Jurnal Inovasi Teknologi dan Rekayasa
Vol. 9, No. 1, January-June 2024, pp. 111-118
ISSN: 2581-1274

The Comparison of Ergonomic Assessment Results in the Automotive Polymer Industry: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and Rapid Upper Limb Assessment (RULA) Methods

Khadijah Sayyidatun Nisa [a,1,*], Abdussalam Topandi [a,2], Isma Wulansari [a,3], Fauziah Aulia [a,4], Bismo Zulfikar Mustofa [a,5]

[a] *Chemical Polymer Engineering Department, Politeknik STMI, Jakarta, Indonesia*
[1] *khadijahnisa@kemenperin.go.id *; [2] atopandi@stmi.ac.id; [3] ismawulansari@kemenperin.go.id,*
[4] *fauziahauliaaa@gmail.com; [5] bismozulfikar.m21@gmail.com*
** corresponding author*

ARTICLE INFO

Article history:
Accepted

Keywords:
Rapid Upper Limb Assessment (RULA)
Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)
Automotive
Polymer
Downstream industry

ABSTRACT

Musculoskeletal disorders (MSDs) encompass injuries to muscles, nerves, joints, and connective tissues, affecting the neck, back, and limbs. The polymer automotive industry, particularly in manufacturing automotive components using plastic injection tools, involves workers with diverse postures. Non-ergonomic postures can lead to muscle tension and health issues, emphasizing the importance of safety and ergonomics. This study employs the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and Rapid Upper Limb Assessment (RULA) methods to assess working postures. In the production sector, the average RULA score is 3.8 (31.67%), indicating moderate risk and suggesting further investigation. Conversely, the non-production sector's average RULA score is 3.4 (28.33%), indicating a lower risk but still necessitating changes. CMDQ analysis on 12 respondents reveals posture variation. In the production sector, the average CMDQ score is 2.5 (20.83%), signaling moderate risk and advocating for further investigation. This study lays groundwork for downstream polymer industries to enhance efficiency, quality, and safety.

I. Introduction

Ergonomics is a scientific approach that aims to interact humans with various interfaces [1]. The main goal of ergonomics is to analyze human performance by considering work posture, the type of task performed, and its impact on the body [2]. Various predictive technologies have been developed to help workers in the workplace by reducing stress and fatigue. Musculoskeletal Disorders (MSDs) can be defined as injuries to muscles, nerves, joints, connective tissue such as ligaments and tendons, or other body structures that support or form the neck, back and limbs [3]. MSD causes enough inflammation and discomfort to disrupt a person's daily functioning, and is a condition that activates over time. MSD often occurs in various fields of work, including jobs with heavy biomechanical loads, such as in the manufacturing and factory sectors, and also jobs with lighter loads such as in office workplaces [4]. According to India's Ministry of Housing and Urban Poverty Alleviation (MHUPI), there are around 10 lakh street vendors operating across the country, and around 20% of them are street vendors [5]. The majority of workers work for 8-10 hours a day with unergonomic body postures, which can cause health problems.

At the end of the 1990s the Musculoskeletal Discomfort Questionnaire (MSD) was developed, which is now recognized as one of the most vital questionnaires in the domain of musculoskeletal disorders [6]. There is another questionnaire that focuses on body posture, namely the CMDQ, where this method, apart from assessing the frequency and severity of discomfort, this questionnaire also

DOI: 10.31572/inotera.Vol9.Iss1.2024.ID309 W : http://inotera.poltas.ac.id | E : inotera@poltas.ac.id

broadcasts how much musculoskeletal discomfort hinders the ability to work [7]. The CMDQ questionnaire was distributed among workers from day one and technology to avoid changes in workers' daily routines during data's collection [8]. Workers who experience ergonomic problems have 10 minutes to fill out the questionnaire and then complete the CMDQ-M, the results of which are used to measure the survey questionnaire [7].

The RULA (Rapid Upper Limb Assessment) method is a method used to assess the risk of musculoskeletal injury associated with manual handling tasks [9]. This method consists of a series of questions rated on a scale of one to five, where a higher score indicates a greater risk of injury [10]. The RULA method has been shown to be a valid and reliable method for evaluating the risk of musculoskeletal injuries to the upper extremities associated with manual work [11]. The RULA method is indeed one of the commonly used ergonomic assessment tools in workplaces, particularly for evaluating and reporting work-related upper body problems. Its structured approach allows for systematic observation and assessment of various factors such as posture, force exertion, and repetition, which are crucial in identifying potential ergonomic risks that could lead to upper body musculoskeletal disorders (MSDs). By using the RULA method, workplaces can effectively gather data on employees' working postures and activities, assess the associated ergonomic risks, and implement appropriate interventions or ergonomic improvements to prevent or mitigate work-related upper body problems. Overall, the RULA method serves as a valuable tool for promoting workplace ergonomics and ensuring the health and safety of employees, particularly in industries where tasks involve repetitive or physically demanding activities [12].

The RULA (Rapid Upper Limb Assessment) method is indeed used to assess and address ergonomic risks related to the human body, particularly focusing on the upper limbs. It involves the use of mathematical prediction models to estimate various factors such as anthropometric measurements, required strength, and muscle activity to evaluate the risk of developing musculoskeletal disorders (MSDs) due to repetitive or awkward tasks [13]. It is particularly beneficial for workers involved in plastic or polymer injection and visual administration tasks that are often associated with certain risk factors [14]. By using work assessment methods such as RULA, it is hoped that it can minimize the risk of musculoskeletal injuries in the workplace and improve the overall health and well-being of workers [15]. The RULA method evaluates the body by classifying it into 8 groups [16]. The trunk, neck, and legs were evaluated in the first group, while the upper and lower arms and wrists were evaluated in the second group [17].

This study aims to examine the working posture of workers in the automotive polymer industry to understand body complaints and possible associated ergonomic risks. The methods used were the Rapid Upper Limb Assessment (RULA) and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). RULA will evaluate posture risks to computer use, while CMDQ will provide subjective insight into the physical and psychological discomfort experienced by workers [17]. This study also aims to provide recommendations for improvements, including changing work postures, improving facilities, and promoting healthy habits in the workplace, to reduce ergonomic risks. Through careful data's analysis, it is hoped that this study will provide valuable insights for automotive polymer industry companies in improving workers' working conditions. The research process involved detailed planning, data's collection through direct observation and CMDQ questionnaires, and data's analysis using various statistical techniques. It is hoped that the research results will provide clear guidance for companies in improving working conditions and worker welfare, as well as becoming a basis for further ergonomics and occupational health research.

II. Method

The research conducted at Sole Company PT. Mada Wikri encompassed workers across multiple divisions, including production, workshop, loading and shipping, office, and quality control. Employing a mixed methods approach, which integrates qualitative and quantitative methodologies, ensured a comprehensive analysis of workplace conditions. The sampling strategy utilized Cluster Random Sampling, facilitating the representation of diverse work groups and areas within the company. Data collection involved administering the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) to gauge employees' musculoskeletal health. This questionnaire likely provided insights into the prevalence and severity of discomfort experienced by workers. Subsequently, analysis of CMDQ and possibly ROSA data identified areas requiring improvement within Sole Company PT. Mada Wikri. These improvements likely revolved around optimizing workstation designs to mitigate musculoskeletal discomfort and enhance overall ergonomics. By addressing the root causes identified through data analysis, the company aimed to foster a healthier and more productive work environment for its employees. Through this systematic research approach, Sole Company PT. Mada Wikri demonstrated its commitment to prioritizing employee well-being and implementing evidence-based solutions to enhance workplace conditions.

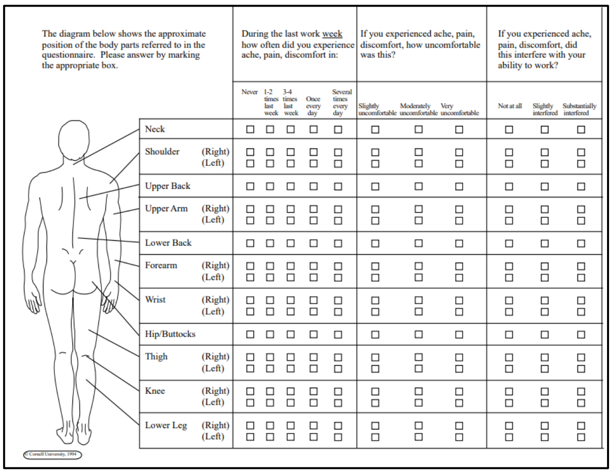

Fig 1. CMDQ method

Table 1. CMDQ assessment as well as risk group recoding

RULA		CMDQ							Risk Level
		Frequency		Uncomfortable		Interfered		Interpretation	
Score	Action	Score	Action	Score	Action	Score	Action		
1 – 2	acceptable	0	never	1	slightly	1	not at all	postures are acceptable if they are not repeated for a long time	1
3 – 4	needs investigation	1,5	1 – 2 times last week					further investigation is needed and changes may be necessary	2
5 – 6	investigation and change are needed	3,5	3 – 4 times last week	2	moderate	2	slightly	investigation and change are needed	3
7	improvements and changes are required immediately	5	once every day					fixed and required changes	4
		10	several times every day	3	very	3	substantially	immediate change is needed	5

The RULA score categorizes risk into four levels, aiding in the identification of potential ergonomic issues. In Figure 1, the CMDQ assessment outcomes are depicted, while Figure 2 illustrates the RULA assessment results generated through ErgoFellow 2.0 software. Comparing CMDQ and RULA results, the risk level in the group is classified from low risk, where no immediate action is needed, to situations demanding immediate changes. Table 1 outlines the correlation between risk groups and the findings from both assessment methods. This comparative analysis allows stakeholders to understand the alignment or discrepancies between the CMDQ and RULA assessments, facilitating informed decision-making regarding ergonomic interventions. By integrating data from multiple sources and employing software-driven assessments, companies like Sole Company PT. Mada Wikri can effectively prioritize and address ergonomic concerns to enhance workplace safety and employee well-being.

Fig 1. RULA method in ErgoFellow software

III. Results and Discussion

In this research, an analysis of 12 work positions operating in the automotive polymer industry was carried out. Based on Table 2, of the 12 different work positions, 50% consists of production unit activities and 50% from non-production unit activities. Through the Kruskal-Wallis test, differences in occupational measures were adjusted using the CMDQ and RULA methods against newly developed scores. The results showed a statistically significant difference between the occupational measures ($p < 0.05$).

The importance of assessing work posture is because suboptimal work positions have long been recognized as a major risk factor in the emergence of work-related musculoskeletal disorders. This is especially true when manual material handling is involved. Thus, understanding the impact of work posture on worker health and well-being is crucial in maintaining work productivity and quality. This research provides valuable insight for practitioners in the automotive polymer industry to identify, quantify, and reduce the risk of musculoskeletal disorders in the workplace, with the hope of improving working conditions and worker well-being.

A. Demographics

A significant proportion of the research participants, comprising 83.33%, were male, while all participants were citizens of Indonesia. Their ages ranged from 20 to 45 years, indicating a relatively youthful workforce. Furthermore, all participants shared a common work background, employed at PT. Mada Wikri Tunggal. This demographic homogeneity suggests a consistent pool of workers from similar socio-cultural and occupational contexts, enhancing the reliability and comparability of research findings. The uniformity in demographics facilitates a focused analysis of workplace conditions and ergonomic risks specific to this particular workforce demographic, aiding in the formulation of targeted interventions to address musculoskeletal discomfort effectively.

B. Validity of RULA and CMDQ

The examination of RULA scores among 12 respondents in the polymer industry, covering both production and non-production sectors, exposes discernible differences in their work posture assessments. In the production sector, the average RULA score was 3.8 (31.67%), indicating a moderate risk level. This underscores the urgency for further scrutiny and immediate corrective actions to mitigate potential ergonomic hazards. Conversely, in the non-production sector, the average RULA score averaged at 3.4 (28.33%), signaling a relatively lower risk level. However, despite the diminished risk, it still warrants proactive interventions to optimize ergonomic conditions. These findings underscore the necessity for sector-specific evaluations and tailored interventions to address varied ergonomic challenges effectively within distinct operational realms of the polymer industry. By addressing these discrepancies through targeted interventions, companies can ensure the well-being and safety of their employees across diverse work environments within the polymer industry.

Table 2. Distribution of risk levels for the CMDQ and RULA methods

Department	Method	Risk Level										Total	
		1		2		3		4		5			
		N	%	N	%	N	%	N	%	N	%	N	%
Production	RULA	1	16.7	1	16.7	1	16.7	2	33.3	1	16.7	6	100%
	CMDQ	1	16.7	2	33.3	2	33.3	1	16.7	0	0	6	100%
Non-Production	RULA	1	16.7	2	33.3	1	16.7	1	16.7	1	16.7	6	100%
	CMDQ	1	16.7	2	33.3	2	33.3	1	16.7	0	0	6	100%

This analysis highlights the need to focus on the production sector, where work posture risks are higher. It is important to take appropriate precautions to reduce the risk of work injury. Thus, further investigation needs to be carried out to understand the specific aspects of work posture that cause high risks and to identify appropriate solutions. In addition, it is important to note that analyzes using the REBA method also show a significant level of risk [18]. This emphasizes the urgency of improving working conditions to minimize the risk of injury. Improvement efforts must be directed at aligning work posture with the principles of ergonomics and work safety. Steps such as equipment adjustments, employee training on good work posture practices, and changes to work procedures may be necessary to achieve safer and ergonomic working conditions. Thus, the results of this RULA and REBA analysis provide a basis for further action to improve working conditions and employee welfare in the polymer industry environment [19].

The results of the CMDQ analysis of 12 respondents in the polymer industry, both in the production and non-production sectors, show variations in their work posture categories. In the production sector, the average CMDQ score was 2.5 (20.83%), indicating moderate risk and suggesting the need for further investigation and immediate changes.

Table 1. Normality distribution of working postures according to the Kolmogorov–Smirnov test for RULA and CMDQ

Method	N	Minimum	Maximum	Mean ± Std. Dev	Significance	Kruskal-Wallis	Durbin-Watson
RULA	12	1	7	5.00 ± 2.17	0.837	7.983	1.075
CMDQ	12	1	3	1.58 ± 0.51	0.651	3.138	

Based on Table 3, there are 12 samples during the work stages including work in production units and non-production units using CMDQ and RULA to assess the risk of musculoskeletal disorders. The risk of musculoskeletal disorders is at level 1, around 57.1% of the working postures of the production units investigated and the risk of musculoskeletal disorders is at levels 2, 3 and 4, respectively, amounting to 28.6% of the working postures of non-production units at the work stage of operating polymer industrial equipment. automotive according to CMDQ. Level 2 and 3 risk groups refer to low and medium risk, respectively. In this study the risk was at level 2 at 57.1% of production units and 28.6% of non-production units, level 3 at 14.3% of production units and 28.6% of non-production units in the assessment carried out using RULA.

Based on the overall results for work stages in production and non-production units, statistically the CMDQ and RULA methods show that work stages in the automotive polymer industry are both associated with the risk of musculoskeletal disorders. The results of the analysis using the CMDQ method show different results from RULA. This difference is due to the fact that both methods were developed taking into account different types of work.

Table 2. Correlation coefficient values for RULA and CMDQ

		RULA		**CMDQ**	
		Production	**Non-production**	**Production**	**Non-production**
Pearson Correlation	RULA Production	1	-0,173	0,463	0,218
	RULA Non-production	-0,173	1	0,281	0,662
	CMDQ Production	0,463	0,281	1	0
	CMDQ Non-production	0,218	0,662	0	1
Kendall's Number	RULA Production	1	-0,160	0,392	0,277
	RULA Non-production	-0,160	1	0,204	0,481
	CMDQ Production	0,392	0,204	1	0
	CMDQ Non-production	0,277	0,481	0	1

Based on Table 4, there is a relationship between RULA and CMDQ in production and non-production units with a Pearson Correlation value > 0.5. Musculoskeletal disorders risk assessment methods fall into three main groups: survey scale, systematic observation, and direct observation [20]. The direct observation method provides the most reliable results, systematic observation is the most commonly used method and this is due to its ease of use and low cost so that the relationship between fatigue and humans is considered based on the method used as a decision in the classification of the chosen ergonomic evaluation method. The systematic observation method used differs from all other observation methods in terms of applicability for assessing recordings of working postures and the whole body.

The CMDQ method considers the work stages of production and non-production units as having similar demands, however, this is most likely due to the fact that the frequency of repetitive movements during work activities is much higher than the frequency of repetitive movements. The RULA method considers the number of different job demands so that the CMDQ and RULA methods are used together, especially the CMDQ method which is easier to use in plastic injection work but RULA provides a more accurate assessment.

IV. Conclusion

Ergonomics is an important scientific approach in evaluating human interactions with the work environment. To help identify and reduce injury risk, various prediction technologies and assessment methods such as the Musculoskeletal Discomfort Questionnaire (MSD), Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and Rapid Upper Limb Assessment (RULA) have been developed. This highlights the importance of using a combination of ergonomic evaluation methods to obtain a more comprehensive picture of ergonomic risks in the workplace. It is hoped that the results of this study can provide guidance for companies in improving working conditions and worker welfare, as well as becoming a basis for further research into ergonomics and occupational health.

Assessment of work posture is very important because suboptimal work positions are a major risk factor in the occurrence of work-related musculoskeletal disorders, especially in manual material handling. The majority of research participants were male Indonesian citizens with ages ranging from 20 to 45 years, all of whom worked at PT. Mada Wikri Tunggal. The results of the RULA analysis show variations in work posture categories, with the production sector having a higher risk of work posture than the non-production sector. Analysis using the CMDQ method also shows moderate risk in the production sector, indicating the need for further investigation and immediate changes. From the analysis results, it can be concluded that the CMDQ and RULA methods show a relationship between the stage of work in the automotive polymer industry and the risk of musculoskeletal disorders. The relationship between these two methods confirms that they can support each other in evaluating ergonomic risks. The use of both methods together allows a more comprehensive evaluation of the risks of work postures and work-related musculoskeletal disorders, although the differences in results between the two are partly due to the different focus of the methods on the type of work observed. In this context, although systematic observation is more commonly used due to its ease of use and low cost, direct observation is considered to provide more reliable results.

Acknowledgment

The author would like to thank Chemical Polymer Engineering Politeknik STMI Jakarta Ministry of Industry of the Republic of Indonesia and PT Mada Wikri Tunggal for the research support.

References

[1] Z. Li, R. Zhang, C. H. Lee, dan Y. C. Lee, “An evaluation of posture recognition based on intelligent rapid entire body assessment system for determining musculoskeletal disorders,” *Sensors (Switzerland)*, vol. 20, no. 16, hal. 1–21, Agu 2020, doi: 10.3390/s20164414.

[2] J. J. Ferreira *et al.*, “The International Journal of Management Science and Information Technology,” *Strateg. Manag. J.*, vol. 47, no. 2, hal. 262–70, 2014, [Daring]. Tersedia pada: http://www.scopus.com/inward/record.url?eid=2-s2.0-59449096567&partnerID=40&md5=7b9a4633bdffaaa25dc5a74553d06e19%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/9109284

[3] P. J. Beliveau, H. Johnston, D. Van Eerd, dan S. L. Fischer, “Musculoskeletal disorder risk assessment tool use: A Canadian perspective,” *Appl. Ergon.*, vol. 102, no. January, hal. 103740, 2022, doi: 10.1016/j.apergo.2022.103740.

[4] S. B. Owonikoko, J. A. Momodu, dan J. B. A. Suleiman, “Trend and pattern analysis of incidents of rape during the period of Covid-19 pandemic in Adamawa state, Northeastern Nigeria,” *African Secur. Rev.*, vol. 0, no. 0, hal. 1–18, 2023, doi: 10.1080/10246029.2022.2159464.

[5] S. Rathore, K. L. A. Khan, A. P. Agrawal, R. Chalisgaonkar, R. K. Raj Singh, dan M. Katiyar, “Modelling of Indian vendors posture using rapid upper limb assessment (RULA),” *Mater. Today Proc.*, vol. 64, hal. 1234–1238, 2022, doi: 10.1016/j.matpr.2022.03.712.

[6] A. N. Aulia, M. M. S. T, dan M. Sc, “Analisis Risiko Ergonomi Menggunakan Metode ROSA dan CMDQ pada Pekerja Dinas Perindustrian dan Perdagangan Jawa Tengah,” hal. 1–7, 2013.

[7] A. Shariat, S. B. M. Tamrin, M. Arumugam, dan R. Ramasamy, “The Bahasa Melayu version of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): Reliability and validity study in Malaysia,” *Work*, vol. 54, no. 1, hal. 171–178, 2016, doi: 10.3233/WOR-162269.

[8] S. Kreuzfeld, R. Seibt, M. Kumar, A. Rieger, dan R. Stoll, “German version of the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): Translation and validation,” *J. Occup. Med. Toxicol.*, vol. 11, no. 1, hal. 1–12, 2016, doi: 10.1186/s12995-016-0100-2.

[9] H. Julianus, “Work Posture Analysis by Using Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) Methods (Case Study: Rice Milling in Malang - East Java of Indonesia),” in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Jan 2019. doi: 10.1088/1757-899X/469/1/012012.

[10] D. Kee, S. Na, dan M. K. Chung, “Comparison of the Ovako Working Posture Analysis System, Rapid Upper Limb Assessment, and Rapid Entire Body Assessment based on the maximum holding times,” *Int. J. Ind. Ergon.*, vol. 77, Mei 2020, doi: 10.1016/j.ergon.2020.102943.

[11] M. R. Herdiana dan A. E. Nugraha, “Penilaian Risiko Postur Kerja Berdasarkan Metode RULA Pada Pekerja Manual Handling di Toko H. Dadang,” *J. Serambi Eng.*, vol. 8, no. 1, hal. 4367–4373, 2023.

[12] M. R. Fikri dan R. Rusindiyano, “Analisis Postur Kerja Pekerja Divisi Minipack Sikatop Menggunakan Metode RULA di PT. Sika Indonesia,” *J. Univers. Tech.*, vol. 2, no. 1, hal. 137–141, 2023.

[13] M. Abdulrahim, “Development of Biomechanic Methods for Ergonomic Evaluation : Comparison With Rula and Ses Methods,” vol. 10, no. 03, hal. 102–109, 2019.

[14] M. & Corlett, “RULA Employee Assessment Worksheet,” *Appl. Ergon.*, vol. 24, no. 2, hal. 91–99, 1993.

[15] S. Dockrell *et al.*, “An investigation of the reliability of Rapid Upper Limb Assessment (RULA) as a method of assessment of children’s computing posture,” *Appl. Ergon.*, vol. 43, no. 3, hal. 632–636, 2012, doi: 10.1016/j.apergo.2011.09.009.

[16] M. Ijaz, S. R. Ahmad, M. Akram, W. U. Khan, N. A. Yasin, dan F. A. Nadeem, “Quantitative and qualitative assessment of musculoskeletal disorders and socioeconomic issues of workers of brick

industry in Pakistan," *Int. J. Ind. Ergon.*, vol. 76, no. February, hal. 102933, 2020, doi: 10.1016/j.ergon.2020.102933.

[17] W. Kim, J. Sung, D. Saakes, C. Huang, dan S. Xiong, "Ergonomic postural assessment using a new open-source human pose estimation technology (OpenPose)," *Int. J. Ind. Ergon.*, vol. 84, no. February, hal. 103164, 2021, doi: 10.1016/j.ergon.2021.103164.

[18] M. MassirisFernández, J. Á. Fernández, J. M. Bajo, dan C. A. Delrieux, "Ergonomic risk assessment based on computer vision and machine learning," *Comput. Ind. Eng.*, vol. 149, no. September, 2020, doi: 10.1016/j.cie.2020.106816.

[19] Indah Yuliani dan Alya Zahrah Zhafirah, "Analisis Penilaian Postur Kerja Menggunakan Metode Nordic Body Map (Nbm), Rapid Upper Limb Assessment (Rula) dan Rapid Entire Body Assessment (Reba) pada Tenaga Kerja," *J. Antara Keperawatan*, vol. 4, no. 3, hal. 101–109, 2021, doi: 10.37063/antaraperawat.v4i3.640.