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Network Meta-Analysis for Determining the Best Lean Tools Synergy to Improve Productivity by Reducing Rework in Garment Factories

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ABSTRACT- The textile industry plays an important role in the global economy; however, it faces persistent challenges related to reducing rework for improving productivity. The purpose of this study is to summarize some scientific researches about production delay caused by rework in a clothing and accessory industry. It provides a general overview of the current state of knowledge concerning the interdependence between reduced productivity and rework rate. The research process is based on the Functional Analysis System Technique. It facilitates a systematic examination of sequential and logical steps necessary to achieve objective and attain outcomes. Functional Analysis System Techniques not only provides a structured methodology but also aids in identifying the successive functions crucial for attaining desired outcomes. The initial phase involves conducting a comprehensive systematic literature review focused on productivity issues stemming from rework within the textile industry. The first phase, related to the Seiri of the 5S methodology, involves conducting a comprehensive systematic literature review focused on productivity issues stemming from rework within the textile industry. Subsequently, the filling of a literature review synthesis matrix using Excel is conducted which represents Seiton. Next, focusing specifically on the Lean tools employed utilized and the corresponding productivity improvements, data are extracted. This corresponds to Seiso step. Following this, a Network Meta-Analysis is applied, representing the Seiketsu. Finally, the identification of the most effective Lean tools combination to reduce rework is undertaken, corresponding to Shitsuke. As results, the Ishikawa Diagram appears to have obtained the best ranking position according to the rankogram. Ishikawa Diagram is often associated with other tools to multiply its performance. The study's findings highlight that the Ishikawa, Pareto, Single-Minute Exchange of Die and Work Study combination emerges as the most effective approach for minimizing rework and enhancing productivity, as indicated by the League Table. This network meta-analysis provides a comprehensive overview of the Lean tools synergy effectiveness in rework reduction and productivity improvement strategies in textile industries. While powerful, Network Meta-Analysis has limitations including reliance on indirect comparisons from studies that may not directly compare all treatments, inheriting biases and complexities, which can pose challenges in assessing result certainty.

Keywords: Lean, Network Meta-Analysis, Productivity, Rework, Textile

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1. INTRODUCTION

The garment industry is one of the most important and dynamic industries, contributing substantially to employment opportunities and economic growth [1]. However, the industry's expansion is accompanied with problems such as resource waste and ineffective labor practices. Rework, in the garment production process, stands out as a crucial problem. After shipping, it is typical for some product to be returned in the clothing industry [2]. It needs to be reworked. Rework involves the process of improving finished product that do not meet customer's standards. Performing reworks can slow down productivity [3]. Thus, a comprehensive analysis of rework reduction strategies becomes necessary to develop the competitiveness of a garment factory. Hence, the central research question emerges: how can rework be minimized to improve productivity? In response to this question, the research hypothesis posits that a synergistic application of Lean tools may effectively reduce rework and enhance productivity within garment production processes. By examining existing research, we aim to discover the most effective ways to combine Lean tools to minimize rework. To determine this optimal synergy, Network Meta-Analysis (NMA) will be employed. NMA is a statistical technique used to combine data from different studies that compare various interventions, even if direct comparisons between some interventions are not available [4].The NMA is frequently used in the field of medicine, but it can be applied in the present case by conducting benchmarking. In this study, NMA is well-suited for integrating findings from different studies that investigate how different Lean tools affect rework reduction and productivity improvement in the garment industry. By using NMA, this research can offer a clear understanding of which combinations of Lean tools are most effective, providing valuable insights for both practitioners and researchers.

2. MATERIALS AND METHODS

The design of the followed steps was based on the Function Analysis System Technique (FAST) approach, which allows structuring the research methodology to ensure a logical and coherent progression throughout the study. FAST is one of the most used techniques in Value engineering [5]. This graphic representation of the links between the functions in the diagram might aid in the development of creative ideas and problem-solving [6]. One strategy for developing such a model is to organize functions according to the How-When-Why structure, a model that demonstrates how to go from higher levels to the lowest order is developed [5]. So, it is utilized to serves as a systematic framework to delineate and guide the sequential steps required to accomplish the research objectives. The Lean approach, particularly the 5S methodology, has also been integrated into the research process to effectively organize documents. It also enhances the robustness and reproducibility of the methodology. In other words, the combined use of FAST and 5S promotes a systematic and structured approach to research. These tools help maintain clarity and efficiency throughout the process.

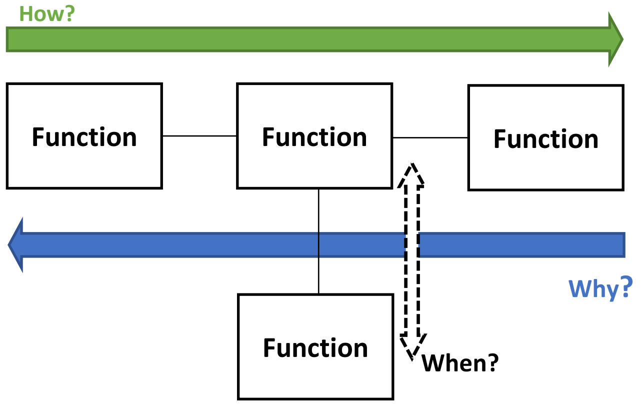

Figure 1. FAST Diagramme

Lean, which is a waste elimination process, has also made its interventions in the process. More specifically, the 5S has allowed for the optimization of the management of the scientific articles considered in the study. The term "5S" is derived from five Japanese terms that all begin with the letter "S," and it indicates the five essential principles of this approach. Seiri: Sorting through everything in the workplace to identify what is required and what is not. Only required objects should remain in the workstation; unnecessary items should be transferred to a storage location or deleted. Seiton: in this stage, the remaining things are organized logically and effectively. Seiso: places a premium on workplace cleanliness and upkeep. It entails regularly cleaning and examining the workstation and equipment to ensure they are in excellent operating order. Seiketsu: To retain the gains obtained in the preceding phases, uniform processes and practices should be created and recorded. Standardization guarantees that everyone in the organization adheres to the same best organizational standards. Shitsuke: The last S focuses on maintaining the 5S methodology's benefits. This involves establishing a culture of constant development and discipline [7].

The figure 2 represents the research process. It begins with a research in scholarly databases to identify relevant papers. During this initial stage, a superficial reading of each paper is undertaken to assess whether it meets the criteria. Papers that meet these criteria are carefully filed in a dedicated folder for further analysis, while those that do not are promptly rejected. In-depth reading of the first batch of papers permits to identify and collect necessary information. It is the data collection process. This stage involves a systematic examination of each paper's methodology, findings, and conclusions. Then the data collected is organized into a literature matrix through an Excel database. That process permits to facilitate the comparison and synthesis of key findings across different studies. A critical aspect of this process is the subsequent meta-analysis, which involves the statistical aggregation of data from multiple studies to highlight meaningful understandings. In this paper, the network meta-analysis approach is utilized to perform that research. An analogy is used to enable the appropriate use of the methodology. In this case, instead of considering treatments, they are replaced by Lean tools. Comparisons will be transformed into synergies. Other concepts remain unchanged.

The 5S approach is beneficial for several reasons within the research process. For data organization, adopting Seiri, Seiton, and Seiso enables systematic classification and organization of collected articles, thus facilitating access to necessary information during subsequent analysis. This also aids in creating a well-structured database. It streamlines information management by retaining only relevant and reliable data, eliminating unnecessary information. This ensures the quality and relevance of data used in research. Moreover, it enables analysis standardization: the Seiketsu phase entails following rigorous protocols to ensure consistent analysis and data interpretation. This ensures result reliability and facilitates comparison across different studies or analyses. Lastly, it upholds quality: by incorporating the Shitsuke phase, the methodology ensures ongoing monitoring of the studied domain, thus maintaining result quality over time. This includes regular knowledge updates and active contribution to advancing the discipline. The 5S approach provides a robust methodological framework for effectively managing data, ensuring analysis quality, and significantly contributing to advancing knowledge in the specific research field.

NMA has allowed us to determine the frequencies of combination of the Lean tools used. Therefore, it enables a thorough analysis of the interactions among the various studies included in the analysis. Widely used in medicine, NMA is a valuable tool for assessing the effectiveness of treatments. Network meta-analysis is a technique for assessing many treatments in a single study by integrating direct and indirect information from randomized controlled trials in a network [8]. Network meta-analysis is an advanced statistical approach interventions in a specific field [9] [8]. By visually inspecting the links between treatments within a graph, a reader can assess the overall strength of evidence within the treatment network and also gauge the level of support for specific comparisons [10]. The circle's diameter and the thickness of the line are elements used to visually depict the analysis results. The diameter of a circle in a network meta-analysis graph is generally proportional to the importance or weight of a particular study in the analysis source. The larger the circle, the more significantly the tool contributed to the research used to synthesize and compare the results of multiple clinical trials or primary studies that evaluate different treatments or source. In other words, tools with larger circles have a greater influence on reducing rework than those with smaller circles. On the other hand, the thickness of the line connecting two circles in the network meta-analysis graph typically represents the frequency of association between the corresponding Lean tools. A thicker line indicates a stronger combination between the tools. In this context network meta-analysis is employed to systematically integrate and analyze data, offering a comprehensive perspective on existing research findings.

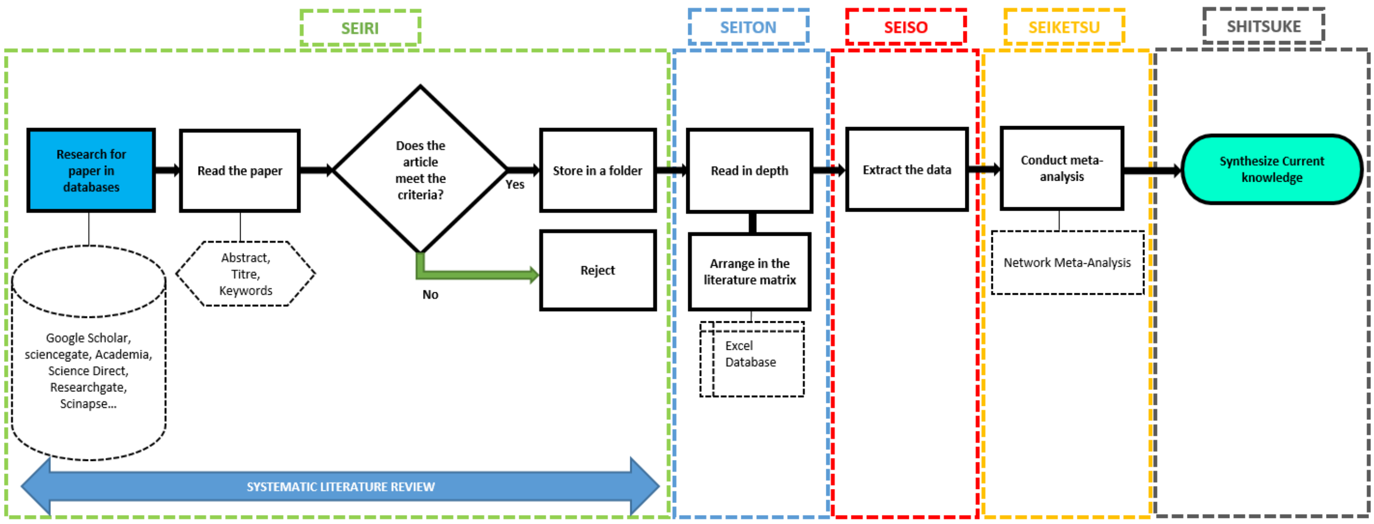

Figure 2. Research Process

According to the *Thomas Lumley* model [11]:

$$Y_{ijk} \sim N(\mu_i + \boldsymbol{\eta_{ik}} - \mu_j - \boldsymbol{\eta_{jk}} + \boldsymbol{\xi_{ij}},\ \boldsymbol{\sigma_{ijk}}^2) \qquad (1)$$

$$\boldsymbol{\eta}_{ij} \sim N(0, \boldsymbol{\tau}^2) \qquad (2)$$

$$\boldsymbol{\xi_{ij}} \sim N(0, \omega^2) \qquad (3)$$

μ_i and μ_j represent the average effects of treatments i and j. So, indirectly they are the productivity improvement of each Lean tools i and j respectively. The random effects $\boldsymbol{\eta_{ik}}$ and $\boldsymbol{\eta_{jk}}$ with variance $\boldsymbol{\tau}^2$ represent the difference between the average effects of treatments i and j and their effects in the study. They capture the heterogeneity of the treatment effect. The second random effect $\boldsymbol{\xi_{ij}}$ represents variation in the treatment effect i when compared to treatment j [11]. The equivalent mixed linear model is then [11]:

$$Y_{ijk} = \mu_i + \boldsymbol{\eta_{ik}} - \mu_j - \boldsymbol{\eta_{jk}} + \boldsymbol{\xi_{ij}} \qquad (4)$$

This equation can be expressed in the following matrix form [12] :

$$Y = X\mu + \boldsymbol{\eta} + \boldsymbol{\xi} \qquad (5)$$

The vector Y represents the set of observations $\boldsymbol{Y_{ijk}}$. The vectors η and ξ represent the two levels of stochasticity. The matrix $\boldsymbol{X}$ is called the design matrix **[12]**. Each column of $\boldsymbol{X}$ represents one of the treatments. The rows represent the comparisons relative to the baseline. Each element takes a value of -1, 0, or 1.

The Moore-Penrose pseudo-inverse is used to solve equation (5) within the framework of NMA. To do this, Let define the Laplacian matrix $\mathbf{n} \times \mathbf{n}$ where n is the number of treatments, as follows **[13]**:

$$L = X^T W X \qquad (6)$$

Where W is a diagonal matrix of $\mathbf{m} \times \mathbf{m}$ dimension whose diagonal elements are the inverse variance weights. The sum of all pairwise comparisons across studies is denoted by m. Let k be the number of independent studies. If all studies are two-arm studies, m corresponds to k, while m is greater than k if at least one study evaluates more than two treatments. However, the Moore-Penrose pseudo-inverse of L is defined by **[14]**:

$$L^+ = (L - \frac{J}{n})^{-1} + \frac{J}{n} \qquad (7)$$

Where J is an $\mathbf{n} \times \mathbf{n}$ matrix with all elements equal to 1. Once L+ is obtained, it is possible to calculate the network treatment estimates according to the expression **[13]**:

$$\hat{\mu} = X L^+ X^T W Y \qquad (8)$$

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This estimation can be performed using the R software with the “netmeta” package. This package enables network visualization, ranking treatments from most to least effective, and indirectly comparing all pairwise treatment effects. The Moore-Penrose pseudo-inverse is one of the techniques it employs to solve the equation. The Moore-Penrose pseudo-inverse also handles cases where the design matrix X is not full rank, which can be common in NMA analyses due to the complex data structure [13]. This ensures that treatment effect estimates are robustly computed, even in situations where data are incomplete or models are complex [13].

3. RESULTS

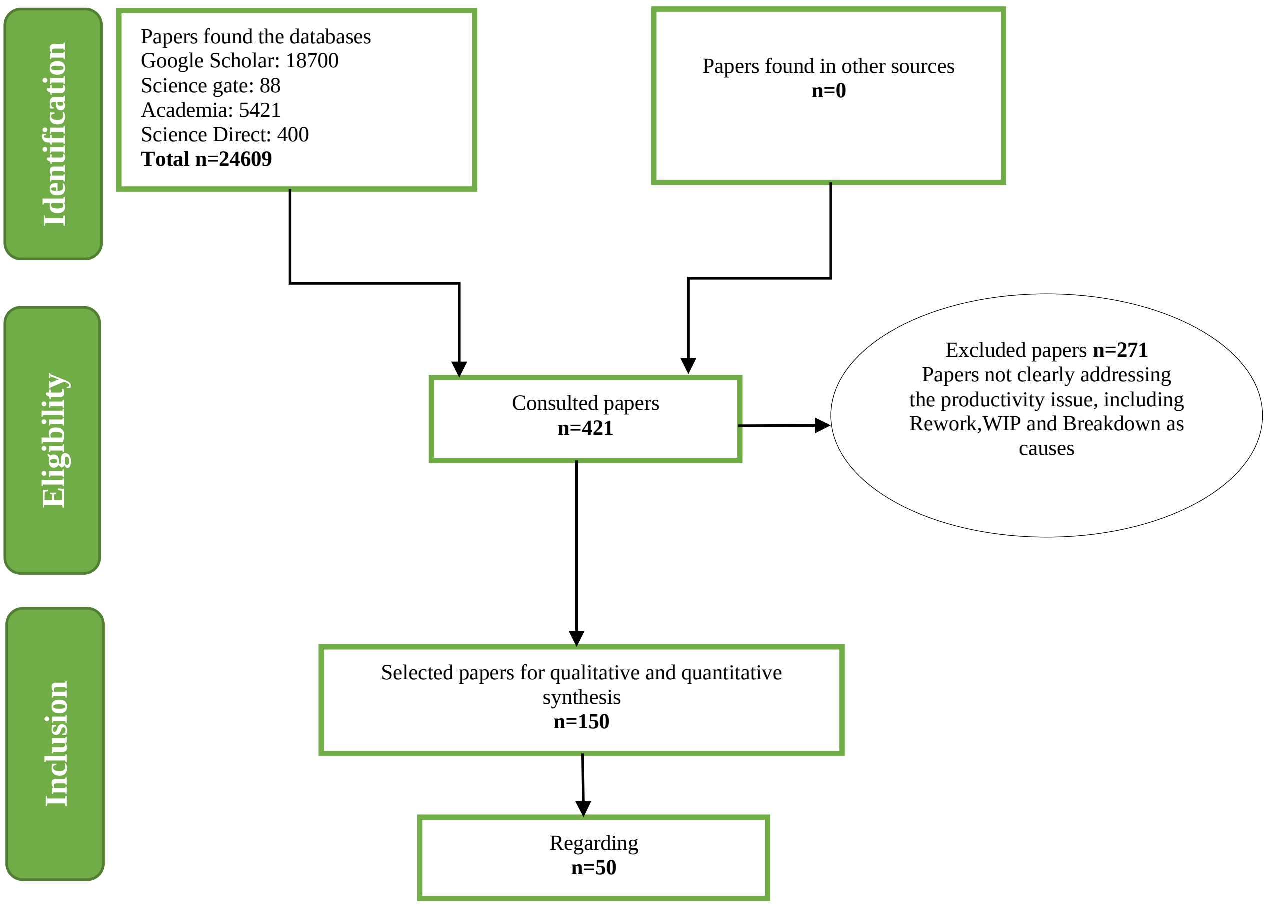

Figure 3. Systematic Literature review

Following the rigorous application of the methods described earlier, this section will present the results obtained. Firstly, we will present the main findings and conclusions derived from our systematic literature review on productivity and rework in the specific context of industrial production. Then, the results reflecting the synthesis of knowledge from the literature review will be discussed. The execution of this systematic literature review followed a rigorous methodology, starting with the articles collection from various databases. The results showed a significant total of 18,700 articles from Google Scholar, 88 from Sciencegate, 5,421 from Academia, and 400 from Science Direct, resulting in a total of 24,609 articles. Special attention was given to searching in other sources, although it did not yield additional results. Subsequently, during the crucial step of article selection, 421 publications were consulted, but 271 were excluded due to a lack of clarity on crucial points related to productivity, such as rework. The following figure summarizes the quantification of articles found, rejected, and included from the formulation of search equations to the final article selection.

The following table presents a list of 50 authors and the Lean tools they have utilized in their research. These studies focus on the textile and apparel industry, aiming to reduce rework to enhance productivity. This table serves as the cornerstone for all subsequent analyses. It is the pivotal focal point of this research, extracted from the literature matrix discussed earlier. The data contained within this table will guide and inform the in-depth examinations and conclusions drawn throughout the study.

Table 1. Lean Tools used by authors

	Diagramme d'Ishikawa	Diagramme de Pareto	VSM	SMED	KAIZEN	5S	SIX SIGMA	JIT	Process Reengineering	Simulation	POKA YOKE	KANBAN	ANDON	TOC	PDCA	TPM	TQM	TRAFFIC LIGHT SYSTEM	WORK STUDY
Dereje G	●	●																	
Dima A.	●																		
Ravikumar et al			●	●															
Patil et al																			
Dragoslav et al					●														
Mazedul Islam	●																		
Wagner C et al					●	●													
Uday Patil et al	●																		
Sabbir Ahmed																			
Madbushanka																			
Afsana Haque								●									●	●	●
Concha et al			●			●	●	●	●	●									
J Cristobal et al			●			●													
Tahiduzzaman	●	●			●	●													
Kankariya et al	●	●					●												
Pravin Ukey						●	●				●	●	●						
Taposh Kumar	●	●			●														●
Sukwadi et al	●		●				●					●		●					
Amarasingha					●	●													
Muhammad A	●	●																	
Dereje et al		●																	
Tarikul I et al	●	●					●												
Saima A et al					●	●					●				●	●			●
Syduzzaman et																	●		
Sumon .M																			
Sohel Ahmed																			
Alimran H	●	●															●		
Uddin S.M	●	●																	
Mehedi H et al																			

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V Sosa-Perez		●	●													●			
Syduzzaman al																			
Cathrine et al								●				●				●			
Yanira A et al						●						●			●				
Nitesh K Sahoo	●	●																●	
Mafzal Ahmed																			
Jaglul H et al	●						●												
Safa Tuna	●	●					●												
Ninge Gowda			●	●	●	●	●									●			
Thilakasiri																			
Dewan M et al	●	●					●												
Faisal H et al																		●	
E. Pazireh							●			●									
Weerasekara al																			
sayyad I et al																			
Chethan K	●	●					●												
Nicole B						●				●						●			
Bharath S et al	●	●								●									●
Rahman et al	●	●															●		
Shimelis T et al	●	●																	
Su Hlaing et al	●	●															●		

Here are some key points that can be drawn from this table: It is evident that different research authors have utilized a variety of Lean tools. Some authors appear to have used the same Lean tools. It is also worth noting that some researchers did not utilize Lean tools to enhance productivity while minimizing rework. The possibility of combining different Lean tools is also apparent. There are even those who combine six different tools simultaneously in a single study. Thus, this table serves as a starting point for further analysis. The synthesis of this table has allowed us to determine the frequency of use of each Lean tool. The following figure provides a consolidated view of the predominant trends.

The next histogram, where the y-axis represents Lean tools and the x-axis represents frequency of use, offers a visually captivating representation of the collective preferences of the 50 authors regarding the adoption of Lean tools used for rework reduction and productivity enhancement. This graphical analysis allows for quick identification of tools that have been frequently used. Alternatively, the result suggests the repeated use of certain Lean tools. Consequently, this visualization facilitates immediate understanding of trends and priorities in Lean tools, highlighting the repeated use of certain ones.

The Ishikawa Diagram is widely predominant, with frequent use by 21 authors, followed by the Pareto Diagram, with 18 occurrences. Six Sigma and 5S are strongly adopted methodologies with 11 and 10 appearances, respectively. Kaizen closely follows with 8 occurrences. We also observe several tools sharing equivalent occurrences, such as VSM and TPM, appearing 6 and 5 times respectively. Similarly, JIT, Traffic Light System, and Simulation approaches are present at a common frequency of 3. Tools such as SMED, Poka Yoke, and PDCA are used twice, while Process Reengineering, Andon, and TOC are identified once. The table below presents the number of studies applying combinations of Lean tools.

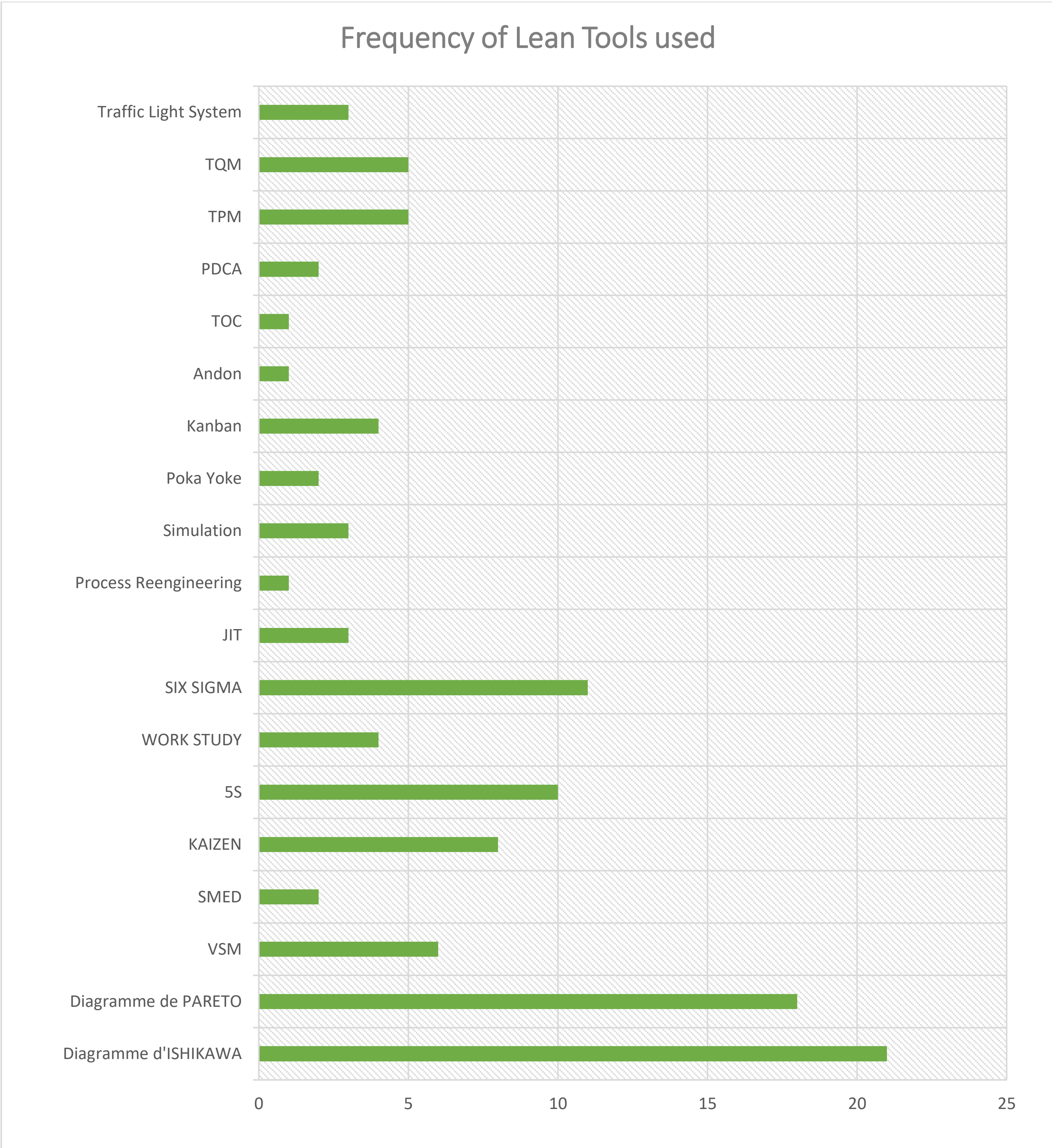

Figure 4. Frequency of Lean Tools used

The table below presents the number of studies applying combinations of Lean tools. The data on previously established usage frequencies, along with those on the frequency of combination, will enable the construction of the network diagram. It is worth noting that they will inform the diameter of each Lean tool circle and the thickness of each connecting line. A value of 0 indicates that no combination has been studied by the authors previously, thus constituting indirect comparisons. The next table includes effect sizes as well Even though it's an analogy.

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Table 2. Number of studies applying combinations of Lean tools

	Diagramme d'Ishikawa	Diagramme de Pareto	VSM	SMED	KAIZEN	5S	SIX SIGMA	JIT	Process Reengineering	Simulation	POKA YOKE	KANBAN	ANDON	TOC	PDCA	TPM	TQM	TRAFFIC LIGHT SYSTEM	WORK STUDY
Diagramme d'Ishikawa		16	1	0	2	1	7	0	0	0	0	1	0	1	0	0	3	1	2
Diagramme de Pareto	16		1	0	2	1	6	0	0	0	0	0	0	0	0	1	3	1	2
VSM	1	1		2	1	3	3	1	1	1	0	1	0	1	0	2	0	0	0
SMED	0	0	2		1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
KAIZEN	2	2	1	1		6	1	0	0	0	2	1	1	0	1	2	0	0	2
5S	1	1	3	1	6		2	1	1	2	2	2	1	0	2	3	0	0	0
SIX SIGMA	7	6	3	1	1	2		1	1	2	0	1	0	1	0	1	0	0	1
JIT	0	0	1	0	0	1	1		1	1	0	1	0	0	0	1	1	0	1
Process Reengineering	0	0	1	0	0	1	1	1		1	0	0	0	0	0	0	0	0	0
Simulation	0	0	1	0	0	2	2	1	1		0	0	0	0	0	1	0	0	0
POKA YOKE	0	0	0	0	2	2	0	0	0	0		1	1	0	1	1	0	0	0
KANBAN	1	0	1	0	1	2	1	1	0	0	1		1	1	0	1	0	0	0
ANDON	0	0	0	0	1	1	0	0	0	0	1	1		0	0	0	0	0	0
TOC	1	0	1	0	0	0	1	0	0	0	0	1	0		0	0	0	0	0
PDCA	0	0	0	0	1	2	0	0	0	0	1	0	0	0		1	0	0	0
TPM	0	1	2	1	2	3	1	1	0	1	1	1	0	0	1		0	0	0
TQM	3	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0		1	0
TRAFFIC LIGHT SYSTEM	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		1
WORK STUDY	2	2	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	1	

The values of the elements range from 0 to 16. Each element of the table represents the intersection of two Lean tools that were used simultaneously. The number of uses of each combination is given by each element of the table. Therefore, this table allows determining the thickness of the lines when plotting the network geometry. If the value is zero for an element, it means that there will be no line connecting the corresponding two nodes in the NMA geometry. The maximum number of elements is found at the intersection between the Ishikawa and Pareto diagrams. These two tools have been used together multiple times compared to other combinations. In the second tier, there is also a frequent association between Lean Six Sigma and the Ishikawa Diagram.

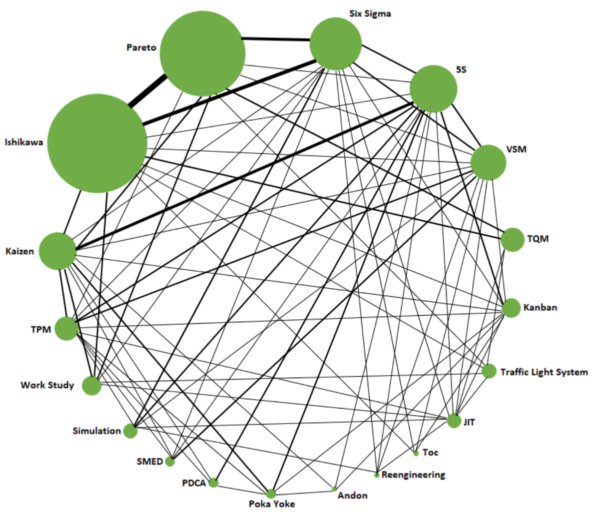

Figure 5. Network Diagram of Lean Tools used

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The *figure 5* illustrates the network geometry of Lean tools used in the studies. It involves understanding how these different tools were employed, individually or in combination. We can observe that the Ishikawa circle is the largest among them all. This may indicate that this Lean tool potentially has a significant influence in the context of rework reduction, which could be related to its ability to identify and visualize root causes of issues. Pareto follows in terms of circle size.

The varying thickness of lines connecting the different methodologies in the network meta-analysis offers some intriguing insights. The thickest line, representing the strongest connection, is observed between the Ishikawa Diagram and the Pareto Diagram. This is the strongest association of usage seen across the 50 different studies. Furthermore, the connections between Ishikawa and Six Sigma, as well as Pareto and Six Sigma, also exhibit significant thickness, indicating a notable synergy between Lean methodologies. Authors tend to integrate Six Sigma with tools that are recognized as robust. A significant association is also observed between Kaizen and 5S, revealing regular collaboration between these two tools. This is marked by the considerable thickness of the line connecting the two tools. In contrast, the less thick lines between other tools suggest weaker associations. These findings provide important insights for professionals looking to optimize their Lean approaches for rework reduction and productivity enhancement by leveraging the identified synergies.

The statistical analysis of productivity improvement data, conducted using the 'netmeta' package in R, yielded the following results using NMA. Indirect comparisons, i.e., those not yet explored by a specific study, are also included in the analysis. The 'netmeta' package in R is a statistical tool used for conducting network meta-analyses, enabling examination of the relative effects of different interventions even in the absence of direct comparisons between them. The primary goal of this analysis is to determine not only the best individual Lean tool for reducing rework but also to ascertain the most effective combination of these tools.

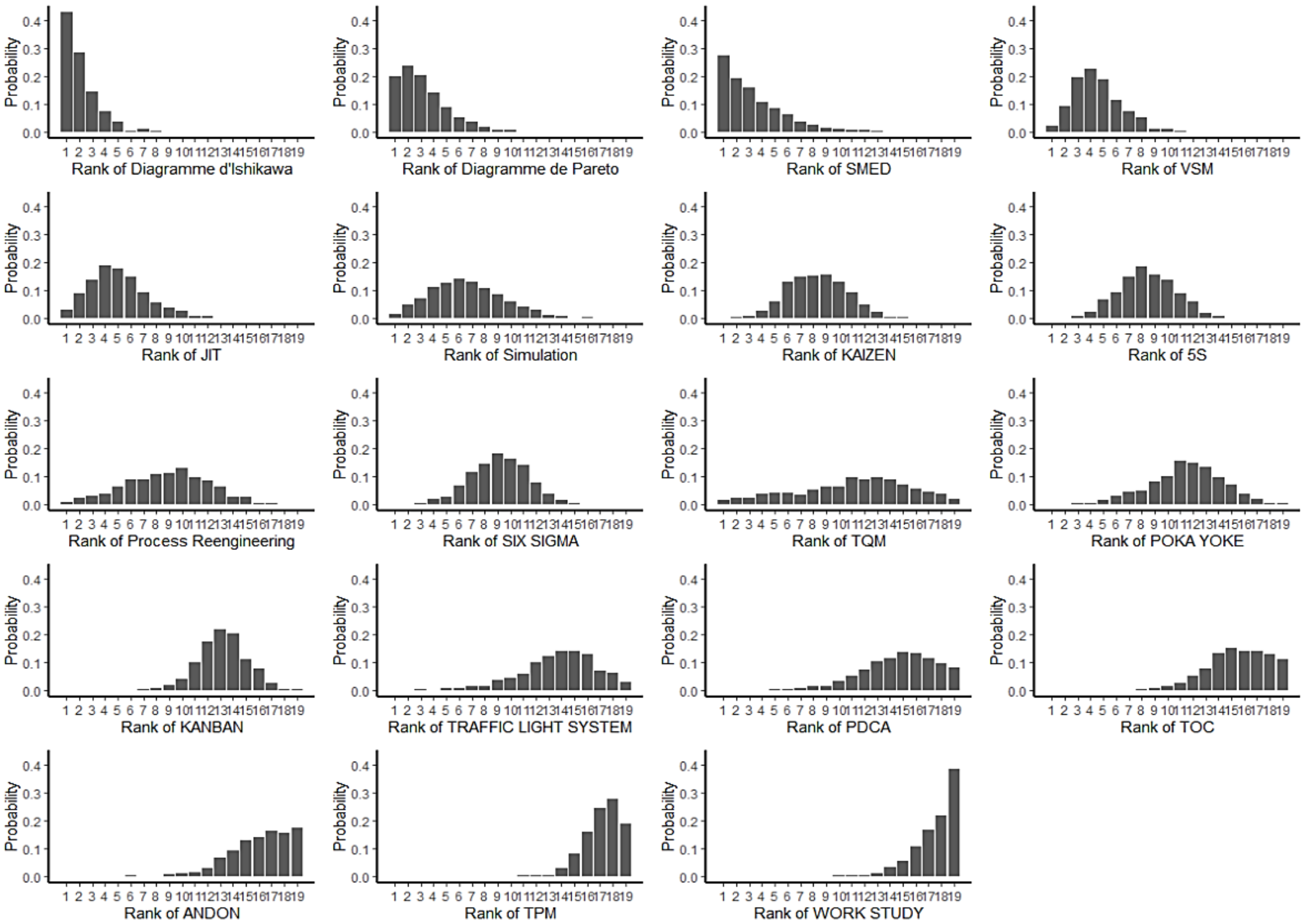

Figure 4. Rankogram of the Lean tools used

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The Rankogram in *figure 4* is a visual representation of the rankings of Lean tools based on the probability of being ranked at the top in terms of effectiveness. It is often used to compare tool rankings across different models or analyses. In the present case, the Rankogram would allow visualization of the rankings of various Lean tools based on their probability values for both common effect and random effect models. This enables researchers and decision-makers to make informed decisions about the most promising tools for improving productivity by reducing rework. The horizontal axis of the graph represents the different Lean tools included in the analysis. The vertical axis represents the SUCRA values. SUCRA (Surface Under the Cumulative Ranking) is a statistical measure used in network meta-analyses to assess the probability of a treatment being ranked at the top compared to all other treatments included in the study [13]. For each Lean Tools, a vertical bar is drawn to indicate the range of possible SUCRA values. The higher the line or bar, the more likely the treatment is to be ranked at the top. According to these graphs, the Ishikawa Diagram appears to have obtained the highest ranking. *Table 4* provides a summary of the estimated effects resulting from combinations of different Lean tools in terms of productivity improvement, along with information on their statistical precision. Each cell in the table represents an estimation of the increase in productivity when the corresponding two Lean tools are used together. The results are expressed as the mean difference with a 95% confidence interval. In this context, a positive value indicates that the use of the intervention listed in the row is associated with an improvement in productivity compared to the intervention listed in the column. A negative value, on the other hand, indicates that the intervention in the row is less effective than that in the column. The width of the confidence interval reflects the precision of the estimation. In the context of this study, the signs of the values are not significant as they represent combinations rather than direct comparisons. This comparison table allows us to conclude that the best combination of Lean tools is the coupling of Ishikawa Diagram and Work Study, followed by SMED and Work Study in second place, and Pareto Diagram and Work Study in third. Therefore, the best synergy of Lean tools for reducing rework would be: Ishikawa-Pareto-SMED-Work Study.

Table 4. League Tables of Lean tools combinations

5S																		
-8.90 (-16.31~1.49)	**ANDON**																	
7.00 (1.06~12.94)	15.90 (7.53~24.27)	**Ishikawa**																
5.21 (-0.87~11.28)	14.10 (5.54~22.67)	-1.79 (-8.17~4.58)	**Pareto**															
3.00 (-2.76~8.76)	11.90 (3.53~20.27)	-4.00 (-10.54~2.54)	-2.21 (-8.92~4.50)	**JIT**														
0.00 (-5.33~5.33)	8.90 (1.55~16.25)	-7.00 (-12.99~-1.01)	-5.20 (-11.36~0.95)	-3.00 (-9.20~3.21)	**KAIZEN**													
-4.71 (-10.55~1.14)	4.19 (-3.33~11.71)	-11.71 (-17.86~-5.56)	-9.91 (-16.65~-3.18)	-7.71 (-13.90~-1.52)	-4.71 (-10.40~0.98)	**KANBAN**												
-6.94 (-15.51~1.63)	1.96 (-8.06~11.97)	-13.94 (-23.19~-4.70)	-12.15 (-21.44~-2.85)	-9.94 (-19.12~-0.76)	-6.95 (-15.02~1.13)	-2.24 (-11.10~6.63)	**PDCA**											
-2.89 (-9.44~3.66)	6.01 (-1.79~13.81)	-9.89 (-17.44~-2.34)	-8.09 (-15.80~-0.39)	-5.89 (-13.38~1.61)	-2.89 (-9.31~3.52)	1.82 (-4.92~8.56)	4.05 (-4.32~12.43)	**POKA YOKE**										
-0.36 (-7.15~6.44)	8.54 (-0.76~17.84)	-7.36 (-15.11~0.40)	-5.56 (-13.46~2.33)	-3.36 (-10.32~3.61)	-0.36 (-7.78~7.06)	4.35 (-3.26~11.96)	6.59 (-3.48~16.65)	2.53 (-6.01~11.08)	**Reengineering**									
1.75 (-4.62~8.12)	10.65 (1.70~19.60)	-5.25 (-12.61~2.11)	-3.45 (-10.93~4.03)	-1.25 (-7.85~5.35)	1.75 (-5.21~8.70)	6.46 (-0.71~13.63)	8.69 (-0.96~18.35)	4.64 (-3.46~12.74)	2.11 (-5.19~9.40)	**Simulation**								
-0.69 (-5.90~4.52)	8.21 (0.30~16.12)	-7.69 (-13.42~-1.96)	-5.90 (-11.87~0.07)	-3.69 (-9.31~1.93)	-0.69 (-6.04~4.65)	4.02 (-1.60~9.64)	6.25 (-2.49~15.00)	2.20 (-4.79~9.18)	-0.33 (-7.07~6.40)	-2.44 (-8.76~3.88)	**SIX SIGMA**							
5.39 (-1.77~12.55)	14.29 (4.88~23.70)	-1.61 (-9.73~6.50)	0.18 (-8.01~8.38)	2.39 (-5.64~10.42)	5.39 (-1.81~12.58)	10.10 (2.17~18.02)	12.33 (2.31~22.35)	8.28 (-0.33~16.88)	5.75 (-3.18~14.68)	3.64 (-4.89~12.17)	6.08 (-1.08~13.24)	**SMED**						
-7.83 (-15.67~0.02)	1.07 (-8.60~10.75)	-14.83 (-22.35~-7.31)	-13.03 (-21.40~-4.66)	-10.82 (-18.99~-2.65)	-7.83 (-15.71~0.06)	-3.12 (-10.59~4.35)	-0.88 (-11.37~9.60)	-4.94 (-13.92~4.05)	-7.47 (-16.56~1.62)	-9.58 (-18.34~-0.81)	-7.13 (-14.43~0.16)	-13.21 (-22.69~-3.74)	**TOC**					
-9.82 (-15.17~-4.47)	-0.92 (-8.80~6.95)	-16.82 (-23.14to-10.50)	-15.03 (-21.24~-8.82)	-12.82 (-18.74~-6.91)	-9.83 (-15.23~-4.42)	-5.12 (-10.91~0.68)	-2.88 (-10.99~5.22)	-6.93 (-13.48~-0.39)	-9.47 (-16.76~-2.17)	-11.57 (-18.10~-5.05)	-9.13 (-14.48~-3.78)	-15.21 (-22.41~-8.01)	-2.00 (-9.96~5.97)	**TPM**				
-2.72 (-13.09~7.64)	6.17 (-5.81~18.16)	-9.73 (-20.03~0.58)	-7.93 (-18.30~2.44)	-5.72 (-15.38~3.94)	-2.73 (-13.22~7.77)	1.98 (-8.63~12.60)	4.22 (-8.34~16.78)	0.16 (-11.23~11.56)	'-2.37 (-13.65~8.91)	-4.48 (-15.51~6.56)	-2.03 (-12.29~8.22)	-8.11 (-19.86~3.64)	5.10 (-6.65~16.86)	7.10 (-3.38~17.58)	**TQM**			
-5.74 (-14.17~2.69)	3.16 (-7.16~13.48)	-12.74 (-20.64~-4.84)	-10.95 (-18.89~-3.00)	-8.74 (-17.16~-0.31)	-5.74 (-14.20~2.72)	-1.03 (-9.77~7.71)	1.20 (-9.78~12.18)	-2.85 (-12.49~6.79)	-5.38 (-15.08~4.32)	-7.49 (-16.88~1.90)	-5.05 (-13.29~3.19)	-11.13 (-21.18~-1.08)	2.09 (-7.90~12.07)	4.08 (-4.51~12.67)	-3.01 (-12.78~6.75)	**TLS**		
3.46 (-1.91~8.82)	12.35 (4.34~20.37)	-3.55 (-9.42~2.33)	-1.75 (-7.87~4.37)	0.46 (-5.32~6.23)	3.45 (-2.10~9.00)	8.16 (2.43~13.90)	10.40 (1.54~19.25)	6.34 (-0.77~13.45)	3.81 (-2.99~10.61)	1.70 (-4.70~8.10)	4.15 (-1.07~9.36)	-1.93 (-9.55~5.69)	11.28 (3.94~18.62)	13.28 (7.76~18.80)	6.18 (-4.19~16.55)	9.19 (0.76~17.63)	**VSM**	
-11.00 (-18.27~-3.73)	-2.10 (-11.44~7.24)	-18.00 (-25.14~-10.86)	-16.20 (-23.44~-8.97)	-14.00 (-21.12~-6.88)	-11.00 (-18.10~-3.91)	-6.29 (-13.89~1.31)	-4.06 (-14.10~5.99)	-8.11 (-16.69~0.47)	-10.64 (-19.27~-2.01)	-12.75 (-21.04~-4.46)	-10.31 (-17.10~-3.52)	-16.39 (-25.39~-7.38)	-3.17 (-12.24~5.90)	-1.18 (-8.59~6.24)	-8.27 (-19.02~2.47)	-5.26 (-13.49~2.97)	-14.45 (-21.75~-7.16)	**WORK STUDY**

4. DISCUSSION

To achieve productivity improvement effectively, a combination of various Lean tools, especially Ishikawa diagrams, Pareto diagrams, Work Study, SMED can be employed simultaneously. This combination could be particularly powerful. The Ishikawa Diagram aids in identifying the root causes of the problem, while the Pareto Diagram allows for prioritizing these causes based on their impact. This assertion is demonstrated in the article "The Use and Implementation of Pareto and Ishikawa Diagram for Defect Minimization in Manufacturing Firms" by Dereje Geleta Oljira & Misgana Lamessa Dinsa [15]. They were able to prioritize or rank the common quality issues of the company they studied using Pareto analysis. Then, the major causes of these issues were further explored using the Ishikawa method. Together, they offer a holistic approach to target the most critical factors to be addressed first in order to minimize rework. This statement is also supported by relevant literature. In the study conducted by M. M. Rahman and A.K.M. titled "Quality improvement in garments industry through TQM approach" [16] the application of Pareto and Ishikawa Diagrams revealed a substantial reduction in rework. This outcome underscores the efficacy of using these Lean tools simultaneously in enhancing garment industry quality. In the study titled "Efficiency Improvement by Reducing Rework and Rejection on the Shop Floor" conducted by Nitesh Kumar Sahoo [17], a significant reduction of 47.6% in Defects per Hundred Units was achieved through the implementation of various lean tools, as well as the application of Ishikawa and Pareto analysis techniques within the garment industry. Work Study allows for the analysis and optimization of existing work processes. By identifying inefficiencies and implementing improvements, it helps reduce errors and defects, thereby contributing to minimizing rework. SMED can reduce rework by simplifying and standardizing the tooling change process, thus minimizing human errors. The study "Application of the SMED methodology in the aluminum alloys production for rework cost reduction" by Marcos Sávio Souza et al [18] highlights that the application of the SMED methodology in aluminum alloys production significantly reduced rework costs. This underscores the necessity of this tool for quality improvement. The research "Productivity improvement through Lean deployment & Work Study methods" by Prathamesh P. Kulkarni and al [19] concludes that the effective combination of Lean tools and work study methods forms a universally applicable system for improving productivity across all industries. This approach ensures 100% positive results when implemented in the correct order, highlighting the complementarity and enhanced effectiveness of these combined tools. Proper application of this system is certain to bring significant improvements to productivity. This study's findings highlight the effectiveness of a comprehensive approach to rework reduction in the garment industry, integrating simultaneously Lean tools. We can observe a similarity between the results found and those of other authors. The reduction of rework can be addressed from different perspectives. For instance, in "Improvement of the Production Quality of the Textile Industries in Madagascar by Knowledge Engineering" [20] the authors employ innovative approaches like knowledge engineering, which involves capturing, organizing, and utilizing the knowledge and expertise of industry professionals. This enables the enhancement of textile product quality from the design phase to production. This, in turn, helps minimize errors and subsequently reduces the need for rework.

So, the NMA approach is powerful but has limitations. It relies on indirect comparisons from studies that do not directly compare all treatments, which may be less reliable. Additionally, NMA inherit biases and limitations from the included studies, and their complexity can make assessing the certainty of results challenging. Despite these challenges, NMAs remain valuable for synthesizing available evidence and providing essential insights for clinical decision-making.

5. CONCLUSIONS

The garment industry plays a pivotal role in job creation and economic growth but faces sustainability challenges, including the significant issue of rework [1]. Rework in the garment production process not only hampers productivity but also raises concerns about product quality [3]. This paper aimed to explore strategies for reducing rework and increasing production in the context of Malagasy textile industries, with a focus on the application of Lean tools. Through a comprehensive literature review and analysis, several key findings emerge. First, Lean tools have been widely employed in the textile and apparel industry to address rework issues. The Ishikawa Diagram, 5S methodology, Kaizen, Pareto Diagram, and VSM were among the frequently used Lean tools. The analysis revealed that researchers often combine Lean tools to enhance their effectiveness in reducing rework. The simultaneous use of the Ishikawa Diagram and the Pareto Diagram, as well as SMED and Work study is particularly prevalent strategies. The literature supports the notion that a comprehensive approach to rework reduction, involving the integration of multiple Lean tools, can lead to significant improvements in productivity and product quality. For instance, studies have shown substantial reductions in defects and rework when implementing these tools together. In summary, the findings of this paper underscore the importance of adopting a holistic approach to tackle rework in the garment industry. Malagasy textile industries can benefit from a synergy of Lean tools to streamline production processes, minimize defects, and ultimately enhance competitiveness. The contribution of this article lies in its enrichment of the literature review by providing a thorough analysis of existing research on Lean tools in the garment industry.

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