

# **Analysis of Maintenance Management Implementation and Strategy Conceptualization: A Case Study of Hospitals' Maintenance Management in Indonesia**

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## **Abstract**

The performance of a health facility and its components depends primarily on a proper maintenance management strategy owned. Facility managers play an essential role in maintenance management and building operations because they are the central pawns in estimating the function of all existing facilities. Hospital cleaning is increasingly becoming more critical with the awareness that pathogens can persist in the long term, coupled with the COVID-19 issue in the healthcare environment. Considering that the hospital is an essential public facility, it is appropriate to maintain its facilities and equipment to serve all stakeholders well. This research aims to assess the effectiveness of cleaning maintenance management in a group of forty-four health care facilities in Indonesia. A geometric mean is carried out to identify factors and sub-factors that are most critical to the maintenance management of hospitals. Cronbach's alpha statistical test is carried out to verify that the survey conducted shows reliable results, continued with the Strength, Weakness, Opportunity, Threat (SWOT) matrix for drawing recommendations for future strategies.

## **Keywords**

Hospital, Maintenance and Cleaning Management, Statistical Analysis, Survey, SWOT Matrix

## **1. Introduction**

A health facility's performance and components depend primarily on its maintenance management strategy (Shohet et al., 2003). Healthcare facilities continue escalating their complexity throughout the period due to growing urbanization and technological advancement in building components and medical equipment (Yousefli et al., 2020). Hospitals are obliged to accommodate more extensive services to increase their patients, providing essential services and being occupied by 24 hours a day, all year round (Yousefli et al., 2017).

Hospitals have experienced a further challenge due to clusters of hospital-acquired COVID-19 infections involving both staff and patients, all primary and supplementary infrastructures needed. It is essential to contemplate fulfilling added actions devised to impede the transmission of pathogens in acute hospitals. Hospital cleaning is increasingly necessary with the awareness that pathogens can persist for a certain period, where the environment allows for the active movement of pathogen transmission. Action is needed to deal with this, one of which is by carrying out routine and periodic cleaning activities. Cleaning can reduce bioburden in the health care environment and the risks associated with HCAI (Dancer, 2014) to preserve all the staff on duty, patients, and visitors are kept protected. Infection prevention approaches include hand hygiene, patient and staff screening, surveillance, personal protective equipment, enhanced cleaning—restricting movement, bathroom management, and ensuring efficient ventilation systems (Dancer, 2021). Healthcare facilities keep advancing their maintenance management practices by ascertaining maintenance strategies into administering performance measurements to address hospital maintenance costs, schedules, and performance to give the best out of overall facility productivity (Gómez-Chaparro et al., 2020).

## 1.1 Objectives

Considering that a hospital is an essential public facility, it is appropriate for a hospital to maintain its facilities and equipment to serve all its stakeholders better. The research aims to assess maintenance management in several topics to determine the effectiveness of maintenance management implementation in a group of health care facilities in Indonesia, further giving recommendations based solely on the current maintenance implementation condition results.

## 2. Literature Review

Maintenance is designated as the combination of all technical and administrative actions, including supervision, intended to retain an item or restore it. It can perform a required function (*BS EN 13306: 2017 BSI Standards Publication Maintenance — Maintenance Terminology*, 2017). The complexity of healthcare facilities' services highlights the importance of its maintenance management function. Manifold concerns were named, including budget limitations, high expenditures, the criticality of services, customer satisfaction, the complexity of information, and decision-making.

### 2.1. Maintenance Management

Maintenance management, with its multiple approaches to activities, resources, and measurement, has continually been essential to healthcare organizations. Maintenance perceives a broader perspective in today's organizations that has shifted from a narrowly defined operational perspective to an organizational strategic perspective (Simões et al., 2011). Maintenance management needs to look into a strategic perspective within an organization, and maintenance strategy becomes a significant challenge for maintenance managers in the industry. (R. Nurcahyo et al., 2018). The impact of maintenance strategy becomes an essential requirement for an organization (Velmurugan & Dhingra, 2015). Consequently, many different strategies have been developed to support the implementation of maintenance management in the industry (Swanson, 2003).

### 2.2. Maintenance Strategies

In order to employ maintenance performance management to advance proactive organizational change, a practice should be devised to monitor and improve the diverse perspectives of the maintenance actions. This process should integrate critical success business factors inferred from the overall organizational strategy (Tsang et al., 1999). In performing so, prioritizing facilities' maintenance components based on recorded information is the primary step towards maintenance strategic planning decisions (Sullivan & Pugh, 2004). The array of maintenance strategies in hospitals with multiple mechanical and electronic components, systems, and equipment can be significantly impacted when the organization has deficient maintenance-related issues (Loosemore & Hsin, 2001). Based on the preceding background, the maintenance role must be observed as a strategic function in an organization. An expanse of improvement in the formulation of maintenance strategies for the organization, specific equipment, or process is selected through certain factors.

### Maintenance Activities

Maintenance, in general, is classified under two sections, failure-based maintenance (i.e., corrective maintenance) and life-based maintenance (i.e., preventive maintenance). PM is planned to maintain plant infrastructure and equipment to improve equipment lifetime by inhibiting excess depreciation and impairment (Velmurugan & Dhingra, 2015). Maintenance activities encompass but are not limited to adjustments, cleaning, lubrication, repairs, replacements, and the extension of equipment life. In PM, the maintenance needs are acquired based on the equipment's actual condition rather than a predetermined schedule. PM comprises predicting the failure before it transpires, distinguishing the root causes for those failure symptoms, before prompting extensive damage to equipment (Jafari et al., 2008; Osborne & Taj, 1992). To an extent, healthcare facilities' activities revolve around scheduling, reporting, and monitoring the implementation of the cleaning service at the hospital, either daily or monthly. There are also records detailing actions related to scheduled maintenance and will do for each hospital facility regularly.

### Equipment and Maintenance Materials

The management of equipment and spare parts availability represents an essential role in maintaining spare part inventory can lead to high maintenance costs. Healthcare facilities ought to reconsider and ensure service continuity while avoiding over-maintenance and maintenance allowance inefficiencies (Yousefli et al., 2017). While this research possesses the same object to examine the hospital maintenance system in Indonesia through third-party stakeholders, continuous improvements in equipment reliability require more cooperation with third-party maintenance service providers (Fischer et al., 2008).

### **Human Resources Maintenance**

The healthcare facilities in Indonesia principally subserve curative, rehabilitative services, and promotive and preventive services. Services provided are an individual patient and the family and community (Rahmat Nurcahyo et al., 2019). Those facilities must possess critical factors in successful maintenance resource planning, including qualifications and training, job motivation, and proper maintenance of human resources (Cholasuke et al., 2004). In this case, maintenance managers and third-part providers must undergo more intensive training to build a corresponding competency base, to optimize maintenance performance. (Fischer et al., 2008).

### **Maintenance Policies and Standard Procedures**

The healthcare facilities in Indonesia principally subserve curative, rehabilitative services, and promotive and preventive services. Services provided are not only an individual patient but also the family and community (Rahmat Nurcahyo et al., 2019). The maintenance policy is a tool that maintenance personnel can use to plan an effective maintenance strategy. The selection of a maintenance strategy, the definition of maintenance standards, and the allocation of maintenance resources are three critical elements in developing a maintenance policy that will allow maintenance activities to be properly planned and implemented (Scott, 2008). Maintenance procedures are important because this process necessitates detailed knowledge of maintenance requirements as well as the resources required to perform maintenance. Labor, parts, materials, and tool costs are among the resources required. If maintenance is contracted, the contractor will often roll all of these costs into one, though in some contracts, parts costs may be kept separate (Odeck, 2008).

### **Financial Aspect**

Maintenance financial control includes controlling the maintenance budget, contractor cost monitoring, and overall labor and material cost control (Cholasuke et al., 2004). Labor costs and maintenance costs for facilities and equipment are significant factors that contributing significantly to hospital operating and maintenance cost budgeting and practical but efficient operating performance (Han et al., 2021). Realizing the distribution of maintenance costs and forecasting future trends is critical for efficiently allocating a limited budget, in order to arrange a reasonable budget to meet the required functions, facility managers must understand the historical cost distribution and predict the future trend of maintenance costs (Lo et al., 2011).

### **Maintenance Data Management**

A maintenance report is a document that comprises information on preceding maintenance operations and their result on future maintenance performance, costs, assets, and business performance. Maintenance data management is typically manifested by technical instructions arranged as a reference or guide to provide technical requirements and conditions for operation and maintenance by applicable requirements. There is also a checklist of equipment and maintenance activities to ensure compliance with applicable standards. Most businesses consider maintenance a task performed by technicians, and the data gathered is primarily cost related. Maintenance will be hampered if data collection is not handled correctly. Effective maintenance management necessitates proper data management, including data collection and analysis for decision-making (Murthy et al., 2015).

### **Supporting Elements of Maintenance**

There are supporting elements in maintenance activities, such as paying attention to the quality of the maintenance process equipment and controlling availability. Inventory management issues must also be considered in providing sufficient and efficient inventory to support operational and maintenance activities in the industry (Rahmat Nurcahyo et al., 2018). Each operational program must consider the maintenance tasks that must be completed and the available resources to ensure that product quality and personnel safety standards are met. Operational demands from service, production lines, or the office environment will significantly impact how the maintenance program is implemented.

### **2.3. Geometric Mean and Cronbach's Alpha**

A geometric mean is used for data that has a different weight among the data. The geometric mean minimizes the influence of extreme values. One of the geometric mean requirements is that no data element has a negative value because it is a process of calculating the root of the power. Equation (1) shows the geometric mean formula.

$$G = \sqrt[n]{x_1 \times x_2 \times x_3 \times \dots \times x_n} \quad (1)$$

G represents geometric mean of a sample,  $x_n$  represents value of the  $n$ th data, while  $n$  represents amount of data in a sample.

In general, reliability testing is a research instrument to obtain reliable information as a data collection tool. A reliability test can be used to test some questionnaires used in a study to determine whether the questionnaire used can be said to be reliable or not. Questionnaires can be reliable if someone's answer to the statement is consistent from time to time.

Reliability testing can use the Cronbach's Alpha method to test the reliability of the questionnaire using a Likert scale. Provisions indicate the high and low reliability, empirically indicated by a number called the reliability coefficient value. The reliability coefficient value ranges from 0 to 1, indicating that high reliability is a reliability coefficient value close to 1. Equation (2) shows the Cronbach's Alpha formula.

$$\alpha = \left( \frac{n}{n-1} \right) \left( 1 - \frac{\sum \sigma_t^2}{\sigma_t^2} \right) \quad (2)$$

$\alpha$  represents the reliability coefficient,  $n$  for number of items tested,  $\sum \sigma_t^2$  for total score variance for each item, and  $\sigma_t^2$  represents the total variance.

## 2.4. SWOT Matrix

SWOT is an acronym used to define strengths, weaknesses, opportunities, and threats that remain strategic factors for an organization (Wheelen & Hunger, 2012). SWOT analysis is an essential tool in strategic management that helps decision-makers understand the current situation in the industry and develop appropriate strategies for stakeholders (Mirzakhani et al., 2014). The external factors used in preceding research are mainly economic, sociocultural, demographic, environment, technological change, and trends. Internal factors to consider include organizational structure and culture, operations, human resources, finance, information technology or system, and research and development.

The SWOT analysis could be helpful to identify the conditions that the medical facilities face. It helps analyze the strengths, weaknesses, opportunities, and threats that might apply to our subjects, hospitals in Indonesia. The SWOT analysis is mainly chosen for its straightforward approach, flexibility, and practical/helpful output (Jasiulewicz-kaczmarek, 2016).

## 3. Methods

The data was gathered by in-depth interviews with forty-four experts from each hospital maintenance representative in Indonesia, supported by extensive literature reviews from journals, references, supporting libraries, and theoretical sources for the writing process related to preventive maintenance, maintenance survey, and cleaning maintenance at the healthcare facilities.

Survey questionnaires are being raised based on the criteria obtained from the literature review and the target to be known, which contains questions that can explain these factors. Seven criteria influencing hospital maintenance management are carried out: maintenance activities, equipment and materials, human maintenance resources, maintenance policies, standard procedures, financial aspects, maintenance data management, and maintenance support elements.

Thirty-three questions from seven criteria were examined over a form that the hospital's maintenance experts representative filled in. Respondents are obliged to write down their hospital area. Each question is equipped with a Likert scale response from range 1-5 (1 for a less critical statement and 5 for an upmost critical statement). The geometric mean and Cronbach's alpha statistical test are carried out in this research. The geometric mean used to find a compromised between the data sets provided, giving an equal results, while Cronbach's alpha calculates the consistency between items in a test that is the test's internal consistency (Christmann & Van Aelst, 2006). It continues with the Strength, Weakness, Opportunity, Threat (SWOT) matrix for drawing recommendations for future strategies.

#### 4. Data Collection

Data collection was carried out through questionnaires sent to hospital employees who have work experience > 10 years in various regions in Indonesia. It is necessary to ensure that the evaluation used in the study follows the actual conditions. Participating organizations are segmented by region.

This survey includes hospitals located in Java and outside Java. Of the 44 answers to the questionnaire, 35 hospitals or 81% are in Java, namely 11 hospitals in Greater Jakarta, 9 hospitals in Central Java, 11 hospitals in West Java, 1 hospital in East Java, and 32 hospitals in Yogyakarta. Meanwhile 9 hospitals outside Java consist of 3 hospitals in Sumatra and 1 hospital each in Bali, Kalimantan (Balikpapan), Sulawesi (Kendari), Pangkal Pinang and Manado. Table 1 shows the Likert scale and its explanations used in the questionnaire.

Table 1. Likert scale

Scale	Description
1	Very Important (the criterion is very unimportant in maintenance management)
2	Not Important (the criterion is not important in maintenance management)
3	Neutral (the criterion is neither agree nor disagree important in maintenance management)
4	Important (the criterion is very important in maintenance management)
5	Very Important (these criteria are important in maintenance management)

Each expert assessment results are assessed on a geometric mean to ascertain the final value of each criterion and sub-criteria. A legitimate criterion provision is if the geometric mean of the experts' answers for each sub-criteria is greater than the geometric mean value for the overall value of the criteria and sub-criteria.

#### 5. Results and Discussion

This study will calculate the Geometric Mean to determine the sub-criteria that are considered significant and influential to become parameters for future maintenance management recommendations and Cronbach's Alpha reliability test to determine whether the results of the criteria validation carried out are consistent or not.

##### 5.1 Geometric Mean

It can be seen in Table 2 that there are 15 selected sub-criteria from a total of 33 previously available sub-criteria. The rejected sub-criteria are considered less significant and influential to be a success factor in maintenance management.

Table 2. Survey Questionnaire Assessment

No.	Criteria	Sub-Criteria	Code	Geomean Respondents	Geomean Criteria	Accept / Reject
1	Maintenance activities	There are scheduled and reports on the implementation of the cleaning service at the hospital either daily or monthly	M1	4,78714	4,72935	Accept
2		There are records detailing actions related to scheduled maintenance and will do for each hospital facility on a regular basis	M2	4,76292		Accept
3	Equipment and Maintenance Materials	Facility maintenance activities use equipment that supports the facility maintenance process	E1	4,84304	4,80579964	Accept
4		There is a routine schedule for equipment inspection	E2	4,82561		Accept

Table 2. Survey Questionnaire Assessment

No.	Criteria	Sub-Criteria	Code	Geomean Respondents	Geomean Criteria	Accept / Reject
5	<b>Equipment and Maintenance Materials</b>	Maintenance equipment used is always in good condition	<b>E3</b>	4,85015		Accept
6	<b>Human Resources Maintenance</b>	Total maintenance personnel in accordance with company procedures	<b>H1</b>	4,87481	4,828192967	Accept
7	<b>Maintenance Policies and Standard Procedures</b>	Hospital maintenance policies and regulations in accordance with applicable standards	<b>P1</b>	4,78714	4,758232582	Accept
8		Maintenance assignments are well structured and divided according to the work and portion of each team member	<b>P7</b>	4,80120		Accept
9		There is a stock of personal protective equipment for the maintenance of facility areas with a high level of risk, such as height, equipment medical, and exposure to disease	<b>P8</b>	4,85015		Accept
10	<b>Financial Aspects</b>	Budget for maintenance costs (labor wages, equipment costs) in accordance with needs	<b>F1</b>	4,86766	4,789479381	Accept
11		Personnel feel hampered by the situation current equipment budget when needed	<b>F3</b>	4,79417		Accept
12	<b>Maintenance Data Management</b>	Maintenance data is stored in a safe place with limited access (only for certain people) and can be accessed easily by the parties concerned	<b>D2</b>	4,76292		Accept
13		There are procedures or technical instructions in carrying out maintenance	<b>D4</b>	4,81854		Accept
14		There is a checklist for the suitability of the current condition of the item with the applicable standard	<b>D6</b>	4,82561		Accept
15	<b>Supporting Elements of Maintenance</b>	There is control regarding the availability and quality of cleaning service equipment on each floor of the hospital	<b>S1</b>	4,81854		4,77851801

On the criteria for maintenance activities, a factor that has a significant effect on the success of maintenance management is the existence of schedules, reports, and detailed records related to the implementation of cleaning services in hospitals that are carried out regularly. The criteria for Equipment and Maintenance Materials that have a significant influence are the condition and suitability of the equipment used and the routine inspection schedule. While the HR Maintenance criteria, the number of maintenance personnel according to company procedures. Structured policies and availability of personal protective equipment, appropriate budget and wages, security, and clarity in maintenance procedures also significantly affect cleaning service management in hospitals.

### 5.2 Cronbach's Alpha Reliability Test

A reliability test was conducted to determine whether the results of the criteria validation carried out in the previous stage were consistent or not. The results of the Cronbach's Alpha reliability test can be seen in Table 3.

Table 3. Cronbach's Alpha Reliability Test

Cronbach's Alpha	N of Items
0,9831	33

It can be seen in Table x that the reliability test results show the Cronbach's Alpha value of 0.9831. This shows that the value of Cronbach's Alpha is greater than the value of the r table for N = 33 (the number of objects tested), is 0.334. It can be concluded that the results of the criteria validation questionnaire conducted are consistent and reliable.

### 5.3 SWOT Analysis

The information established for the SWOT analysis was deduced from in-depth interviews with maintenance experts and extensive literature reviews. Suggested research can identify the importance of maintenance criteria and help identify the factors that might induce the success or failure of hospital maintenance activities. As per the below mentioned Table-4, the findings of this analysis could help provide a development strategy for hospital maintenance systems by maintaining identified supportive factors and mitigating harmful factors.

Table 4. Recommendation based on SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Maintenance routine activity schedule and detailed activities report existing</li> <li>Maintenance essential equipment (including health and safety equipment) is complete and in good condition</li> <li>Implementation of maintenance policy and procedures which complies with applied standards</li> <li>Portioning work to personnel has been done in structured and equitable manners according to personnel's' capabilities and responsibilities</li> <li>Maintenance data security is provided</li> </ul>	<ul style="list-style-type: none"> <li>Problem with users because of the outscore work carried out by the maintenance officer so that the main work is disrupted</li> <li>High rise work (maintenance of facilities with a height of 1.75 m and above) is carried out by maintenance officers who have operational licenses. Sometimes some users order regular maintenance officers to do it because it has a high risk</li> <li>Monitoring and inspection must be carried out by the user &amp; outsourced. Sometimes inspections are only carried</li> <li>There is a possibility of delays in the delivery of chemical and consumables for use in cleaning maintenance</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>Provided personnel (outsourced or internal hiring) as needed</li> <li>Budget planned and available as needed to maintain excellent maintenance quality</li> </ul>	<ul style="list-style-type: none"> <li>Because every manpower is different, it is now necessary to create a workforce analysis that can be plotted anywhere. Therefore, continuous training must always be carried out so that human resources can continue to be productive</li> <li>There is a possibility of a high turnover of the workforce due to the relatively young age of the workers</li> </ul>

### Strengths

A company's traits that provide it an advantage internally over others are called strengths (Dess & Eisner, 2019; Agyekum, 2020). We formulate those six strengths could help develop and maintain the quality of medical facilities' maintenance systems. These factors are the internal factors that could help hospitals in Indonesia develop their

maintenance system quality. The hospitals have schedules of routine maintenance, also reports that break down maintenance activities done in detail. Hospitals could develop their scheduling system through technology, as developed systems nowadays could facilitate workflow and resource allocation processes following a maintenance schedule to gain advantages of time effectiveness (Yousefli et al., 2020).

Healthcare facilities also provided essential equipment which could support the maintenance activities. Maintenance equipment is essential, as lack of preparedness could impose a significant struggle on hospitals, especially during this COVID-19 situation, the requirement for health and safety became more demanding, especially for the essential workers working in hospitals. Personal protective equipment (PPE) for healthcare workers, hospital equipment, sanitizing supplies, toilet paper, and water is crucial to ensure the safety of workers working in COVID-19 handling centers (Kaye-kauderer et al., 2021), whereas for the maintenance policy, the affiliated hospitals have already implemented policies aligned with international standards.

Maintenance activities require specific offices, which are defined by the level of competence and credentials allowing them or not to execute maintenance activities of varying lengths (Touat et al., 2018). The hospitals actually could gain an advantage through the structured allocation of personnel's workloads. This could be helped with developing technologies to gain advantages of time effectiveness (Yousefli et al., 2020). Data became a vital aspect in maintenance, as it will provide information about past maintenance activities, the condition of the maintained facilities, and the results of the conducted maintenance. We found out that the hospitals already implemented security for their maintenance data.

### **Weaknesses**

Weaknesses are the physiological characteristics that put a company at a disadvantage internally compared to others (Dess & Eisner, 2019; Agyekum, 2020). The findings of harmful internal factors are then identified. Following our findings on the hospitals' weaknesses, we see that work scope creep are crippling hospitals maintenance system by bringing disruption in work focus. Besides, high-rise hospital maintenance, mostly involving windows cleaning, is sometimes carried out by uncertified officers, imposing safety threats. Another thing is that the hospitals are putting their trust in monitoring and inspection activities carried out by the outsourced party, which is supposed to be done by both parties. Finally, delays in cleaning maintenance chemicals and consumables made the cleaning maintenance activities hampered.

### **Opportunities**

The opportunities are the aspects of the environment that a company could use to its benefit (Dess & Eisner, 2019; Agyekum, 2020). From our findings, we found out that the hospitals could take advantage of the external factors. Most of the hospitals used outsourced maintenance workforces, besides internally hired forces. The provider of the workforce actually could help the hospitals support their maintenance system vision through enough needed forces. This could be good, as it could answer the need for forces to maintain maintenance workflow, especially during a crisis, such as in the COVID-19 pandemic (Winkelmann et al., 2021).

The hospitals are also at an advantage as they do not have any problems regarding receiving planned and available budgets for commencing the maintenance activities. Budgets are crucial, as most of the time, budgets to maintain facilities are under pressure of financial capabilities limits. Although having those advantages, hospitals should keep on effective management to their budget so that it will help the maintenance cost and improve the facilities' financial capabilities (Demirdögen et al., 2021).

### **Threats**

Threats are aspects in the company's environment that could cause problems with the project's successful implementation (Dess & Eisner, 2019; Agyekum, 2020). The hospitals could conduct a manpower analysis, as well as continuous training, are highly needed in order to keep productivity. Training could help increase knowledge towards maintenance officers, especially regarding work safety (Green et al., 2019). Having supporting resources and infrastructure could facilitate patient containment and other healthcare activities, which hopefully could be ready for facing crises, like the COVID-19 situation (Winkelmann et al., 2021).



## 6. Conclusion

Criteria of success factors were analyzed the in hospitals' maintenance and cleaning management using the geometric mean and Cronbach's alpha statistical test. Suggested research found that of the seven criteria consisting of 33 consistent and reliable sub-criteria, 15 significant sub-criteria influence hospital cleaning service management success. Hospitals can place their focus on these variables to implement their hygiene maintenance system policies and strategies. SWOT analysis also found some strengths and opportunities that the hospital could utilize to develop its current system. Weaknesses and threats are also identified so that hospitals can remove impediments in performing their cleaning maintenance system. Responding hospitals have already shown remarkable performance in conducting their cleaning system. During this COVID-19 pandemic, healthcare facilities' cleaning is one of the importance any hospital should look to maintain their safe operation. There are plenty of room to increase the depth and quality of the cleaning maintenance system study. The utilization of TOWS analysis can be conducted for future research.

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