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| RESEARCH ARTICLE

Implementation of Total Productive Maintenance and Lean Manufacturing in the Pharmaceutical Industry: An Empirical Study

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| ABSTRACT
This study aimed to determine the relationship between the implementation of total productive maintenance and lean manufacturing on overall equipment effectiveness at PT Kimia Farma Tbk Plant Banjaran. This research design is quantitative, with multiple linear regression methods to determine the independent variable on the dependent variable. Data was collected by giving questionnaires directly to respondents. This study's results show a positive and significant relationship between the Total Productive Maintenance program and the Overall Equipment Effectiveness measured at PT Kimia Farma Tbk Plant Banjaran. A positive and meaningful relationship exists between the Lean Manufacturing program and the Overall Equipment Effectiveness measured at PT Kimia Farma Tbk Plant Banjaran. TPM is one of LM's tools in terms of equipment, apart from other tools that measure process aspects such as Standard Work, 5S, VSM, JIT, Line Balancing, and SMED. A positive, simultaneous, and significant relationship exists between the combination of Total Productive Maintenance and Lean Manufacturing programs on Overall Equipment Effectiveness as measured at PT Kimia Farma Tbk Plant Banjaran. The combination of a good TPM and LM program directly causes an increase in the effectiveness and efficiency of the production process. It reduces the occurrence of production defects so that OEE also increases.

| KEYWORDS

Pharmaceutical Industry, Total Productive Maintenance, Lean Manufacturing, Overall Equipment Effectiveness

| ARTICLE INFORMATION

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1. Introduction

Kimia Farma is the first pharmaceutical industry company in Indonesia which was founded by the Dutch East Indies Government in 1817. The name of this company was originally NV Chemicalien Handle Rathkamp & Co. Based on the nationalization policy of former Dutch companies in the early days of independence, in 1958, the Government of the Republic of Indonesia merged several pharmaceutical companies into PNF (State-Owned Pharmacy) Bhinneka Kimia Farma. Then on August 16, 1971, the legal entity form of PNF was changed to a Limited Liability Company, so the company name changed to PT Kimia Farma (Persero). Based on the approval of the Minister of Law and Human Rights of the Republic of Indonesia with his Decree Number AHU-0017895.AH.01.02 of 2020 dated February 28, 2020, and Letter Number AHU-AH.01.03-0115053 dated February 28 and stated in the Deed of Minutes of EGMS Number 18 dated September 18, 2019, there was a change in the company name from PT Kimia Farma (Persero) Tbk to PT Kimia Farma Tbk, effective as of February 28, 2020.

Kimia Farma Plant Banjaran is a manufacturing unit under PT Kimia Farma Tbk located at Jalan Raya Banjaran KM 16, Batukarut Village, Banjaran District, Bandung Regency, West Java. This factory produces traditional Indonesian medicines and medicines. Production facilities have been equipped with Good Manufacturing Practices Certificates and Traditional Good Manufacturing Practices Certificates from The Indonesian Food and Drug Authority. This factory implements a quality management system ISO-9001:2015, ISO 14001:2015, ISO 45001:2018, SMK3, and receives a Proper Blue Rating in environmental management from the

Ministry of Environment. Kimia Farma Plant Banjaran is the largest production site in the Kimia Farma Group, with an area of 51,592 m2 and a production capacity of more than one billion tablets annually. Apart from tablet preparations, Kimia Farma Plant Banjaran also has other types of practices with the following details:

Table 1. Production Capacity of Kimia Farma Plant Banjaran

Facility	Preparation Type	Unit	Capacity	
			1 shift	2 shift
Farma	Tablet	Tablet	1.125.000.000	2.025.000.000
	Salute tablets	Tablet	750.000.000	1.350.000.000
	Capsule	Capsule	122.500.000	220.500.000
Herbal	Fluid	Bottle	3.748.500	6.747.300
	Powder	Sase	42.500.000	76.500.000
	Salute Tablets and Tablets	Tablet	93.750.000	168.750.000
	Capsule	Capsule	28.000.000	50.400.000
	Internal Medicine Liquid	Bottle	3.500.000	3.500.000
	External Medicine Liquid	Bottle	5.250.000	6.336.806
	Internal Medicine Liquid	Sase	4.375.000	7.875.000
	Powder	Sase	2.625.000	4.725.000

Along with today's increasingly competitive conditions, the industry must meet customer requirements in terms of quality, cost, flexibility, and delivery time, including the Kimia Farma pharmaceutical industry. Raouf (1994) in Ahuja & Khamba (2008) states that the rapidly changing global market requires increasing company performance by cutting costs, increasing productivity levels, and quality and delivery guarantees to satisfy customers. Low productivity, high downtime, and poor machine performance are often associated with inadequate factory maintenance, causing decreased production rates, increased costs, reduced profits, and lost opportunities (M.Jasiulewicz-Kaczmarek, 2016). Inadequate factory maintenance hurts organizational competitiveness, thereby reducing the throughput and reliability of production facilities, causing rapid damage to production facilities, low availability of equipment due to large amounts of downtime, reducing production quality, and increasing stock, resulting in product delivery not meeting expectations (Ahuja & Khamba, 2008).

In the manufacturing process, machines play an essential role because downtime can hinder or even stop production. One approach to improving the performance of maintenance activities is to implement and develop a Total Productive Maintenance (TPM) strategy (Ahuja & Khamba, 2008). The forerunner of TPM came from the concept of Productive Maintenance introduced by M/s Nippon Denso Co. Ltd. Japan, supplier of M/s Toyota Motor Company, Japan, in 1971. Subsequently, Nakajima (1988) developed the concept and gave birth to the TPM philosophy. TPM is a manufacturing program designed to maximize machine effectiveness through the total participation of all resources (Kristy et al., 2001). TPM is an applicable method that aims to obtain maximum effectiveness in an industrial or organizational facility by creating a productivity maintenance system, including maintenance of all machines by involving all parts and employees' total participation in maintenance independently (Kumar et al., 2012). Based on research by Kathleen et al. (1999), TPM has a positive and significant relationship with reduced costs as measured by higher inventory turnover, high levels of quality as measured by higher conformance to specifications, and high delivery performance. Currently, the TPM concept is not only applied in Japan or by Japanese companies but has been implemented by companies worldwide to maintain factory operations (Irsan, 2022). TPM is one of the tools of the Lean Manufacturing (LM) system because a reliable and effective machine is an essential requirement for implementing Lean Manufacturing initiatives in organizations (Sekine & Arai, 1998).

The LM concept originated in 1927 by Henry Ford with the philosophy of the Ford Production System (FPS). Taiichi Ohno was inspired by FPS and developed the Toyota Production System (TPS) in 1978. Furthermore, Womack, Jones, and Roos published "The Machine that Changes The World" in 1990, which characterized TPS as Lean Production or Lean Manufacturing (Shah & Ward, 2007). The first objective of TPS is to increase productivity and reduce costs by eliminating waste or non-value-added activities. LM is a multi-dimensional approach that covers a wide range of management practices, just-in-time (JIT), quality systems, work teams, cellular manufacturing, supplier management, etc., in an integrated system (Shah & Ward, 2002).

LM optimizes the value in the process so that the company gets the desired results. LM focuses on systematically eliminating waste from organizational operations through a series of synergistic work to produce products and services as needed (Womack et al., 1990; Shah & Ward, 2007). LM in an organization creates an integrated system to increase employee responsibility and involve employees in every effort to reduce waste (Shah & Ward, 2002). LM reduces lead time, eliminates bottlenecks in the process, and optimizes the utilization of company resources. LM focuses on eliminating as much waste and non-value-added activities as possible. Seven waste types are transport, inventory, motion, waiting, over-processing, over-production, and defects (Esmaeilian et al., 2016). As a result of the emergence of corporate waste, it consumes more resources than it should, so applying LM is essential to implement so that the organization has competitiveness.

Kimia Farma Plant Banjaran is implementing TPM and LM as an integrated maintenance system to support effective and efficient production activities by reducing unplanned breakdowns and eliminating activities that do not provide added value. Common problems related to engine conditions include abnormal sound or vibration, missing nuts, suboptimal lubrication, and dirt on machine parts that cannot be seen, triggering an unplanned breakdown. The application of TPM here aims to anticipate these problems so that the machine usually operates and produces output as expected. Conversely, LM acts as an activity to increase efficiency by eliminating activities that do not add value. TPM is an integral part of implementing LM because the efficiency targeted by LM will only occur if machines and equipment work optimally. In short, applying TPM and LM as a whole can increase the effectiveness and efficiency of the production process.

The large number of preparations in Kimia Farma Plant Banjaran means that there are also more types of machines and different processes for each preparation to be maintained. This condition certainly requires special attention in managing the machine and operator skills because of the varied types of products. Nakajima (1988), in the 1980s, provided a quantitative metric called overall equipment effectiveness (OEE) to measure the productivity of each piece of equipment in a factory. OEE identifies and measures losses from important manufacturing aspects: availability, performance, and quality. This supports an increase in the equipment's effectiveness and productivity (Muchiri & Pintelon, 2008). Thus, OEE is a tool to measure the success of the TPM concept.

Nakajima (1988) suggests that the ideal value for measuring OEE components is availability (availability) of more than 90 percent, performance efficiency (performance) of more than 95 percent, and quality (quality) of more than 99 percent. Such availability, performance, and quality levels would result in an OEE of around 85 percent. The literature regarding acceptable availability, performance, and quality levels is still a topic of continuous research. Ljungberg (1998) reports OEE rates of between 60 percent and 75 percent, respectively. In comparing scores regarding each element of OEE, Ljungberg (1998) reports that the average percentage of OEE across a sample of cases is 55 percent. Using the same data source, the average availability figure is 80 percent. This value is close to the standard suggested by Nakajima, that 90 percent availability will result in world-class performance.

The average performance efficiency is 68 percent, but Ljungberg (1998) distinguishes between engine idle and minor stoppage losses in research. Ljungberg (1998) shows that most companies perform at over 70 percent, with one reaching 95 percent, the standard set by Nakajima (1988). The last component of OEE reported by Ljungberg (1998) is quality, with an average value of 99 percent. Again this is by the standards suggested by Nakajima (1988). Based on the results of this research, there are differences in determining the optimal OEE value for each industry.

Companies have widely used the strategy of implementing the TPM and LM concepts to improve their business performance. However, the implementation and integration of TPM into LM have yet to be carried out; in other words, both stand independently. The integration of TPM into LM will form a series of comprehensive and consistent manufacturing practices, which will further affect performance improvement because TPM and LM have mutually supportive roles. The literature investigating the relationship between TPM and LM is quite extensive, but the comprehensive research available to integrate the concept of TPM into LM still needs to be improved, particularly in the pharmaceutical industry. Further research is needed to comprehensively integrate these concepts and their impact on Overall Equipment Effectiveness. Based on this theory and the limited comprehensive research available to integrate the TPM concept into LM in the pharmaceutical industry, the authors are interested in conducting research with the title: ‘Implementation of Total Productive Maintenance and Lean Manufacturing in the Pharmaceutical Industry: An Empirical Study’.

2. Methods

This study uses a quantitative survey method regarding the analysis method and the data type. Quantitative research is a systematic scientific investigation of components and phenomena and their relationships. According to Sugiyono (2017), quantitative research is a research method based on the philosophy of positivism, which is used to study specific populations or samples, collect data using research tools, and analyze quantitative or statistical data to test established hypotheses. The variables used for this study are Independent Variables (Total Productive Maintenance with indicators and Lean Manufacturing) and the second is Dependent Variables (Overall Equipment Effectiveness). This study will explain the causal relationship between variables through hypothesis testing. The TPM and LM variables are used as independent variables and are measured through their indicators, and OEE is the dependent variable. The analytical method used is multiple regression.

The population of the study was employees of PT Kimia Farma Tbk Plant Banjaran who were directly involved with the implementation of TPM and LM. Researchers can take samples from this population. Whatever is examined from several samples originating from that population, the conclusions can apply to that population. In this case, it is necessary to select a sample that is representative of the population. The sampling technique in this study used a purposive sampling technique, namely the technique of determining the sample by applying specific considerations. The minimum sample size is determined based on the Slovin formula with an error rate of 5%. The researcher chose this sampling method because he understood that the information needed could be obtained from a specific target group that could provide the information as expected. They met the terms and criteria determined by the researcher. This study's sample requirements were all employees directly involved with the TPM and LM processes.

The data collection technique used was an observation, documentation, maintenance procedures, literature, and innovation programs related to this study and obtained from questionnaires distributed directly to the respondents. A literature study was conducted using a research process and a field survey approach with parties involved in implementing TPM and LM. This is carried out to analyze what activities and conditions support the successful implementation of TPM and LM in increasing the value of OEE through their respective indicators.

Data analysis is part of the data testing process after collecting data through secondary data, direct observation, interviews, and questionnaire results. The data analysis technique used in this study is a multiple linear regression analysis techniques to see whether the independent variables, namely Total Productive Maintenance (TPM) and Lean Manufacturing (LM), have a direct effect on Overall Equipment Effectiveness (OEE) as the dependent variable.). The software used is Statistical Product Service and Solutions 25.0, or IBM SPSS 25.0, to perform validity, reliability, heteroscedasticity, multicollinearity tests, and other statistical tests. The advantage of SPSS is that besides providing more complete analysis tools, it also can accommodate and process extensive data.

3. Results and Discussion

Table 2. Validity Test Results for Total Productive Maintenance Statement Items

Item Code	r count	r table	Validity
X1.1	0.716	0.156	Valid
X1.2	0.730	0.156	Valid
X1.3	0.729	0.156	Valid
X1.4	0.640	0.156	Valid
X1.5	0.693	0.156	Valid
X1.6	0.723	0.156	Valid
X1.7	0.754	0.156	Valid
X1.8	0.635	0.156	Valid
X1.9	0.721	0.156	Valid
X1.10	0.783	0.156	Valid
X1.11	0.740	0.156	Valid
X1.12	0.694	0.156	Valid
X1.13	0.758	0.156	Valid
X1.14	0.738	0.156	Valid
X1.15	0.734	0.156	Valid
X1.16	0.684	0.156	Valid
X1.17	0.785	0.156	Valid
X1.18	0.763	0.156	Valid
X1.19	0.689	0.156	Valid

Source: (Primary Data Processed, 2023)

Based on Table 2 above, count is the value of the Corrected Item-Total Correlation and looks at the value of r with a significance of 0.05 for the 2-tailed test and N = 157, df = (N-2), df = 157-2 = 155, then we get table (0.05; 155) = 0.156, so it can be concluded that all 19 (nineteen) question items in the variable Total Productive Maintenance (X1) meet the validity requirements.

Table 3 Validity of Lean Manufacturing Statement Items

Item Code	r count	r table	Validity
X2.1	0.439	0.156	Valid
X2.2	0.306	0.156	Valid
X2.3	0.697	0.156	Valid
X2.4	0.684	0.156	Valid
X2.5	0.741	0.156	Valid

X2.6	0.710	0.156	Valid
X2.7	0.606	0.156	Valid
X2.8	0.690	0.156	Valid
X2.9	0.533	0.156	Valid
X2.10	0.556	0.156	Valid
X2.11	0.749	0.156	Valid
X2.12	0.761	0.156	Valid
X2.13	0.714	0.156	Valid
X2.14	0.710	0.156	Valid
X2.15	0.670	0.156	Valid
X2.16	0.761	0.156	Valid
X2.17	0.679	0.156	Valid
X2.18	0.631	0.156	Valid
X2.19	0.754	0.156	Valid

Source: (Primary Data Processed, 2023)

Based on Table 3 above, count is the value of the Corrected Item-Total Correlation and looks at the value of r with a significance of 0.05 for the 2-tailed test and N = 157, df = (N-2), df = 157-2 = 155, then we get table (0.05; 155) = 0.156, so it can be concluded that all 19 (nineteen) question items in the Lean Manufacturing variable (X2) meet the validity requirements.

Table 4 Validity of Overall Equipment Effectiveness Statement Items

Item Code	r count	r table	Validity
Y.1	0.828	0.156	Valid
Y.2	0.861	0.156	Valid
Y.3	0.854	0.156	Valid
Y.4	0.847	0.156	Valid
Y.5	0.884	0.156	Valid
Y.6	0.895	0.156	Valid
Y.7	0.827	0.156	Valid
Y.8	0.841	0.156	Valid

Source: (Primary Data Processed, 2023)

Based on Table 4 above, count is the value of the Corrected Item-Total Correlation and looks at the value of r with a significance of 0.05 for the 2-tailed test and N = 157, df = (N-2), df = 157-2 = 155, then we get table (0.05; 155) = 0.156, so it can be concluded that all 8 (eight) question items in the Overall Equipment Effectiveness (Y) variable meet the validity requirements.

After testing the validity of the questionnaire, the questionnaire can be tested for reliability. In this technique, the measurement is carried out only once; then, a comparison is made with other questions or by measuring the correlation between answers. SPSS software can also be used for reliability testing with Cronbach's alpha (α) statistical test. The questionnaire was reliable if Cronbach's alpha value was > 0.7000 (Sarjono & Julianita, 2011).

Table 5 Reliability Statistics for Total Productive Maintenance
Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.949	.949	19

Source: (Primary Data Processed, 2023)

From the results of the statistical reliability test data processing, it shows that the Cronbach's alpha value, r = 0.949, thus all 19 (nineteen) statement items are reliable because the Cronbach's alpha value is above the minimum limit of 0.7000, so it can be concluded that the Total Productive Maintenance measurement scale has high reliability. Good.

Table 6 Reliability Statistics Lean Manufacturing Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.922	.925	19

Source: (Primary Data Processed, 2023)

From the results of statistical reliability test data processing, it shows that the Cronbach's alpha value, r = 0.922, thus all 19 (nineteen) statement items are reliable because the Cronbach's alpha value is above the minimum limit of 0.7000, so it can be concluded that the Lean Manufacturing measurement scale has good reliability.

Table 7 Reliability Statistics Overall Equipment Effectiveness Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.947	.947	8

Source: (Primary Data Processed, 2023)

From the results of statistical reliability test data processing, it shows that the Cronbach's alpha value, r = 0.947, thus all 8 (eight) statement items are reliable because the Cronbach's alpha value is above the minimum limit of 0.7000, so it can be concluded that the Overall Equipment Effectiveness measurement scale has good reliability.

The normality test is a test of the normality of the data distribution. The normality test is used because, in parametric statistical analysis, the assumption that the data must own is that the data must be normally distributed. The meaning of normally distributed data is that the data will follow the shape of a normal distribution (Santosa & Ashari, 2005). The normality test can be done in two ways: the "Normal P-P Plot" and the "Kolmogorov Smirnov Table." The Normal P-P Plot is the most commonly used. In the Normal P-P Plot, in principle, normality can be detected by looking at the distribution of data (points) on the graph's diagonal axis or the residuals' histogram.

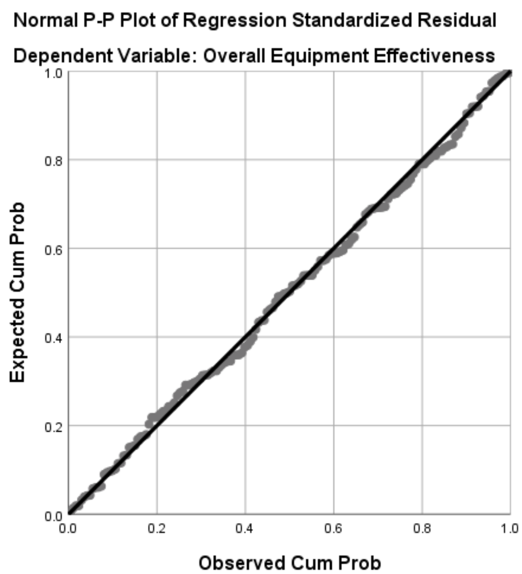

Figure 1 Normality Test

The standard probability plot in Figure 1 shows that the data points form a linear pattern consistent with the normal distribution. The normality test was also carried out using the Non-Parametric Kolmogorov-Smirnov (K-S) statistical test. The data is usually distributed if the significance level exceeds 0.05. The results of the Kolmogorov-Smirnov (K-S) test can be seen in the following table:

Table 8 Kolmogorov-Smirnov Test Results One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		157
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	3.25143920
Most Extreme Differences	Absolute	.036
	Positive	.036
	Negative	-.032
Test Statistic		.036

Asymp. Sig. (2-tailed)	.200[c,d]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Source: (Primary Data Processed, 2023)

The results of the normality test in the table above show that the significant value is Asymp. Sig. (2-tailed) is 0.200 and shows a value greater than 0.05, so it can be concluded that the data used in this study are typically distributed data. This test is used to see whether the confounding variables have the same variance. To detect the presence or absence of heteroscedasticity, that is by looking at the plot graph between the predicted value of the dependent variable, namely ZPRED, and the residual SRESID. Detection of the presence or absence of heteroscedasticity can be done by looking at whether there is a specific pattern on the scatterplot graph between SRESID and ZPRED where the Y axis is the Y that has been predicted, The X axis is the residual (Y prediction – Y actually) that has been studied.

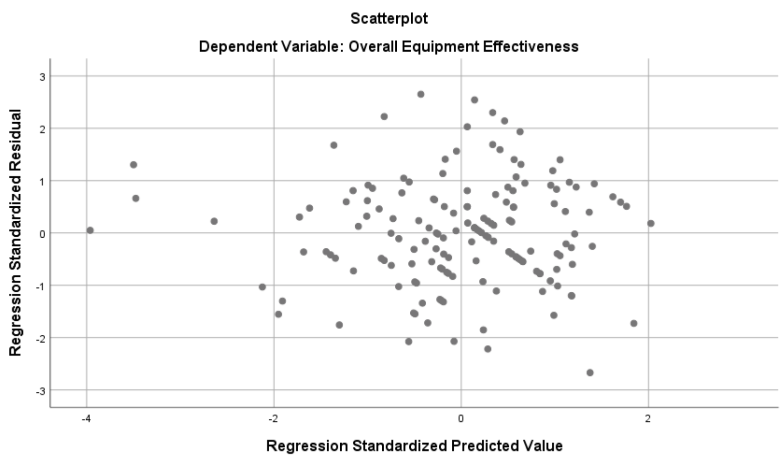

Figure 2 Heteroscedasticity Test

From the picture above, it can be seen that there is no heteroscedasticity because there is no clear pattern, and the points spread above and below the number 0 on the Y-axis. So, the heteroscedasticity test is fulfilled. Another method used to perform the heteroscedasticity test in this study is the Glejser test. If the probability of each independent variable is > 0.05, it can be concluded that there is no heteroscedasticity in the regression model.

Table 9 Heteroscedasticity Test Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	3.023	1.361		2.222	.028
	Total Productive Maintenance	.016	.015	.092	1.017	.311
	Lean Manufacturing	-.022	.019	-.104	-1.150	.252

a. Dependent Variable: ABS_RES

Source: (Primary Data Processed, 2023)

Using the Glejser method in the heteroscedasticity test, it can be concluded that this regression model is free from heteroscedasticity because the variables Total Productive Maintenance and Lean Manufacturing have sig values of 0.311 and 0.252, respectively, which are more significant than 0.05.

Table 10 Multicollinearity Test

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Total Productive Maintenance	.784	1.275
	Lean Manufacturing	.784	1.275

Source: (Primary Data Processed, 2023)

Based on the table above, the independent variables must be free from symptoms of multicollinearity or correlation between independent variables. Santoso (2005) states that multicollinearity symptoms can be seen if the results of the collinearity statistic (Variance Inflation Factor value) for each variable are > 10. A good regression model should not correlate with the independent variables. The data processing results using IBM SPSS 25.0 software show that the VIF value for TPM is 1.275, and LM is 1.275. The tolerance value of the two independent variables is less than 1, with both VIF values less than 10, so it can be concluded that the data from the questionnaire results did not have multicollinearity.

Table 11 Multiple Linear Regression Test Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.783	2.223		.352	.725
	Total Productive Maintenance	0.300	.025	.676	11.971	.000
	Lean Manufacturing	0.107	.032	.191	3.383	.001

a. Dependent Variable: Overall Equipment Effectiveness

Source: (Primary Data Processed, 2023)

Based on Table 11, the two independent variables influence, if regressed together, Overall Equipment Effectiveness. From the results of the multiple regression test in the table above, the following equation can be made:

$$\mathbf{Y = 0.783 + 0.300X_1 + 0.107X_2} \quad (1)$$

From the regression equation formed above, the interpretation can be explained as follows:

a. βo (constant) = 0.783, meaning that the value of the Overall Equipment Effectiveness (Y) variable is 0.783 if the Total Productive Maintenance (X1) and Lean Manufacturing (X2) variables are absent or equal to zero.
b. β1 = 0.300, meaning that if the variable Total Productive Maintenance (X1) increases and other variables remain constant, the Overall Equipment Effectiveness (Y) variable will increase by 0.300.
c. β2 = 0.107, meaning that if the Lean Manufacturing (X2) increases and other variables remain constant, then the Overall Equipment Effectiveness (Y) variable will increase by 0.107.

Table 12 Partial T Test

Model		t	Sig.
1	**(Constant)**	**.352**	**.725**
	Total Productive Maintenance	**11.971**	**0.000**
	Lean Manufacturing	**3.383**	**0.001**

Source: (Primary Data Processed, 2023)

3.1 Partial Hypothesis Test for Total Productive Maintenance Variable

The Total Productive Maintenance variable shows a Significance value of 0.000; because the value is below 0.05, it can be said to be significant. Testing using the t-test is, the value of the t table at alpha 0.05 (two tails) df=n-2=157-2=155 is 1.975. at the same time, the calculated t value in the table above is the t-test = 11,971. It means that count> table, then H1 is accepted and Ho is rejected, thereby showing that Total Productive Maintenance has a direct, positive, and significant effect on Overall Equipment Effectiveness.

3.2 Partial Hypothesis Test for Lean Manufacturing Variables

The Lean Manufacturing variable shows a Significance value of 0.001; because the value is below 0.05, it can be said to be significant. Testing using the t-test is, the value of the t table at alpha 0.05 (two tails) df=n-2=157-2=155 is 1.975. Meanwhile, the calculated t-value in the table above is the t-test = 3,383. It means that count> table, then H2 is accepted and Ho is rejected, thereby showing that Lean Manufacturing has a direct, positive, and significant effect on Overall Equipment Effectiveness.

Table 13 Simultaneous F Test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2626.357	2	1313.179	122.622	.000[b]
	Residual	1649.210	154	10.709		
	Total	4275.567	156			

a. Dependent Variable: Overall Equipment Effectiveness
b. Predictors: (Constant), Lean Manufacturing, Total Productive Maintenance

Source: (Primary Data Processed, 2023)

Simultaneous significant test results can be seen in Table 13. The F test was conducted to determine the effect of Total Productive Maintenance and Lean Manufacturing variables on Overall Equipment Effectiveness simultaneously. Sig. A value equal to 0.000 indicates that an alpha significance level of 0.05 two-tailed is significant. Whereas for testing with the F, the test is to compare the value of Ftable with Fcount. The Fcount value is 122,622, and Ftable is 3,050 (see Table F); thus, the results obtained for Fcount (122,622) > Ftable (3,050), then Ho is rejected, and H3 is accepted. It can be concluded H3: Total Productive Maintenance and Lean Manufacturing have a direct, positive, and significant effect on Overall Equipment Effectiveness simultaneously.

Table 14 Determinant Coefficient

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.784[a]	.614	.609	3.272

a. Predictors: (Constant), Lean Manufacturing, Total Productive Maintenance

Source: (Primary Data Processed, 2023)

Based on Table 14 above, it can be said that the magnitude of R or the correlation of the independent variable Total Productive Maintenance (X1) and Lean Manufacturing (X2) together with the dependent variable Overall Equipment Effectiveness (Y) is 0.784 with a relationship level of " Strong." R square or determinant coefficient is 0.614 or 61.4%, indicating that Overall Equipment Effectiveness is influenced by the two independent variables used in this study (namely the independent variables Total Productive Maintenance (X1) and Lean Manufacturing (X2), and) 61.4%, and still there is an influence of 38.6% of other factors.

4. Discussion

4.1 Total Productive Maintenance directly, positively, and significantly affects Overall Equipment Effectiveness

Based on the calculation results, the t-statistic value is 11,971, which means > 1,975, and the sig. 0.000 below 0.05, then H1 is accepted, which means that Total Productive Maintenance has a positive and significant effect on Overall Equipment Effectiveness. Changes in the value of Total Productive Maintenance have a unidirectional effect on changes in Overall Equipment Effectiveness. In other words, if Total Productive Maintenance increases, there will be an increase in Overall Equipment Effectiveness, and statistically, it has a significant effect. Based on the data processing results with SPSS version 25.0, it is also known that the coefficient value of Total Productive Maintenance on Overall Equipment Effectiveness is 0.300, which means that Total Productive Maintenance has a direct, positive, and significant effect on Overall Equipment Effectiveness.

4.2 Lean Manufacturing directly, positively, and significantly affects Overall Equipment Effectiveness

Based on the calculation results, the t-statistic value is 3,383, which means > 1,975, and the sig. 0.001 below 0.05, then H2 is accepted, which means that Lean Manufacturing has a positive and significant influence on Overall Equipment Effectiveness. Changes in the Lean Manufacturing value have a unidirectional effect on changes in Overall Equipment Effectiveness. In other words, if Lean Manufacturing increases, there will be an increase in the Overall Equipment Effectiveness level. Based on the data processing results with SPSS version 25.0, it is known that the Lean Manufacturing coefficient on Overall Equipment Effectiveness is 0.107, meaning that Lean Manufacturing has a direct, positive, and significant effect on Overall Equipment Effectiveness.

4.3 The combination of Total Productive Maintenance and Lean Manufacturing has a direct, positive, and significant effect on Overall Equipment Effectiveness

Based on the calculation results, the f-statistic value is 122,622, which means > 3,050, and the sig. 0.000 below 0.05, then H3 is accepted, which means that the combination of Total Productive Maintenance and Lean Manufacturing has a direct, positive, and significant effect on Overall Equipment Effectiveness simultaneously for employees involved with the TPM and LM processes. Changes in Total Productive Maintenance and Lean Manufacturing values have a simultaneous unidirectional effect on changes in Overall Equipment Effectiveness. In other words, if Total Productive Maintenance and Lean Manufacturing increase simultaneously, there will be a significant increase in the Overall Equipment Effectiveness level. Based on the results of data processing with SPSS version 25.0, it is known that the value of R square or the determinant coefficient is 0.614 or 61.4%, indicating that Overall Equipment Effectiveness is influenced by the two independent variables used in this study (Total Productive Maintenance and Lean Manufacturing) of 61.4%, and still, there is influence from other factors, namely 38.6%.

5. Conclusion

Based on data analysis and discussion, it can be concluded that there is a positive and significant relationship between the Total Productive Maintenance program and the Overall Equipment Effectiveness measured at PT Kimia Farma Tbk Plant Banjaran. The TPM program that runs well causes the equipment to operate according to capacity and continuously produce the best quality, which increases OEE. A positive and significant relationship exists between the Lean Manufacturing program and the Overall Equipment Effectiveness measured at PT Kimia Farma Tbk Plant Banjaran. TPM is one of LM's tools in terms of equipment apart from other tools that measure process aspects, for example, Standard work, 5S, VSM, JIT, Line Balancing, and SMED (Bhamu & Sangwan, 2013). Exemplary LM implementation causes work processes to be efficient so that OEE, measured based on availability, performance, and quality, also increases. A positive, simultaneous, and significant relationship exists between the combination of Total Productive Maintenance and Lean Manufacturing programs on Overall Equipment Effectiveness as measured at PT Kimia Farma Tbk Plant Banjaran. The combination of a good TPM and LM program directly causes an increase in the effectiveness and efficiency of the production process. It reduces the occurrence of production defects so that OEE also increases.

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