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Service Management Model Based on Lean Service Tools and Ergonomic Design to Increase the Productivity of Cleaning Operations in a Food Court

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Abstract

The restaurant industry in Peru has experienced an annual growth rate of over 9% and contributes nearly 3% to the national GDP, supported by substantial investments in new shopping centers. This upward trend underscores the growing relevance of food courts, which play a vital role in customer satisfaction within shopping malls—where cleanliness is a critical factor. However, cleaning operations often lack efficiency due to poor task standardization, ergonomics, and waste segregation design. This study proposes a Service Management Model based on Lean Service tools to improve the productivity of the cleaning process in a food court in a Peruvian shopping mall. The main objective was to assess the feasibility of enhancing this operation through: (1) Work Standardization to reduce non-value-adding movements; (2) Ergonomic Design to improve tools and the working environment; and (3) Layout Design to optimize waste collection routes. A pilot plan and Arena software were used to validate results statistically. Implementation led a 30% reduction in man-hours for core tasks, enabled by improved cleaning tools, clearer task assignments, and better waste bin placement encouraging customer tray disposal. The solution proved economically viable, projecting annual savings of $12,886.20 (21%) for the company. The model allowed a reassignment of staff time without affecting current break schedules, opening the possibility for operatives to support additional tasks. Continued process monitoring and staff engagement are recommended to ensure long-term sustainability.

Keywords
Lean Service, Food Court, Cleaning Operations, Work Standardization, Ergonomic Design

1. Introduction
In 2023, the restaurant sector grew by 9.28% compared to the previous year (INEI 2023), reaffirming its importance within the Peruvian economy. One of the preferred spaces for citizens to enjoy the culinary offerings is the food court, characterized by the presence of various food establishments sharing a common area. In these spaces, customer satisfaction is influenced by multiple factors beyond food quality alone. Uddin (2019) found that food quality, price, and service were positively related to customer satisfaction in fast food establishments. Similarly, Kim et al. (2006)

identified five key factors that explain 60.76% of the variation in customer satisfaction in a university food court, with the dining environment — including cleanliness — accounting for 12.65% of this variation.

Cleanliness not only affects customer perception but also represents a critical element in ensuring hygiene and sanitary standards. Dingsdag and Coleman (2013) warned about the presence of bacteria ranging from 102 to 105 cfu/m^2 on tables in food courts in Sydney, highlighting the risk of cross-contamination between cleaning equipment and table surfaces. In Putrajaya, Malaysia, only 27.4% of food courts were found to meet optimal cleanliness standards, while 9.1% were in unacceptable conditions (Mohd-Firdaus-Siau et al. 2015).

From an operational perspective, cleaning services represent a significant cost. Mun and Jang (2018) reported that salaries are among the largest components of operating costs in restaurants. In food courts, monthly cleaning costs are estimated at $9,176, including personnel, supplies, equipment, trays, and waste segregation. During pre-operation hours, more staff is required, which increases ergonomic strain and labor costs due to the physical demands of cleaning all tables and chairs.

Alvarado (2012) demonstrated that improving the productivity of cleaning operations helps reduce customer complaints and increases profitability. Likewise, Castro and Huamancondor (2023) emphasized that implementing Lean tools such as 5S, layout redesign, and method improvement can raise customer satisfaction by up to 26%, consequently boosting sales. However, despite these proven benefits, the application of Lean Service tools to food court cleaning operations remains limited.

In Peru, the Lima Chamber of Commerce (Cámara de Comercio de Lima) announced in 2022 an investment of US$1.44 billion for the development of 18 new shopping centers (La República 2022), while the restaurant sector currently accounts for 2.8% of the national GDP (ComexPeru 2025). In this context, promoting studies aimed at optimizing food court operations not only improves customer experience but also contributes to the economic growth of the sector.

1.1 Objectives

The main objective of this research is to improve labor productivity in the cleaning process of a shopping mall food court through the implementation of Lean Service tools and ergonomic design principles.
Specific Objectives:

- Conduct a state-of-the-art review of the cleaning process in food courts of shopping malls in Peru.
- Perform an analysis and diagnosis of the cleaning process problem in a food court of a shopping mall in Peru.
- Design and develop improvement proposals to enhance productivity.
- Validate the proposed solution by evaluating its economic feasibility and its impact on key stakeholders.

2. Literature Review

Process improvement in the service sector has become increasingly relevant due to its potential to enhance operational efficiency and customer satisfaction. Nonetheless, limited research has addressed productivity enhancement specifically in cleaning operations and food courts within shopping malls. This literature review focuses on improvement tools successfully applied in related service contexts, categorized under Lean Service, work standardization, layout design, and ergonomic integration.

Lean Service adapts Lean Manufacturing principles to service environments, focusing on streamlining service delivery rather than physical production processes (Pérez and Morato 2021). It retains tools like 5S, Kaizen, and Just In Time, and emphasizes eliminating non-value-added activities. Through work standardization, Lean enables performance consistency and root-cause problem solving (Moreno et al. 2023). Williams et al. (2022) demonstrated that standardizing procedures in a hospital reduced nurses' time in emergency care from 205 to 150.4 minutes and lowered the rate of patients leaving without being seen from 4.7% to 0.7%. Similarly, Calmet and Rosas (2022) reported a 30.53% increase in productivity and an additional weekly income of $115.35 after implementing standardized processes in a veterinary clinic.

Systematic Layout Planning (SLP) optimizes the physical arrangement of service spaces to minimize transport and unnecessary motion (Salins et al. 2024). Dube and Gupta (2023) reported that machine rearrangement using 5S and SLP eliminated unnecessary movements, increasing process efficiency from 53% to 66% while optimizing space and reducing costs. In the service sector, Tarigan et al. (2020) reported that reconfiguring a clinic's layout led to a 64.49% reduction in travel time and 22.64% decrease in processing time. Likewise, Onaga-Nishimura et al. (2022) applied SLP in a restaurant, achieving reductions in average wait time (from 25 to 22.54 minutes) and cycle time (from 35 to 28.28 minutes).

Ergonomic design complements Lean by reducing physical strain, waste from excess motion, and improving work quality (Brito et al. 2020). Realyvásquez-Vargas et al. (2020) highlighted that integrating anthropometric design with standardized tasks reduced overprocessing and improved productivity. Suranuntchai and Chutima (2023) found that applying ergonomic principles along with the ECRS (Eliminate, Combine, Rearrange, Simplify) method cut cycle time by 6.82% in manual assembly. Domínguez et al. (2023) used Ergo-VSM in metalworking, improving psychosocial risk by 11.8% and productivity by 4.4%. Ergonomics also supports organizational sustainability by aligning productivity with worker health (Hasanain 2024, Bortolini et al. 2023).

The reviewed literature shows that tools like work standardization, layout design, and ergonomic integration—when applied under Lean Service principles—can significantly enhance productivity and service quality. Although evidence in shopping mall cleaning and food courts is scarce, results from similar service environments provide a strong foundation for adapting these tools to such contexts.

3. Methods

The overall structure of the proposed model designed to achieve the objectives of this study is presented in Figure 1.

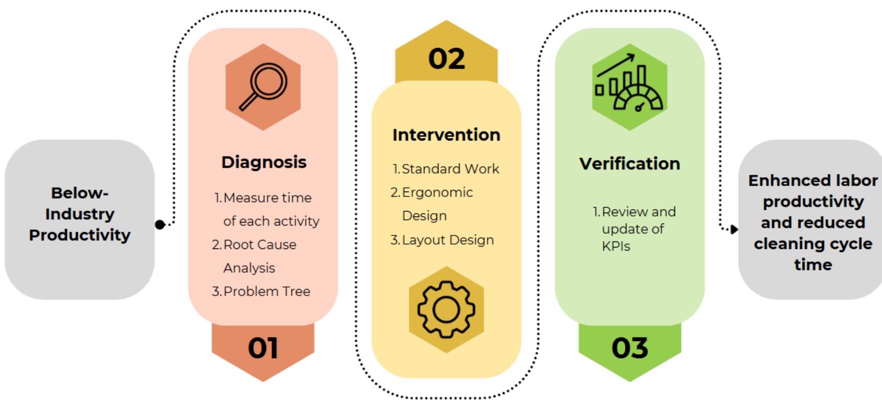

Figure 1. General structure of the proposed model

3.1 Phase 1: Diagnosis

First, a detailed analysis was conducted of each activity within the pre-operation cleaning process of the food court (prior to opening to the public), as well as of the overall process. These times were compared with those of other shopping centers, which made it possible to identify improvement opportunities, as productivity was below the industry average. Second, a literature review was carried out to address the root causes of wasted labor hours, using the problem tree methodology to link the main problem (Figure 2), its causes, and the tools required to reduce or eliminate it. The primary cause of waste (48%) was identified as excessive cleaning time, due to overexertion in cleaning tables and a lack of standardization in chair cleaning (the most time-consuming activity). The second issue (38%) was poor waste segregation, as most customers left their trays on the tables, requiring staff to make multiple trips to dispose of the trash. Lastly, the absence of standardized procedures (14%) led to unnecessary movement when arranging tables and chairs.

To address these issues, ergonomic design, layout design, and standard work tools were applied.

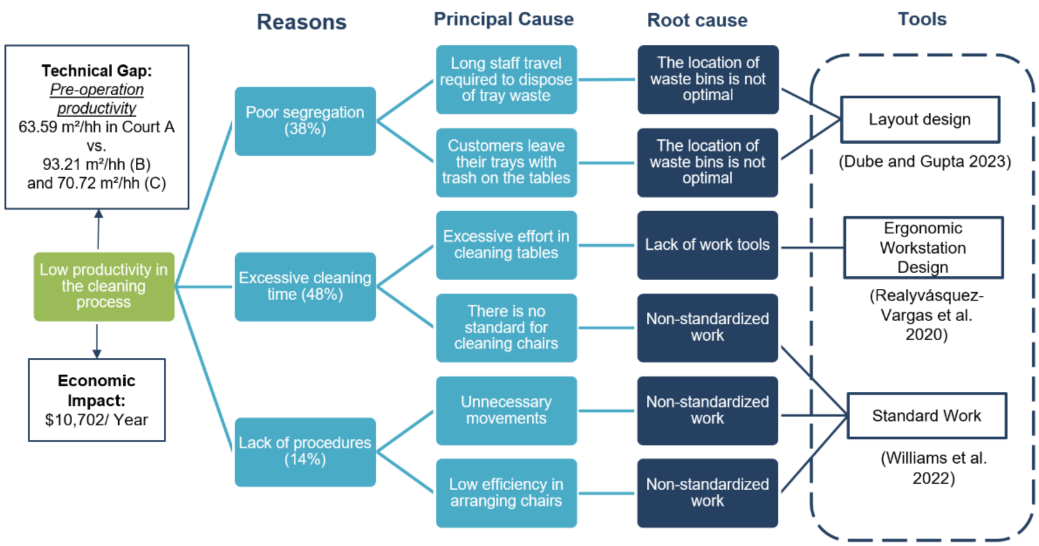

Figure 2. Problem Tree

3.2 Phase 2: Intervention

Standard Work: The implementation of this tool will begin with a detailed observation of the workers' movements during their daily tasks. The cleaning activities of each employee will be recorded to identify unnecessary or redundant movements that do not add value to the process. Additionally, an initial Flow Process Chart will be created. After identifying the inefficiencies, the best method to perform the tasks will be proposed, and training recordings will be prepared for future employees. This will ensure that the proposed method is sustained over time.

Ergonomic Design: Currently, operators clean tables manually using a fiber cloth and disinfectant in a zigzag motion, which causes physical overexertion due to repetitive arm extension and retraction. To reduce physical strain from repetitive table cleaning, the current manual method will be replaced by a two-person system: one applies disinfectant with a manual sprayer, while the other uses a specially designed mop with a microfiber cloth and telescopic handle to clean and dry the entire surface of the tables efficiently, working row by row.

Layout Design: Trash bins will be relocated to increase the coverage radius and improve accessibility from more tables when operators need to collect wast. in succession, this will encourage customers to move their own trays to trash bins, reducing operator workload. A dedicated operator will manage all mall bins based on a schedule tailored to usage patterns, with flexibility for adjustments communicated by security or supervisors.

3.3 Phase 3: Verification

KPIs in Table 1 are established to measure the root causes of the current situation and to assess the variation after implementing the tools from the model.

Table 1. Key Performance Indicators (KPIs) of the proposed model

Name	Objetive	Indicator
Pre-operation Productivity	Measure pre-operation productivity	$\frac{Food\ Court\ m^2}{Pre-operation\ Total\ Man-Hours}$
Man-Hours for Chair Cleaning before opening	Measure the cleaning time for chairs before opening	MH = Average chair cleaning time × Number of chairs to clean
Man-hours arranging chairs	Measure the time of arranging chairs	MH = average time to arrange chair × Number of chairs
Man-hours in transit	Measure the time of unnecessary movements	MH = Total time of movements
Man-Hours for Table Cleaning before opening	Measure the cleaning time for tables before opening	MH = Average table cleaning time × Number of tables to clean
% Customers who return their tray	Optimize the tray collection task for the staff	$\frac{\text{Customers who return their tray}}{\text{Customers who return tray} + \text{Customers who do not return tray}}$

4. Data Collection

To collect the times, an initial sample of 40-time recordings per variable was taken on both high-traffic and low-traffic days. The data can be seen in Figure 3 and Figure 4.

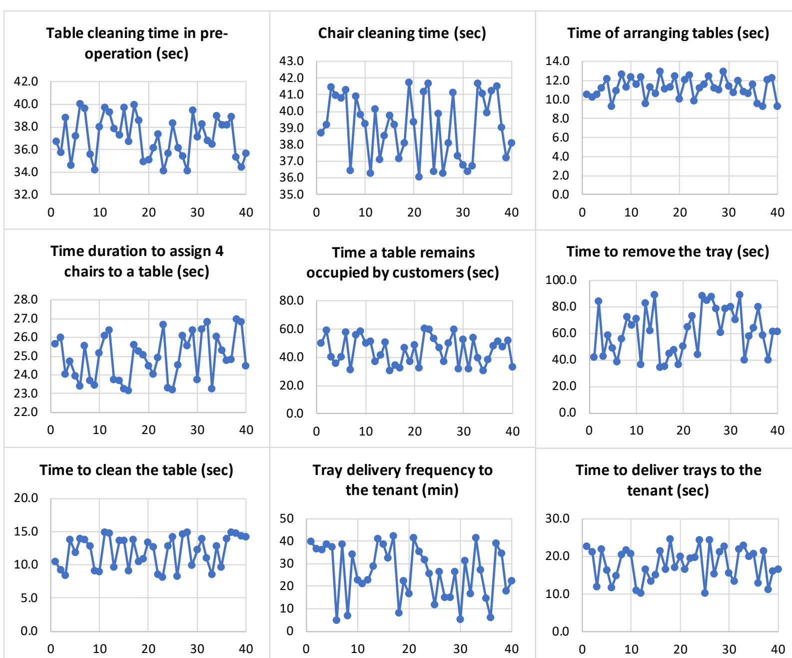

Figure 3. Timing of cleaning tasks

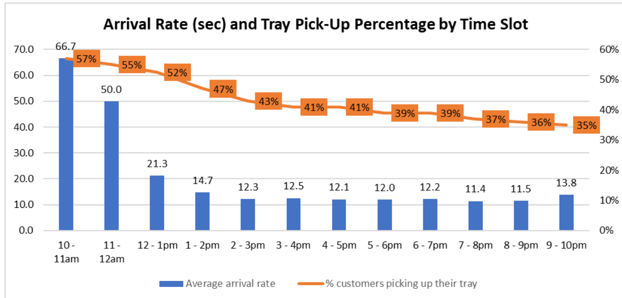

Figure 4. Customer arrival average time and Tray Pick-Up by time slot

5. Results and Discussion

5.1 Numerical Results

The effectiveness of the proposed Service Management Model is supported by findings from relevant studies. Realyvásquez-Vargas et al. (2020) achieved an 18.44% reduction in standard time through standardization and ergonomic design. Williams et al. (2022) reported a reduction in patient stay time and up to 94% less walking time after implementing standard nurse work. Dube and Gupta (2023) improved process efficiency by 13 percentage points through layout optimization. In comparison, as shown in Table 2, this study reduced table cleaning time by 32.12% through the implementation of ergonomic design, achieved a 20% increase in pre-cleaning productivity, and cut unnecessary transit time by 35% through work standardization. Additionally, layout redesign boosted customer tray disposal by 65.85%, demonstrating comparable or even greater effectiveness of Lean Service tools in food court operations.

Table 2. Table of Results

Tools	Indicator	As Is	To be	% variation
SW- Ergonomic Design	Pre-operation Productivity	63.59	76.32	+20%
Standard Work	Man-hours for chair cleaning before opening	12.8	8	−37.5%
Standard Work	Man-hours arranging chairs	1.98	1.51	−23.74%
Standard Work	Man-hours in transit	3.59	2.33	−35.1%
Ergonomic Design	Man-hours for table cleaning before opening	2.74	1.86	−32.12%
Layout Design	% of customers picking up their tray	41%	68%	+65.85%

5.2 Graphical Results

The Flow Process Chart of the TO BE process (Figure 5) corresponding to the food court pre-operation is presented, detailing the optimized activities along with the improvement in time for each of them. This diagram allows for a clear visualization of the proposed changes and their impact on process efficiency.

FLOW PROCESS CHART				
ACTIVITY	PRE-OPERATION CLEANING PROCESS OF THE FOOD COURT			
EVENT			PROPOSED	PRESENT
OPERATION	○	5	12.04	18.17
INSPECTION	□	0	0.00	0.00
TRANSPORTATION	⇨	5	2.33	3.59
STORAGE	△	0	0.00	0.00
DELAY	D	0	0.00	0.00
	TOTAL	10	14.37	21.76

N°	DESCRIPTION OF ELEMENTS	TIME (MAN HOUR)	○	□	⇨	△	D
1	Clean table base	0.86	•				
2	Move to replenish buckets and rinse rags to clean tables	0.23			•		
3	Clean table legs	1.01	•				
4	Move to replenish buckets and rinse rags to clean tables	0.23			•		
5	Reallocate table to a fixed position	0.66	•				
6	Return for another table to move	0.30			•		
7	Clean chairs	8.00	•				
8	Move to replenish buckets and rinse rags to clean chairs	1.44			•		
10	Assign 4 chairs to a table	1.51	•				
11	Move stacks of chairs	0.13			•		

Figure 5. Flow Process Chart of the TO BE process

5.3 Proposed Improvements

A pilot plan was carried out in the food court for one week with the aim of implementing the previously mentioned tools. First, supervisors and operators were trained with instructional videos demonstrating the most efficient task methods, based on those previously performed by selected operators (Figure 6). Regarding ergonomic design, a mop with a microfiber cloth the length of a table was introduced to cover the entire surface in a single motion, reducing physical effort, especially when cleaning chairs (Figure 7). Finally, the Layout Design tool was applied to optimize the placement of trash bins, assigning each an approximate reach radius (blue circles) to facilitate access. In Figure 8, on the left side ("As Is"), some tables were outside any bin's coverage area, increasing travel time. The layout was redesigned so more tables were within each bin's reach radius, improving process efficiency.

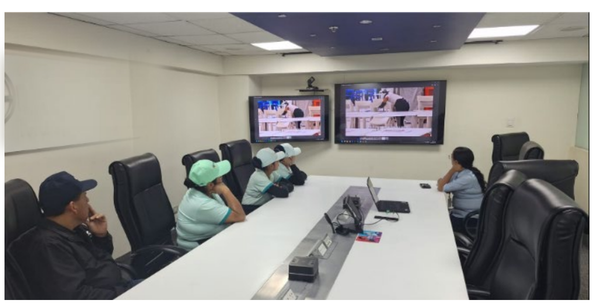

Figure 6. Training for cleaning operation team

Figure 7. Telescopic Microfiber Mop

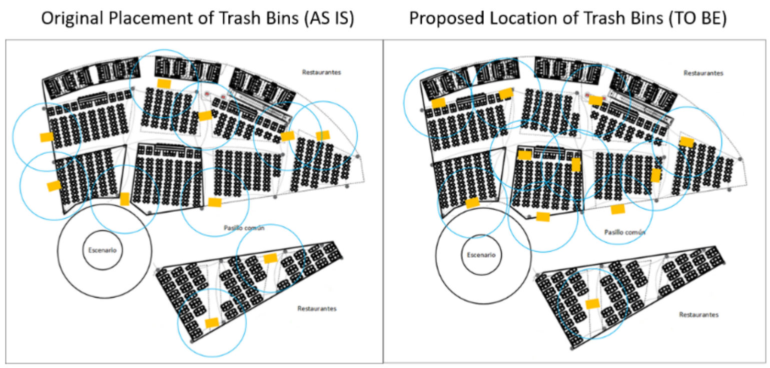

Figure 8. Comparison of Trash Bin Locations

5.4 Validation
5.4.1 Description of the Validation Method
For this study, a statistical validation of the current process (AS IS) was carried out through simulation using Arena software. Then, for the proposed process (TO BE), durations of key activities were adjusted based on data obtained from the pilot plan, and a reduction in staffing was evaluated to ensure that the operation would not be affected.

A total of 40 initial samples per variable were collected, and the final sample size per variable was calculated using the statistical formula for infinite or unknown populations (Torres 2013). The values can be found in Table 3.

$$n = \left(\frac{Z\sigma}{e}\right)^2$$

Table 3. Table of Values

Symbol	Meaning	Value
Z	Confidence level	95%
σ	Standard deviation from an initial sample	1.64
e	Maximum tolerable error	10%

The variables in Figure 3 were excluded from this calculation due to their exponential behavior. To complete the total sample, values were projected using a uniform distribution based on the indicated formula (Torres 2013):

$$Uniform\ behavior = a + (b - a) * ri$$

Where:

a: Minimum value
b: Maximum value
ri: Pseudorandom number

Based on the complete dataset, the statistical behavior of each variable was analyzed using Arena's Input Analyzer. All variables passed the Chi-Square and Kolmogorov-Smirnov tests (p-value > 0.05), validating that they follow a uniform distribution. To define the optimal number of model replications, an initial run of 30 replications was performed, yielding a Half Width of 867 seconds for the main output (total man-hours for cleaning). Seeking 50% greater precision, the formula from Torres (2013) was applied, concluding that 120 replications were necessary to reduce the confidence interval.

$$N = n\left(\frac{h_0}{e}\right)^2$$

Where:
n: Initial number of replications
h_0: Initial Half Width
e: Desired Half Width

With the AS IS model statistically validated (both inputs and outputs), the improved process (TO BE) was modeled using the times obtained during the one-week pilot in which all proposed improvements were implemented.

The TO BE model proposes a reduction in personnel: 1 person in the pre-operation stage, 1 person during the morning shift, 1 person during the afternoon shift as shown in Table 4.

Table 4. Adjustment of Man-Hours: AS IS vs TO BE

Activity	**Duration in hours**	**AS IS**		**TO BE**	
		Workers	**Available Man-Hour**	**Workers**	**Available Man-Hour**
Pre-operation	3.8	6	22.8	5	19
AM shift operations	4	4	16	3	12
PM shift operations	8	4	32	3	24
Total	15.8	14	70.8	11	55

The TO BE model was run with 120 replications, as in the AS IS model. The results (Table 5) show a 30% to 34% reduction in man-hours. Notably, in the morning shift (AM), the required man-hours do not even reach the total assigned to a part-time worker, suggesting an overstaffing situation during that time slot.

Table 5. Simulation Results of the AS IS vs TO BE Process

Output	**Average (sec)**		**Average (MH)**		**Average (FTE)**		**Average (PTE)**		**% variation**
	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	AS IS	TO BE	
Total cleaning MH	204,070	137,820	56.69	38.28	7.09	4.79	14.17	9.57	-32.5%
MH Pre-operation	78,016	54,141	21.67	15.04	2.71	1.88	5.42	3.76	-30.6%
MH Operation AM shift	16,510	10,982	4.59	3.05	0.57	0.38	1.15	0.76	-33.5%
MH AM shift	94,526	65,124	26.26	18.09	3.28	2.26	6.56	4.52	-31.1%
MH Operation PM shift	109,540	72,692	30.43	20.19	3.8	2.52	7.61	5.05	-33.6%
MH Operation	126,050	83,675	35.01	23.24	4.38	2.91	8.75	5.81	-33.6%

The simulation results were validated by performing a paired t-test in Output Analyzer to determine whether there is a statistically significant difference between the AS IS and TO BE process time.

Figure 9 shows the mean differences and confidence intervals for each output, in seconds. Positive values reflect that the AS IS process time is greater than TO BE process time. Figure 10 shows that the Output Analyzer rejected the null hypothesis (H_0) for each result: the means are not equal at the 5% significance level.

Therefore, at a 95% confidence level, there is a statistically significant difference between the improved and actual process time, so the TO BE process time has been satisfactorily reduced.

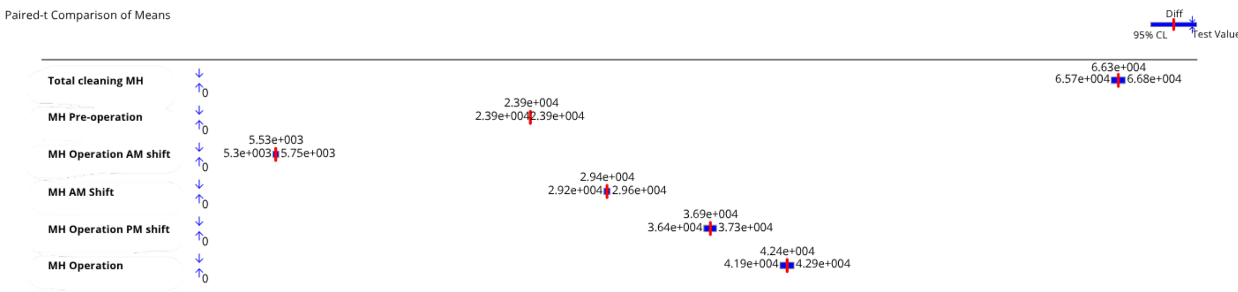

Figure 9. Paired t-test of simulation results AS IS vs TO BE

```
         Paired-T Means Comparison :

      IDENTIFIER         ESTD. MEAN   STANDARD  0.950 C.I.   MINIMUM    MAXIMUM  NUMBER
                         DIFFERENCE  DEVIATION  HALF-WIDTH     VALUE      VALUE  OF OBS
--------------------------------------------------------------------------------------
Total cleaning MH          6.63e+004   2.8e+003         506  1.98e+005   2.1e+005    120
                                                              1.34e+005  1.42e+005    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
MH Pre-operation           2.39e+004       24.6        4.45  7.77e+004  7.82e+004    120
                                                              5.39e+004  5.43e+004    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
MH Operation AM shift      5.53e+003  1.25e+003         227  1.41e+004  1.91e+004    120
                                                              9.14e+003   1.3e+004    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
MH AM Shift                2.94e+004  1.26e+003         227  9.21e+004  9.72e+004    120
                                                              6.33e+004  6.71e+004    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
MH Operation PM shift      3.69e+004  2.56e+003         462  1.05e+005  1.15e+005    120
                                                              6.77e+004  7.65e+004    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
MH Operation               4.24e+004   2.8e+003         507   1.2e+005  1.32e+005    120
                                                              7.93e+004  8.81e+004    120
         REJECT H0 => MEANS ARE NOT EQUAL  AT  0.05 LEVEL
```

Figure 10. Null hypothesis Validation

5.4.2 Functional Validation

Current labor regulations allow minimum shifts of 4 hours, but all cleaning staff currently work full 8-hour shifts. According to Table 5, there is a reduction in man-hours (M-H) in the TO BE model, but staff utilization was also analyzed to ensure the workload does not increase.

Table 6 shows that in the pre-operation and PM shift operations, staff utilization drops from 95% (AS IS) to 79% and 84% (TO BE), making it feasible to reduce staff without affecting operations. In the AM shift, the decrease from 29% to 25% reveals prior overstaffing.

Table 6. Operator utilization in the process AS IS vs TO BE

Activity	AS IS			TO BE		
	Available Man-Hour	**Operative Man-Hours**	**% Utilization**	**Available Man-Hour**	**Operative Man-Hours**	**% Utilization**
Pre-Operation	22.8	21.67	95%	19	15.04	79%
AM shift operations	16	4.59	29%	12	3.05	25%
PM shift operations	32	30.43	95%	24	20.19	84%
Total	70.8	56.69	80%	55	38.28	70%

It is proposed to start the day with 2 Part-Time and 3 Full-Time workers, ending with 3 Full-Time workers. Breaks should be scheduled between 12:00 PM and 1:00 PM, as this is the time with the lowest demand (Tables 5 and 6) and overlaps with the start of the afternoon shift.

5.4.3 Economical Validation

The operational cost of the new staffing structure, which includes 6 Full-Time and 2 Part-Time workers, was evaluated with unit monthly costs. Since there are no shifts after 10:00 PM, the cost for a Full-Time worker is the same for both morning and afternoon shifts, amounting to $571.50 per worker per month, while each Part-Time worker incurs a cost of $320.33 per month.

The total monthly cost with the new staffing is $4069.70, as shown in Table 7 In comparison, the AS IS model operates with 9 Full-Time workers, with a monthly cost of $5,143.50. This personnel optimization results in monthly savings of $1073.90 and an estimated annual savings of $12,886.20 (21%).

Table 7. Monthly labor cost in the TO BE process

Activity	Schedule	Part Time	Full Time	Total Cost
Pre-operation	6:00 AM - 10:00 AM	2	0	$640.70
Pre-operation and AM shift operation	6:00 AM - 15:00 PM	0	3	$1,714.50
PM shift operation	13:00 PM - 22:00 PM	0	3	$1,714.50
				$4069.70

6. Conclusion

The improvement of the food court cleaning process—through work standardization, layout redesign, and ergonomic design—led to significant reductions in man-hours: 37.5% in chair cleaning, 23.74% in chair arrangement, 35.1% in transit movements, and 32.12% in table cleaning. Additionally, better placement of trash bins increased the percentage of customers who return their trays from 41% to 68%. These changes allowed for staffing adjustment without affecting worker utilization and resulted in a 20% improvement in productivity and an estimated annual cost saving of 21%. It is recommended to include variables such as customer flow to calculate staffing adjustments, as this research revealed that due to low customer demand during the morning shift, staff only used 25% of their time generating value for the cleaning operation. Furthermore, it is important to compare productivity with experience indicators such as CSAT and NPS to determine the impact these operational strategies can generate on customer perception. Finally, before implementing the staffing changes, the complete team should be adapted to the new process, and to sustain and further optimize the process, it is vital to maintain ongoing monitoring, like a dashboard to track these productivity indicators and above all, dialogue spaces with staff to promote commitment, collect valuable information and generate acceptance to change.

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