Plant Layout and Design of Central Supply Laundry Department: A Case Study of a Hospital in Songkhla Province

Nitipat Laomongkholchaisri[1,*], Naruporn Arandorn[2], Teerapat Wangsaward[3] and Suparat Musikanit[2]
[1] Policy and Planning Analysis Section, Faculty of Medicine, Prince of Songkla University, Hat Yai, Hat Yai, Songkhla, 90110, Thailand
[2] Central Supply Laundry Department, Faculty of Medicine, Prince of Songkla University, Hat Yai, Hat Yai, Songkhla, 90110, Thailand
[3] Department of Industrial Engineering and Manufacturing, Faculty of Engineering, Prince of Songkla University, Hat Yai, Hat Yai, Songkhla, 90110, Thailand
***Corresponding Author E-mail:** nitipat.l@psu.ac.th
Received: Aug 14, 2024; **Revised:** Nov 12, 2024; **Accepted:** Nov 19, 2024

Abstract

This research focuses on minimizing the distance clean clothes are moved from the drying process to the shipping process by modifying the sorting area for efficient adjustments. The analysis employs the Systematic Layout Planning (SLP) methodology, categorizing relationships between activities into three types: Type A (3 relationship connections), Type I (2 relationship connections), and Type O (2 relationship connections). Two factory layout designs were developed based on this analysis. Layout 1 achieves a total movement distance of 2,014.72 meters from drying to daily shipping, resulting in a significant reduction of 1,160.06 meters compared to the original layout, representing a 37.69% decrease. Layout 2 reflects a total movement distance of 2,073.46 meters, which corresponds to a reduction of 1,218.80 meters from the original layout, or a 35.88% decrease. Qualitatively, the new factory layout enhances workplace safety by reducing the risk of accidents from collisions involving cloth carts, fostering a more positive work environment and increasing employee satisfaction. The design optimizes space efficiency, improving overall organization and workflow within the facility. Furthermore, although the article does not directly address service quality, the reduction in movement distance and time for transporting clean clothes indirectly contributes to improved service quality. This efficiency allows for quicker delivery of clean clothes to various departments, thereby enhancing responsiveness and operational effectiveness.

Keywords: Plant Layout and Design, Lean, Central Supply Laundry Department, Hospital

1. Introduction

Songklanagarind Hospital is a tertiary-level university hospital that provides advanced care for complex conditions using advanced medical technology. Serving the healthcare needs of 14 provinces in Southern Thailand, it handles a substantial volume of patients daily, including 90,000 outpatient visits per month, 4,000 inpatient admissions per month, as well as emergency and accident cases. Efficient management is crucial to ensuring both direct and indirect service quality.[1][2]

The central cloth distribution unit provides indirect services to patients. Its primary mission is to procure, launder, and process various types of clothes used in the hospital to support the teaching and medical services of the Faculty of Medicine. The management of this unit is divided into two main parts: the administrative office, which handles coordination and management both within and outside the unit to ensure a continuous and sufficient supply of clothes; and the factory, which is responsible for washing, drying, and preparing clothes according to service needs. Daily, the central cloth distribution unit processes approximately 5.7 tons of clothes. The factory operations start with collecting soiled clothes and end with delivering clean clothes to service users. The factory is divided into two zones: the dirty zone, which contains fixed machinery such as washing machines and dryers, and the clean zone, which can be easily adjusted and moved, including areas for sorting clean clothes, folding clothes, and dispatching clothes. The total movement distance for clean clothes from the drying process to daily dispatch is 3,233.52 meters.

Due to the increasing demand for clothes and space management constraints in the factory, there is a need to redesign the factory layout. This redesign will incorporate theories to ensure efficient space utilization, increase productivity to meet rising demand, and achieve optimal operational efficiency.

Lean systems aim to enhance process efficiency by reducing non-value-added activities or waste. There are seven types of waste in this context: overproduction, inventory, transportation, motion, processing, delay, and defects. Layout design is one method to minimize unnecessary transportation waste. Systematic Layout Planning (SLP) is a method for designing factory layouts based on the relationships between workstations or activities and process flow, which helps to reduce movement distances. [3–5]

Systematic Layout Planning (SLP) is a structured method for designing facility layouts to optimize efficiency, productivity, and space utilization. The process begins by defining the layout's goals and requirements, followed by an analysis of the existing setup to identify inefficiencies. It then determines space needs, establishes relationships between activities, and generates and evaluates different layout options. The most suitable layout is selected, implemented, and monitored for performance to ensure it meets objectives and adapts to changes. Various research studies have applied different tools and methodologies to improve layout efficiency and operational workflows.[6] One study utilizing Process Mining aimed to reduce patient wait times and enhance resource utilization in hospital emergency departments by optimizing the layout based on real-time data.[7] In contrast, research on copra factories employed SLP to optimize production area layouts, minimizing material movement and boosting production efficiency.[8] A study that combined Analytic Hierarchy Process (AHP) with SLP incorporated social responsibility criteria, balancing operational efficiency with employee welfare and environmental impact.[9] Another study used SLP to enhance facility layouts by reducing material handling costs and improving space utilization.[10] Similarly, SLP was applied in PT.ABC and PT Transplant Indonesia to reduce transport distances and material handling costs in the production process, contributing to more efficient operations. [11],[12]

Therefore, the objective of this article is to reduce the distance that clean clothes travel from the drying process to the shipping process by analyzing activity relationships and process flow and designing a systematic layout to minimize the total movement distance.

2. Methodology

This research focuses on designing the layout for the Central Supply Laundry Department using the Systematic Layout Planning (SLP) method. The SLP process involves several structured steps to optimize facility layouts, starting with defining the objectives and requirements of the layout. It then gathers information on current operations and analyzes the existing setup to identify inefficiencies. Next, space requirements for various functions are assessed, and a relationship diagram is developed to visualize interactions between activities. Multiple layout alternatives are generated and evaluated against established objectives, leading to the selection of the best option for implementation. Finally, the layout's performance is monitored and adapted as necessary to ensure it continues to meet operational needs. This methodical approach enables organizations to enhance productivity, reduce waste, and improve overall efficiency in their facilities. The steps involved in the process are as follows:

2.1 Research and Data Collection

In this study, data collection on movement distances focuses on direct observation methods to accurately measure work processes. Researchers systematically track the movements of materials and personnel within the facility by timing and recording each movement cycle. This includes documenting the starting and ending points and measuring the distance traveled using measuring tools such as measuring tapes or digital distance measuring devices. Additionally, video recordings may be employed to capture movement patterns, allowing for a detailed analysis of the frequency and duration of each movement. By combining these observational techniques, the study aims to gain insights into movement patterns, ultimately leading to an optimized layout design that minimizes unnecessary travel and enhances overall operational efficiency.

2.2 Conceptual Framework Design

Designing a conceptual framework to solve the problem for comparing the workflow diagrams of the old and new Central Supply Laundry Department processes as shown in **Figure 1**.

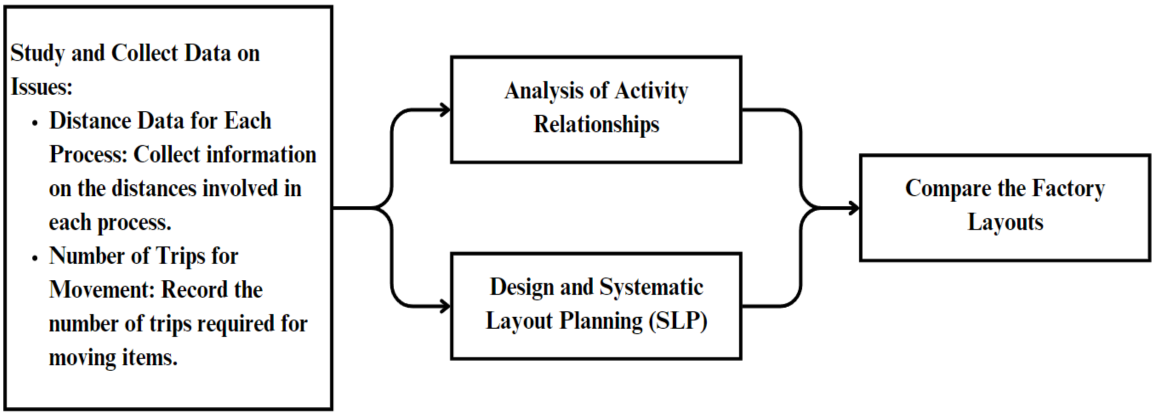

Figure 1 Conceptual Framework

2.3 Analysis of Production Process Flow

The production process flow is a vital tool for documenting and visualizing each step involved in a production process, allowing for a clear and comprehensive analysis of the workflow from beginning to end. This tool is instrumental in identifying inefficiencies and areas for improvement by providing an overarching view of the entire process. Complementing this, the from-to chart is used to record the movement of various items throughout the process, offering valuable insights into the interactions and relationships between different activities. This helps in pinpointing potential bottlenecks or redundancies that may hinder efficiency. The spaghetti diagram, meanwhile, visually represents the complexity and redundancy in workflow paths by mapping out the physical routes taken by items or information. This diagram highlights unnecessary movements and areas where the workflow could be streamlined, making it easier to identify where improvements are needed. Integrating Lean principles into the analysis of these tools can greatly enhance process efficiency. Lean methodology, which focuses on maximizing value while minimizing waste, uses insights from the production process flow, from-to chart, and spaghetti diagram to eliminate wasteful activities and reduce redundancy. For instance, Lean tools like Value Stream Mapping can be combined with the process flow and from-to chart to offer a detailed view of value-adding versus non-value-adding activities, enabling organizations to target specific areas for improvement. Additionally, analyzing the spaghetti diagram through a Lean perspective helps in reducing unnecessary movement and complexity, further streamlining workflows. By applying Lean principles, organizations can redesign workflows to reduce lead times, enhance productivity, and ultimately deliver greater value to customers. This systematic approach to integrating Lean principles with process analysis tools ensures the elimination of waste, optimization of workflows, and improved operational performance, leading to more efficient and cost-effective production processes.

2.4 Analysis of Activity Relationships

Analyzing the production process flow alone is not sufficient for designing a factory layout. This issue can be addressed by analyzing the relationships between activities. This involves assigning scores to indicate the level of support for each relationship, as shown in **Table 1**.

2.5 Design and Comparison

The design and comparison of the layout for the Central Supply Laundry process will employ Systematic Layout Planning (SLP) to systematically design the layout of the laundry distribution process. This approach will facilitate the comparison of movement distances between the old and new layouts.

Table 1 Activity Relationships

Rating	Closeness	Rule
A	Absolutely necessary	2–5%
E	Especially important	3–10%
I	Important and core	5–15%
O	Ordinary	10–25%
U	Unimportant	Not specified
X	Prohibited or Undesirable	Not specified

3. Results and Discussion

The researcher collected data on work processes, movement cycles, and distances. This data was systematically analyzed to design an efficient factory layout. The analysis involved breaking down the information into specific areas such as material flow, equipment placement, and resource allocation. This approach ensures improved efficiency, safety, and effectiveness in the factory layout. The analysis can be divided into the following areas:

3.1 The Central Laundry Process

The central laundry process begins with receiving soiled clothes from patient wards in the hospital. The soiled clothes are then washed using washing machines. After washing, the clothes are transferred to drying machines to be disinfected and dried with heat. Following this, the clothes are sorted by type and either folded using automatic folding machines or manually by staff. The folded clothes are then stored on shelves in preparation for delivery, marking the end of the process as illustrated in **Figure 2**.

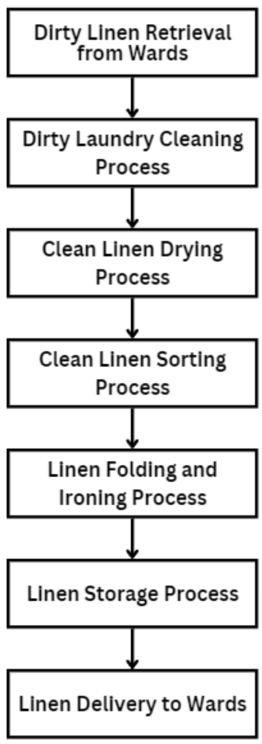

Figure 2 Conceptual Framework

The process flow for central laundry operations begins with the retrieval of dirty linen from the wards, where soiled clothes are collected for processing. Following this initial collection, the dirty laundry undergoes a thorough cleaning process to remove dirt and contaminants. After cleaning, the linen is dried to eliminate moisture, which prepares it for sorting. Once dried, the linen is categorized based on type and destination during the sorting process. This sorting is essential for efficient handling in subsequent steps. The next phase involves folding and ironing the sorted linen, enhancing its presentation for storage. After folding, the linen is organized and stored until needed. Finally, the delivery of clean linen back to the wards completes the cycle, ensuring that it is returned to the respective areas of the hospital.

After obtaining the process flow diagram for these operations, a spaghetti diagram can be created to visually map out the actual paths taken by the clothes and other materials within the facility. By overlaying these paths on the facility layout, the spaghetti diagram helps identify inefficiencies such as excessive movement or bottlenecks. This visual representation allows for more informed decisions to optimize workflow and reduce unnecessary handling, ultimately enhancing overall operational efficiency in the laundry department. This structured approach not only streamlines the laundry process but also contributes to improved productivity and resource utilization within the facility, as shown in **Figure 3**.

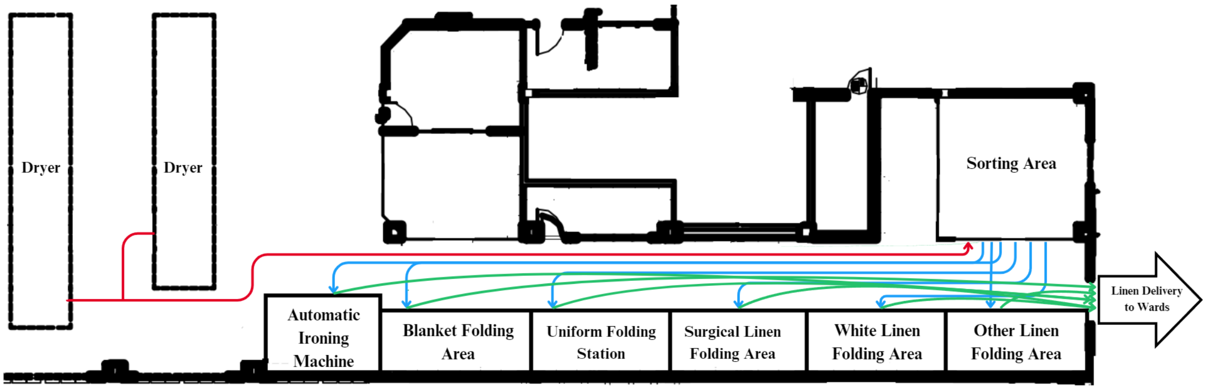

Figure 3 The spaghetti diagram

Based on **Figure 3**, it is observed that before the improvement, the clean clothes sorting area, which follows the drying process, was located at the far end, approximately 40.85 meters away, with a total of 6 trips per day. Meanwhile, the folding areas for different types of clothes (blankets, sets, surgical clothes, white clothes, and out-of-list clothes) were situated at distances of 15.74, 20.94, 25.61, 29.90, and 36.31 meters from the clean clothes dryer, respectively. This information is detailed in **Table 2**, which shows the distances for each process, and **Table 3**, which presents the number of trips for clothes transportation

Table 2 Distances for Each Process

	Dryer	Sorting Area	Other Linen Folding Area	White Linen Folding Area	Surgical Linen Folding Area	Uniform Folding Station	Blanket Folding Area	Automatic Ironing Machine	Linen Delivery to Wards
Dryer	0.00	40.85	36.31	29.90	25.61	20.94	15.74	14.71	41.87
Sorting Area	40.85	0.00	4.54	10.95	15.24	19.91	25.11	26.14	10.10
Other Linen Folding Area	36.31	4.54	0.00	10.95	10.70	15.37	20.57	21.60	5.56
White Linen Folding Area	29.90	10.95	10.95	0.00	4.29	8.96	14.16	15.19	16.51
Surgical Linen Folding Area	25.61	15.24	10.70	4.29	0.00	4.67	9.87	10.90	16.26
Uniform Folding Station	20.94	19.91	15.37	8.96	4.67	0.00	5.20	6.23	20.93
Blanket Folding Area	15.74	25.11	20.57	14.16	9.87	5.20	0.00	1.03	26.13
Automatic Ironing Machine	14.71	26.14	21.60	15.19	10.90	6.23	1.03	0.00	27.16
Linen Delivery to Wards	41.87	10.10	5.56	16.51	16.26	20.93	26.13	27.16	0.00

Table 3 Number of Trips for Cloths Transportation

	Dryer	Sorting Area	Other Linen Folding Area	White Linen Folding Area	Surgical Linen Folding Area	Uniform Folding Station	Blanket Folding Area	Automatic Ironing Machine	Linen Delivery to Wards
Dryer	0	50	0	0	0	0	0	0	0
Sorting Area	0	0	12	8	6	6	8	0	0
Other Linen Folding Area	0	0	0	0	0	0	0	0	12
White Linen Folding Area	0	0	0	0	0	0	0	0	8
Surgical Linen Folding Area	0	0	0	0	0	0	0	0	6
Uniform Folding Station	0	0	0	0	0	0	0	0	6
Blanket Folding Area	0	0	0	0	0	0	0	3	5
Automatic Ironing Machine	0	0	0	0	0	0	0	0	3
Linen Delivery to Wards	0	0	0	0	0	0	0	0	0

Table 2 provides detailed distances for each stage of the workflow, showing how far the clothes need to be moved between different locations. **Table 3** outlines the number of trips required to move the clothes between these stages. By combining the data from both tables, we can determine the cumulative distance that clothes are moved daily as they are processed and prepared for dispatch. It can be observed that the total distance involved in transporting clean clothes within the facility—from the end of the drying process to the final dispatch stage each day—is 3,233.52 meters. This measurement helps in understanding the efficiency of the current layout and may highlight areas where improvements could be made to reduce the total distance covered, thereby enhancing overall operational efficiency.

3.2 Activity Relationships

The analysis of activity relationships in the central laundry process involves ranking activities from highest to lowest based on the number of trips required to move linen after drying. This process begins with sorting the linen by type and continues through to the folding of linen. Certain areas of the process, such as the soiled linen washing area and the drying area, are constrained and could not be modified due to operational limitations. The results of this activity relationship analysis, which highlight the flow and movement of linen through various stages, are illustrated in **Figure 4**. This analysis provides a clear understanding of the interactions between different activities and identifies potential inefficiencies in the workflow, offering insights into how to optimize the process for improved efficiency and reduced operational constraints.

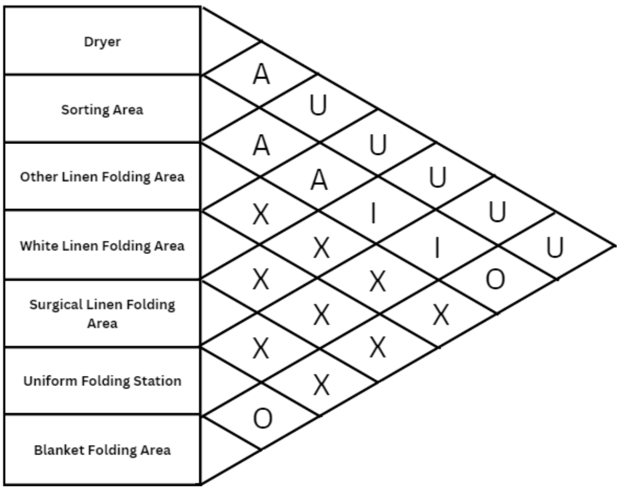

Figure 4 Activity Relationships

From **Figure 4**, it is observed that the relationships among the various workflow areas are categorized into distinct patterns, each highlighting different aspects of the process. Pattern A stands out due to its involvement in high-volume movement. It encompasses three significant relationships that are crucial for managing the substantial amount of clothes that need to be processed. First, there is a complete relationship between the dryer area and the sorting area. This connection is particularly important because it handles a large volume of clothes transitioning from drying to sorting. The efficiency of this relationship is vital for maintaining a smooth workflow and ensuring that the substantial amount of clothes is properly organized and processed. Second, Pattern A includes the complete relationship between the sorting area and the folding area for out-of-list clothes. This relationship is crucial for efficiently managing clothes that do not fall into standard categories, ensuring that these items are handled appropriately despite the high volume involved. Third, the pattern also includes the complete relationship between the sorting area and the folding area for white clothes. This connection is essential due to the large volume of white clothes that need to be sorted and folded, underscoring the importance of an effective and organized process for these items. Pattern I, while important, involves secondary relationships compared to Pattern A. It is characterized by two key relationships: the first is the significant connection between the sorting area and the folding area for surgical clothes. This relationship is crucial for ensuring that surgical clothes, which require specialized handling, are processed efficiently. The second relationship in this pattern is between the sorting area and the folding area for sets of clothes. This connection emphasizes the need for a smooth transition from sorting to folding coordinated sets of clothes, ensuring proper management and organization. Pattern O encompasses general relationships that, while still important, are routine in nature compared to Patterns A and I. It includes the relationship between the sorting area and the folding area for blankets. This relationship is essential for the effective handling and processing of bulky blankets. Additionally, the relationship between the folding area for sets of clothes and the folding area for blankets highlights the need for a well-organized workflow to manage different types of folding tasks, ensuring smooth transitions between them.

3.3 Systematic Layout Planning

Systematic Layout Planning (SLP) is a process that involves detailed data analysis to design an efficient factory layout. This approach often utilizes relationship charts between activities as a basis for decision-making, which helps in creating an effective layout that minimizes unnecessary movement. By incorporating data from these relationship charts, two main types of factory layouts can be designed as follows:

Factory Layout 1 involves the repositioning of the cloth sorting station to enhance workflow efficiency. Originally placed at the front of the facility, the sorting station was moved between the blanket folding area and the folding area for out-of-list clothes. This relocation aims to reduce the travel distance for clothes during processing by placing the sorting station closer to the folding areas that frequently interact with it. The blanket folding area remains in its original position to handle bulky items without disruption. On the other hand, the out-of-list clothes' folding area is shifted nearer to the newly positioned sorting station, enabling a more seamless transition between sorting and folding operations, as illustrated in **Figure 5**.

Additionally, **Table 4** showcases the changes in travel distances for different stages of the workflow, emphasizing the impact of this new arrangement. The table provides a detailed comparison, showing a significant reduction in travel distances, which ultimately enhances operational efficiency. As the drying machine and sorting station have a high number of transport cycles, their relocation to adjacent areas optimizes the workflow, minimizing the movement required and contributing to smoother, more efficient operations across the facility.

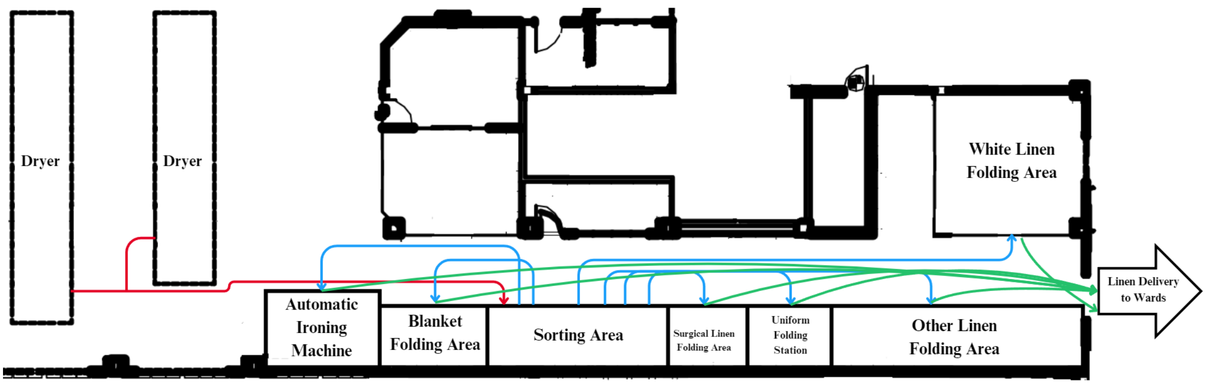

Figure 5 Plant Layout Design 1

Table 4 Process Distances for Factory Layout 1

	Dryer	Sorting Area	Other Linen Folding Area	White Linen Folding Area	Surgical Linen Folding Area	Uniform Folding Station	Blanket Folding Area	Automatic Ironing Machine	Linen Delivery to Wards
Dryer	0.00	20.94	29.90	40.85	26.14	28.74	15.74	14.71	41.87
Sorting Area	20.94	0.00	6.82	19.91	5.20	7.80	5.20	6.23	20.93
Other Linen Folding Area	29.90	6.82	0.00	17.58	10.70	10.95	28.47	29.50	21.05
White Linen Folding Area	40.85	19.91	17.58	0.00	4.60	4.60	25.11	26.14	10.10
Surgical Linen Folding Area	26.14	5.20	10.70	4.60	0.00	4.29	22.72	23.75	5.56
Uniform Folding Station	28.74	7.80	10.95	4.60	4.29	0.00	22.97	24.00	4.17
Blanket Folding Area	15.74	5.20	28.47	25.11	22.72	22.97	0.00	1.03	26.13
Automatic Ironing Machine	14.71	6.23	29.50	26.14	23.75	24.00	1.03	0.00	27.16
Linen Delivery to Wards	41.87	20.93	21.05	10.10	5.56	4.17	26.13	27.16	0.00

According to **Table 4**, the total distance covered daily in transporting clean clothes from the drying process to the dispatch stage is 2,014.72 meters. This measurement reflects the cumulative distance that clothes travel within the facility as they move from the end of the drying process to their final destination for dispatch. Understanding this total distance is crucial for evaluating the efficiency of the current workflow. It provides insight into the extent of movement required and can reveal inefficiencies or areas where the process could be streamlined. By analyzing this data, opportunities to optimize the layout or workflow may be identified, potentially leading to reduced transportation time, lower operational costs, and improved overall efficiency.

Factory Layout 2 involves relocating the sorting area from its original position at the front of the facility to a new location between the blanket folding area and the other linen folding area. The blanket folding area will remain in its original location, as depicted in **Figure 6**. This adjustment aims to streamline the workflow by positioning the sorting area closer to the related folding areas. Due to the high number of transportation rounds between the sorting area and the other folding stations, this relocation brings both stations closer together. By doing so, it is anticipated that the changes will reduce transportation time and facilitate a smoother working process. The distances associated with each process in this new layout are detailed in **Table 5**. This modification has the objective of creating a more efficient operational process, potentially enhancing overall operational effectiveness within the facility.

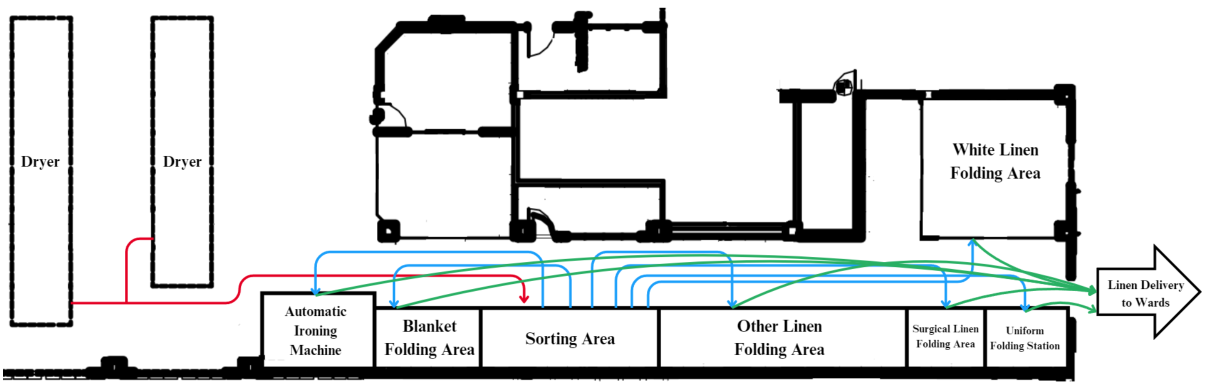

Figure 6 Plant Layout Design 2

Table 5 Process Distances for Factory Layout 2

	Dryer	Sorting Area	Other Linen Folding Area	White Linen Folding Area	Surgical Linen Folding Area	Uniform Folding Station	Blanket Folding Area	Automatic Ironing Machine	Linen Delivery to Wards
Dryer	0.00	20.94	36.31	40.85	25.61	29.90	15.74	14.71	41.87
Sorting Area	20.94	0.00	15.37	19.91	4.67	8.96	5.20	6.23	20.93
Other Linen Folding Area	36.31	15.37	0.00	4.54	10.70	10.95	20.57	21.60	5.56
White Linen Folding Area	40.85	19.91	4.54	0.00	15.24	19.91	25.11	26.14	10.10
Surgical Linen Folding Area	25.61	4.67	10.70	15.24	0.00	4.29	9.87	10.90	16.26
Uniform Folding Station	29.90	8.96	10.95	19.91	4.29	0.00	14.16	15.19	16.51
Blanket Folding Area	15.74	5.20	20.57	25.11	9.87	14.16	0.00	1.03	26.13
Automatic Ironing Machine	14.71	6.23	21.60	26.14	10.90	15.19	1.03	0.00	27.16
Linen Delivery to Wards	41.87	20.93	5.56	10.10	16.26	16.51	26.13	27.16	0.00

According to **Table 5**, the total distance for moving clean clothes from the drying process to the dispatch stage each day is 2,073.46 meters.

4. Conclusion

In a comprehensive case study conducted at a hospital in Songkhla, the research team focused on optimizing the workflow for handling clean clothes, from the drying stage to the final dispatch stage. The primary objective was to reduce the distance that clothes traveled during this process, as minimizing these distances can lead to increased operational efficiency and reduced labor costs. The initial analysis revealed that the total daily distance for moving clothes from the drying process to the dispatch area was 3,233.52 meters. To address this issue, the team decided to make adjustments to the cloth sorting point, which was identified as a flexible area that could be easily modified without requiring significant changes to other parts of the workflow. To improve efficiency, the team designed a new layout for the factory. This redesign was informed by the analysis of various patterns of activity relationships. Pattern A highlighted three critical connections: the link between the drying machine and the sorting point, the connection between the sorting point and the folding area for out-of-list clothes, and the relationship between the sorting point and the folding area for white clothes. These connections were deemed essential for ensuring smooth and efficient operations between these key areas. Pattern I focused on two important relationships: the connection between the sorting point and the folding area for surgical clothes, and the relationship between the sorting point and the folding area for sets of clothes. These connections were significant for managing specialized clothes that require careful handling and organization. Pattern O emphasized two key relationships: the link between the sorting point and the folding area for blankets, and the connection between the folding areas for sets of clothes and blankets. These relationships were crucial for effectively sorting and folding different types of clothes. Based on the analysis of these patterns, the team developed two alternative factory layouts. Layout 1 was designed to significantly reduce the daily distance for moving clean clothes to 2,014.72 meters. This layout achieved a reduction of 1,160.06 meters, or 37.69%, from the original distance. This improvement was accomplished by relocating the sorting point to a more central position between key folding areas, thereby minimizing unnecessary movement. Layout 2 also aimed to reduce the distance but resulted in a total daily distance of 2,073.46 meters. This layout reduced the distance by 1,218.80 meters, or 35.88%, from the original layout. Although this layout also provided improvements, it did not offer as significant a reduction as Layout 1. After evaluating the benefits of each layout, the research team chose to implement Layout 1. This decision was based on its superior performance in reducing the total distance traveled by the clothes, thereby enhancing overall operational efficiency and potentially reducing labor costs. Additionally, the new layout design maximized the use of limited space and enhanced workplace safety by reducing the likelihood of accidents from linen cart collisions. This safety improvement contributed to greater employee satisfaction and a better working environment. By minimizing unnecessary movement and enhancing safety, the redesign added value to hospital operations, improving service quality and resource utilization.

5. Suggestion

To further enhance workflow efficiency and operational effectiveness based on the findings from the case study , several recommendations can be made. First, continuous monitoring and adaptation of the layout are essential to address changes in workload or equipment needs over time. Integrating technology, such as automated carts or conveyor belts, could further reduce manual labor and improve safety. Employee training should be prioritized to ensure staff are well-versed in the new processes, while simulation-based analyses could identify additional bottlenecks for improvement. Sustainability efforts, such as energy optimization, could further increase efficiency and align with the hospital's corporate social responsibility goals. These recommendations, combined with the implemented layout, would result in improved operational efficiency, better service delivery, and a safer work environment.Recommendation

6. Acknowledgements

I would like to express my sincere gratitude to all those who have supported the completion of this study. First and foremost, my deepest appreciation goes to the staff at the hospital for their cooperation and assistance in providing valuable data that formed the foundation of this research. I would also like to extend my thanks to my academic advisors, whose guidance and feedback were instrumental in shaping the direction of this project. Special thanks to my colleagues for their insightful discussions and support throughout the research process. Lastly, I am grateful to my family and friends for their unwavering encouragement and understanding, which motivated me to complete this work. This study would not have been possible without the collective efforts and contributions of all involved.

7. References

[1] Faculty of Medicine Prince of Songkla University. "Songklanagarind hospital history." hospital.psu.ac.th. https://hospital.psu.ac.th/1DataHos.php (accessed Jan. 12, 2024).

[2] Songklanagarind hospital. "Medical Record Section." medinfo2.psu.ac.th. http://medinfo2.psu.ac.th/medrec/index.php (accessed Jan. 12, 2024).

[3] N. D. Minh, N. D. Nguyen, and P. K. Cuong, "Applying Lean Tools and Principles to Reduce Cost of Waste Management: An Empirical Research in Vietnam," *Management and Production Engineering Review*, vol. 10, no. 1, pp. 37–49, 2019, doi: 10.24425/mper.2019.128242.

[4] S. Furterer and P. Kancharla, "Applying Lean Six Sigma and Systematic Layout Planning to Improve Patient Transportation Equipment Storage in an Acute Care Hospital," in *Proc. Eighth Int. Conf. Lean Six Sigma*, West Lafayette, IN, USA, Jun. 22–23, 2021, doi: 10.5703/1288284317338.

[5] A. Chiarini, "Waste savings in patient transportation inside large hospitals using lean thinking tools and logistic solutions," *Leadership in Health Services,* vol. 26, no. 4, pp. 356–367, 2013, doi: 10.1108/LHS-05-2012-0013.

[6] G. B. Benitez, G. J. C. Da Silveira and F. S. Fogliatto, "Layout Planning in Healthcare Facilities: A Systematic Review," *Health Environments Research & Design Journal*, vol. 12, no. 3, pp. 31–44, 2019, doi: 10.1177/1937586719855336.

[7] F. Rismanchian and Y. H. Lee, "Process Mining–Based Method of Designing and Optimizing the Layouts of Emergency Departments in Hospitals," *Health Environments Research & Design Journal*, vol. 10, no. 4, pp. 105-120, 2017, doi: 10.1177/1937586716674471.

[8] R. Erwanda, "Layout Design of Copra Factory Facilities in Small and Medium Industry Centers Using Systematic Layout Planning Method", *Jurnal Riset Ilmu Teknik*, vol. 1, no. 2, pp. 115–127, 2023, doi: 10.59976/jurit.v1i2.13.

[9] L. S. Goecks, T. Mareth, A. L. Korzenowski, J. A. R. Moraes and E. O. B. Nara, "Analytic hierarchy process as a decision-making tool for systematic layout planning, involving social responsibility criteria: A case study," *International Journal of Industrial and Systems Engineering*, vol. 40, no. 1, pp. 29–50, 2022, doi: 10.1504/IJISE.2022.120806.

[10] V. Kumar and V. N. Malleswari, "Improvement of facility layout design using Systematic Layout planning methodology," *Journal of Physics: Conference Series*, vol. 2312, 2022, Art. no. 012089, doi: 10.1088/1742-6596/2312/1/012089.

[11] M. F. Hafidin and A. E. Nugraha, "Analisis Dan Usulan Perencanaan Tata Letak Pabrik Bagian Produksi Menggunakan Metode Systematic Layout Planning (SLP) Di PT.ABC," *Industrika: Jurnal Ilmiah Teknik Industri*, vol. 7, no. 2, pp. 161–171, 2023, doi: 10.37090/indstrk.v7i2.964.

[12] D. Muslim and A. Ilmaniati, "Usulan Perbaikan Tata Letak Fasilitas Terhadap Optimalisasi Jarak dan Ongkos Material Handling Dengan Pendekatan Systematic Layout Planning (SLP) di PT Transplant Indonesia," *Jurnal Media Teknik dan Sistem Industri*, vol. 2, no. 1, pp. 45–52, 2018, doi: 10.35194/jmtsi.v2i1.327.