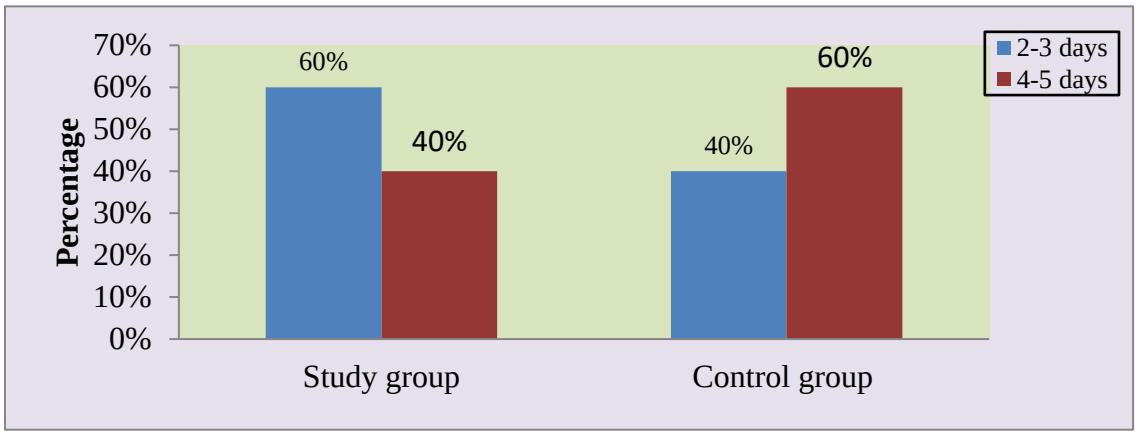

Figure 2. Percentage distribution of number of days on ventilator (N=40).

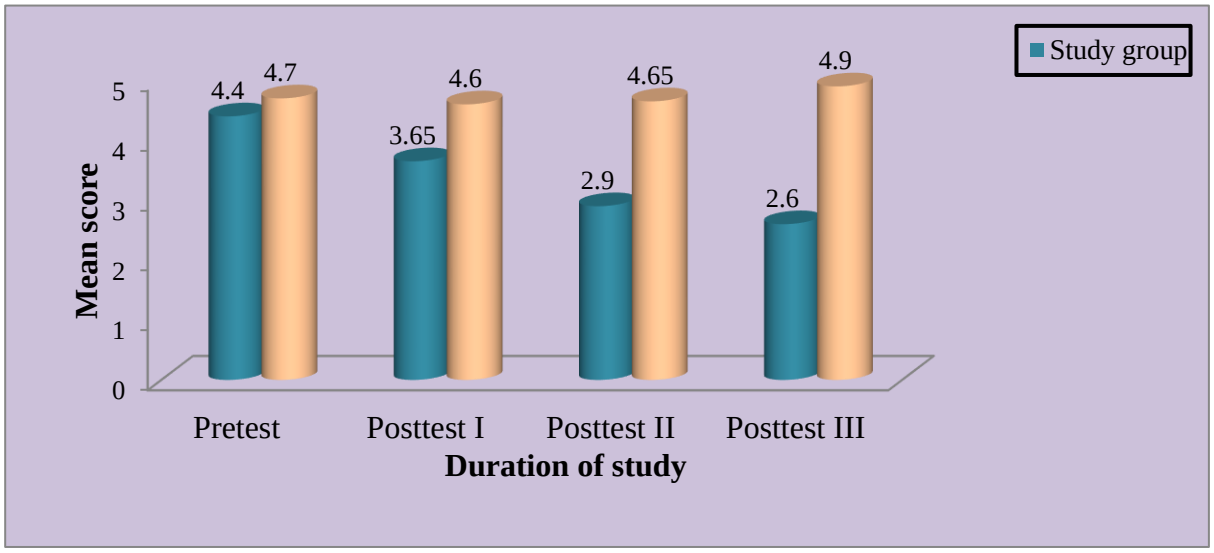

Figure 3. Comparison of CPIS mean score between the study and control group (N=40).

DOI: https://doi.org/10.52756/ijerr.2024.v38.015

The second objective was to assess the effectiveness of nursing strategies on risk for pneumonia among patients connected to mechanical ventilator. The pretest values between the study and the control groups did not show any significant difference. In the post-test I, the mean value was 3.65 for the study group and 4.60 for the control group, which was statistically significant at p<0.001. In post-test II, the mean values showed 2.90 and 4.65 in the study and control groups, respectively. This was statistically significant at p<0.01. High level of significance was noted in the post-test III between the study and the control group at p<0.001(Table 4).

Table 4. Mean, standard deviation and independent 't' value on CPIS among patients connected to mechanical ventilator between study and control group (N=40).

Duration of study	Study group (n=20)		Control group (n=20)		Mean Difference	t and p value
	Mean	SD	Mean	SD		
Pretest	4.40	0.59	4.70	1.08	-0.30	1.09 0.28 (NS)
Post-test I	3.65	0.87	4.60	0.88	-0.95	3.42 0.002***
Post-test II	2.90	0.72	4.65	1.18	-1.75	5.68 0.000***
Post-test III	2.60	0.60	4.90	1.07	-2.30	8.38 0.000***

Table 5. Mean, standard deviation and independent 't' value on CPIS among patients connected to mechanical ventilator between pretest and post-test I, II and III among study and control group (N=40)

Variables	Duration	Study group		Control group		Mean difference	t and p value
		Mean	SD	Mean	SD		
CPIS	Pretest Post-test I	0.75	0.78	0.10	0.91	0.65	2.41 0.021
	Pretest Post-test II	1.50	0.76	0.05	1.09	1.45	4.85 0.000***
	Pretest Post-test III	1.80	0.52	0.20	1.24	2.00	6.64 0.000***

This study's result is consistent with a study conducted by Jahanshir et al. (2023) to investigate clove mouth-wash's effect on ICU VAP incidence. After the intervention, 20.2% (n=17) of the patients in the intervention group and 41.7% (n=35) in the control group acquired VAP. The incidence rate of VAP was 2.06 times higher in the control group than in the intervention group (RR=2.06, 95% CI: 1.26–3.37, p=0.005). Similarly, Safavi et al. (2023) conducted a study to determine the effect of implementing infection control guidelines on the incidence of VAP in patients admitted to the intensive care unit. The two groups had no significant differences regarding their baseline GCS, body temperature, white blood cell counts, Pao2/fio2 and MCPIS score (P>0.05). However, the intervention group had lower body temperature (P<0.001), lower white blood cell counts (P<0.038), lower MCPIS score (P <0.001) and higher PaO2/FIO2 (P<0.013) at the end of the study. The incidence of VAP was significantly lower in the intervention group when compared to the control group (i.e., 30% vs. 65.6%, P<0.001).

Ghezeljeh et al., 2017 conducted a study comparing the head of bed (HOB) elevation to 30 and 45 degrees on the incidence of VA. The Chi-square test results confirmed a statistically significant difference regarding VAP after 3 days (P = 0.01, χ 2 = 9.451). It was noted that 52.50% of the patients in the control group suffered from VAP. VAP in the intervention groups was reported as 32.50% and 20.00% in 30 degrees as well as 45 degrees groups, respectively (Table 5).

DOI: https://doi.org/10.52756/ijerr.2024.v38.015

Also, the patients in the 45 degrees group suffered less (12%) from VAP compared to the 30 degrees group. Similarly, a study by Drakulovic et al. showed that raising the head of the bed can significantly reduce the incidence of VAP (Güner et al., 2022; Mahmoodpoor et al., 2017; Lauzier et al., 2008; Love and Kao, 2013).

Conclusion

In the present study, implementing an infection control guideline could significantly reduce the incidence of VAP and its diagnostic indicators in patients admitted to intensive care units. These findings confirm that designing and implementing simple and evidence-based guidelines can reduce the risk and incidence of VAP in intensive care units. The study findings suggest that nursing strategies such as demand endotracheal suctioning, 4th hourly oral care using chlorhexidine solution, second hourly position changes, and ventilator circuit change every 72 hours prevent ventilator-associated pneumonia. Monitoring the patients using CPIS every shift is very important as a screening for early identification of ventilator-associated pneumonia. Effective nursing care and the application of VAP bundles should be rigorously applied in developing countries for VAP prevention. Using different strategies for VAP prevention is a continuously evolving field. Our study's results suggest that using a dynamic supervised oral health care guideline is more effective than the routinely used protocols in the ICU of hospitals. Thus, continuous patient surveillance and nursing interventions using CPIS to prevent complications and participation in the treatment and care become the major roles of nurses in critical care units. The nurse administrator must take essential steps to organize and encourage the staff to participate in programs like continuing nursing education workshops, as these measures will help to keep abreast of the current trends in patient care.

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How to cite this Article:

Gopinath Duraivelu, Porkodi Arjunan, Kavitha Ramanathan, Shenbaga Sundaram Subramanian, Manjula Annamalai, and Poongodi Ramalingam (2024). Effectiveness of Nursing Strategies on Risk for Pneumonia Among Patients Connected to Mechanical Ventilator in Intensive Care Unit. *International Journal of Experimental Research and Review*, *38*, 164-172.

DOI : https://doi.org/10.52756/ijerr.2024.v38.015